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# RESPONSE OF SUPPLEMENTAL SOME MINERAL ELEMENTS IN RABBIT'S DIETS ON DIGESTIBILITY, NUTRITIONAL BALANCES AND FEED EFFICIENCY

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## ABSTRACT

Ninety-six NewZeland White rabbits of 35 days old (48 males and 48 females) were randomly allocated to six treatments groups of 8 rabbit each in an individual Stainless Steel cages. Through the experimental period (12 weeks), two digestibility trials were applied at 8 and 12 weeks of the start of the experiment. Three rabbits from each treatment were housed in metabolic cages. The diets fed to the animals were covered the maintenance requirements according to NRC (1977). The feeding plan of the six experimental groups (males or females) were as follows: G1: basal diet containing 16% CP and 2650 kcal DE/kg DM diet (control) without supplementation. G2: as G1 plus 0.30% mineral premix in diet. G3: as G1 with 0.30% Di-calcium phosphate in diet (alone). G4: as G3 plus 122.7 ppm Zn $SO_4$. G5: as G3 plus 20.2 ppm CoCL. G6: as G3 plus Zn $SO_4$ and CoCL. Rabbits were offered the water and tested diets *ad-libitum.* The composition of diets was nearly similar with some differences.

Digestibility, feeding values, N-balance and intakes from DM and feed units were significantly ($P<0.05$) higher for G6 followed by G2 at 8 weeks of age. Meanwhile, groups (G2, G3, G5 and G6) were similar in nutrients digestibility and N-balance at 12 weeks of age. Since, Minerals content of all diets were varied due to the supplementation. However, rabbits of G5 and G6 were in positive minerals balance (Ca, P, Mg, K, Cu, Zn, Mn and Co), while it was in negative balance for Cu (G1, G3 and G4) and Co (G1, G2, G3 and G4) at 8 weeks of age. But all groups had showed positive minerals balance except Cu for G1, G3, G4, G5 and G6 and Co for G1, G2, G3 and G4 at 12 weeks of age. The absolute values of body weight gain (BWG) for rabbits (G2, G3 and G6) at 8 weeks of age increased, while it was numerically increased for groups G2, G3, G5 and G6 at 12 week of age. It could be concluded that supplemented rabbit's diets (males or females) with Di-calcium phosphate alone or with Zn plus Co, improved nutrients digestibility, feeding values, intake from DM and feed units, which reflected on BWG from 35 days to 12 weeks of age and cost of ration formulation.

**Keywords**: Rabbits , digestibility , mineral balances , feed efficiency.

## INTRODUCTION

The adequate intake of feed by animals is essential in meeting mineral requirements. The actual amount of mineral in the diets may also influence utilization (Underwood, 1977). There are some factors that greatly reduce intake, consequently, reduce the total mineral consumed by animals. For instance, in monogastric animals, there is a much greater likelihood for a dietary deficiency of calcium than phosphorus, because grains and protein supplements make up a very large portion of their feed. Generally, feed grains and especially oil meal protein supplements, are relatively rich in phosphorus, therefore, animal receiving high concentrate diet will meet a high proportion of their requirements from these feeds. Unfortunately, the majority of P in corn and soybean meal and oil seed meals is organically bound as phytin P, a form that not well utilized by non-ruminants (McDowell, 1992).

Many of commercial trace-mineralized salt mixture provide an insignificant amount of zinc relative to animal requirements (Underwood, 1977). Therefore, supplemental zinc is easily and cheaply provides by fortifying complete diet, as mineralized salt. Supplementation to supply 50-60 ppm Zn in total diet is normally sufficient for most situation (NRC, 1977).

Cobalt is essential one as a component of vitamin $B_{12}$. Most monogastric species have only a limited ability to synthesize vitamin $B_{12}$ in lower portion of intestinal tract except horse and rabbits, which make good use of microorganisms in digestive tract to synthesize vitamin $B_{12}$ from cobalt. Utilization of cobalt by bacterial flora is much more efficient in rabbits than ruminants. Although, little is known about cobalt metabolism in rabbits, 0.10 ppm dietary cobalt could be adequate (RNC, 1977).

This study was designed to investigate the effect of supplementing some mineral elements (Ca, P, Zn and Co) separately or in different combination during formulated diets and its interaction with other elements (Mg, K, Cu and Mn) on digestibility, feeding values and rabbits performance through growing and finishing stages.

## MATREIALS AND METHODS

This study was conducted at Sids Animal Production Research Station, Ben-Sweef Governorate, belonging to Animal Production Research Institute, during the period from June to September 1998.

Forty-eight rabbits from each sex as a total number of 96 weaned NewZeland White rabbits at 35 day of age were randomly divided into 6 treatments, of 8 rabbits each in individual cages according to their weight. Hence, the mean live body weight of rabbits was nearly similar. Rabbits in all treatments were kept under similar environmental and managerial as well as the hygienic conditions, with free access to feed and water. At 8 and 12 weeks of age, 3 experimental rabbits of each treatments were gone under digestibility evaluation in metabolic Stainless- Steel cages in such a way that feces and urine can be collected separately. A basal diet was formulated to be contained 16% CP and 2650 kcal DE/ kg. Its components and chemical analysis were presented in Tables 1 and 2.

The diets were fed to the animals to cover the maintenance requirements for normal consumption according to the recommendation of NRC, (1977). The feeding plan of the six experimental groups (males or females) used in this study was as shown in Table 3. The experimental period was lasted for 12 weeks. The daily intake from different diets was recorded after weighting the residues, whereas amount consumed were recorded weekly. The animals were fed individually their assigned diets, according to the treatments in metabolism trials.

**Table1: Components and calculated of basal diet.**

| Ingredients | (%) | Contents | Calculated values |
|---|---|---|---|
| Clover hay | 40.20 | CP (%) | 16.05 |
| Wheat bran | 19.00 | DE Kcal/kg | 2650 |
| Barley | 15.00 | CF (%) | 14.51 |
| Soybean meal (44%) | 12.00 | Methionine+Cystine(%) | 0.68 |
| Yellow corn | 9.20 | Lysine (%) | 0.82 |
| Molasses | 3.00 | Ca (%) | 0.907 |
| Limestone | 1.00 | Total-P (%) | 0.474 |
| Salt | 0.50 | K (%) | 1.524 |
| DL- Methionine | 0.10 | Mg (%) | 0.310 |
| --- | -- | Cu (ppm) | 12.15 |
| --- | -- | Zn (ppm) | 41.87 |
| --- | -- | Mn (ppm) | 44.89 |
| Total | 100.00 | Co (ppm) | 0.179 |

**Table 2: Chemical analysis (%) of diets used during experimental periods.**

| DM | OM | CP | CF | EE | NFE | Ash |
|---|---|---|---|---|---|---|
| 100 | 88.36 | 17.62 | 12.68 | 2.81 | 55.25 | 11.64 |

**Table 3: Design of the experimental treatments.**

| Supplements (g/100 kg DM) | Diets | | | | | |
|---|---|---|---|---|---|---|
| | G1 | G2 | G3 | G4 | G5 | G6 |
| Min. Mix * | -- | 300.0 | -- | -- | -- | -- |
| Di-Ca-P ** | -- | -- | 300.0 | 300.0 | 300.0 | 300.0 |
| Zn | -- | -- | -- | 12.27 | -- | 12.27 |
| Co | -- | -- | -- | -- | 2.02 | 2.02 |

**Min. Mix : Registed trade mark Rovimix from Rovogypt Company, Hoffman–La-Loche Limited, supplied per kg diet: Mg 400 mg; Cu, 5mg; I, 0.75 mg; Se, 0.1 mg; Fe, 75 mg; Mn, 30 mg and Zn, 70 mg.**

***Ca and P were added in the form of di-calcium phosphate (CaHPO4), Zn and Co were added in the form of zinc sulphate ($ZnSO_4.7H_2O$) and cobalt chloride ($CoCl_2.2H_2O$).**

The proximate analysis of feed and feces were done according to A.O.A.C. (1980). Composite samples of feed, feces and urine were prepared for mineral determination according to Fick *et al*. (1979). Phosphorus was determined colorimetrically according to A.O.A.C. (1980) and the other elements (Ca, Mg, K, Cu, Zn, Mn and Co) were determined using Shimatzu Atomic Absorption-Flame Spectrophotometer (Model AA-640-13).

Data were statistically analyzed according to SAS 1986 system. The differences among treatment means by Duncan's Multiple Range Test (1955). The statistical model used is one way classifications in all parameters as follows:

$$Y_{ij} = U + T_i + e_{ij}$$

Where,

$Y_{ij}$ = The observation of the *j th* treatment

U = Overall mean

$T_i$ = Effect of the *i* th treatments

$e_{ij}$ = Random error of treatment

# RESULTS AND DISCUSSION

## Digestibility and feed units (at 8 weeks of age)

Results in Table 4 indicated that all nutrients digestibility for G6 were significantly higher (P<0.05), followed by G2 and the lowest digestibility were noted with G1 and G5. The digestibility of fiber in rabbits is low, because cecum selectively retains small particles and soluble constituents for fermentation, while fiber excreted rapidly (Charch 1984). Hintz *et al*. 1978 mentioned that CF digestibility for rabbits did not exceed than 15%. This was confirmed for the basal diet in this study, but it was not for other diets. The TDN and DCP were in similar trend to digestibility coefficients (Table 4). These results may be attributed to the associated effect of the combination of Ca, P, Zn and Co (G6) or to the combination of elements in premix supplements (G2). The daily intake was varied among the experimental groups. Data in Table 4 showed high daily intake (g/h/d) of DM, TDN and DCP with G6 and the lowest daily intake was recorded with G2, G4 and G5. These results may be related to the palatability of mineral salt added to the rations and the synchrony effect of Co together with Ca, P, and Zn.

**Table 4: Digestibility, feeding values, daily intake and N-balances of rabbits fed the tested rations at 8 weeks of age.**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| **Digestion coefficients %** | | | | | | |
| DM | 63.44±0.87 d | 74.20±1.05 a | 71.67±1.07 b | 67.35±2.10 cd | 65.70±1.70 c | 78.16±1.88 a |
| OM | 62.34±0.59 e | 73.73±1.02 a | 70.62±1.14 b | 67.38±1.98 c | 65.15±1.65 d | 78.15±1.87 a |
| CP | 69.54±0.84 c | 79.13±0.67 a | 77.03±0.91 b | 64.06±5.23 d | 70.65±0.95 bc | 82.32±0.89 a |
| CF | 15.07±2.86 d | 31.64±4.70 b | 21.83±3.58 c | 23.73±2.06 b | 16.27±3.90 d | 44.13±6.85 a |
| EE | 72.31±1.08 b | 73.25±0.86 b | 83.30±1.49 a | 81.40±1.89 a | 53.23±2.53 c | 80.93±2.81 a |
| NFE | 70.70±1.69 d | 81.27±1.12 a | 79.64±0.77 b | 76.94±1.38 bc | 74.03±1.81 cd | 85.08±1.00 a |
| **Feeding values %** | | | | | | |
| TDN | 57.57±0.21 d | 67.99±0.92 b | 65.63±0.96 bc | 62.26+1.74 c | 56.33±1.39 d | 72.24±1.54 a |
| DCP | 12.79±0.15 b | 14.37±0.12 a | 14.07±0.16 a | 10.79±0.88 c | 12.07±0.16 b | 13.96±0.14 ab |
| **Daily intakes (g/h/d)** | | | | | | |
| DM | 80.20±4.57 b | 68.78±1.79 d | 86.61±0.29 b | 74.48±4.32 c | 80.85±4.29 b | 99.30±2.83 a |
| TDN | 46.71±2.69 c | 46.77±1.56 c | 56.84±0.64 b | 46.12+8.10 c | 45.44±1.27 c | 71.75±2.66 a |
| DCP | 10.25±0.52 b | 9.89±0.32 b | 12.19±0.10 a | 7.83±0.98 c | 9.77±0.58 b | 13.86±0.39 a |
| **Daily N-balances (g/h/d)** | | | | | | |
| NI | 2.36±0.13 | 2.18±0.16 | 2.53±0.01 | 2.02±0.38 | 2.21±0.70 | 2.69±0.07 |
| FN | 0.72±0.05 a | 0.41±0.00 c | 0.58±0.02 b | 0.75±0.25 a | 0.64±0.02 b | 0.47±0.02 c |
| UN | 0.20±0.07 c | 0.09±0.05 d | 0.14±0.06 cd | 0.16±0.01 c | 0.36±0.10 b | 0.41±0.06 a |
| NB | 1.43±0.08 b | 1.40±0.05 b | 1.81±0.07 a | 1.08±0.15 c | 1.19±0.19 c | 1.81±0.04 a |
| NB% | 60.96±2.50 c | 64.22±2.87 c | 71.54±2.91 a | 53.54±4.90 d | 53.85±5.90 d | 67.29±2.71 b |

**a, b, c, d and e : Means not followed by the same letter in the same row are Significantly differ at (P<0.05).**

## Nitrogen balance (at 8 weeks of age)

Table 4 showed that N-intake was almost similar for all groups without significantly differences, but the differences were observed among fecal-N and urinary-N excretion. It may be related to mineral intake and electrolytes equilibrium. McDowell, (1992) found that high level of Co in diets may have a markedly adverse effect on N-absorption by excessive urinary which is similar with G5 and G6. The N-balance was significantly higher (P<0.05) for G6 and

G3 followed by G1 and G2 and the lowest was recorded by G4 and G5. The N-balance as a percentage of dietary intakes was varied depending on N-intake and urinary–N excretion, however, the high precentage was noted with G3 followed by G6, while lower percentage was obtained for G4 and G5. So better N-utilization was recorded by Ca, P, Zn and Co supplementation.

**Mineral contents of tested diets**

Data in Table 5 showed that Ca content in all tested rations was quite similar except for G1, which was the lowest one (970 mg/100 g DM).

**Table 5: Minerals content (mg/100g DM) of tested diets used during the experimental periods.**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| **Mineral contents (mg/100 g DM)** | | | | | | |
| Ca | 970.00 | 1259.00 | 1147.00 | 1050.00 | 1024.00 | 1072.00 |
| P | 412.00 | 439.00 | 420.00 | 465.00 | 404.00 | 442.00 |
| Mg | 453.00 | 359.00 | 467.00 | 386.00 | 416.00 | 337.00 |
| K | 1340.00 | 1230.00 | 1390.00 | 1065.00 | 1170.00 | 1470.00 |
| Cu | 1.63 | 2.55 | 1.59 | 1.69 | 1.80 | 1.58 |
| Zn | 5.66 | 5.66 | 6.24 | 7.50 | 6.64 | 7.25 |
| Mn | 4.85 | 5.40 | 5.80 | 5.98 | 5.33 | 5.52 |
| Co | 0.16 | 0.20 | 0.29 | 0.28 | 0.39 | 0.36 |

These results could be attributed to addition of Di-calcium phosphate in the diets. Phosphorus and Mg contents were nearly the same in tested rations, while K content was higher in G1, G3 and G6. The copper content was nearly the same except for G2 supplemented by mineral premix. The content of Zn was similar in the supplemental rations (G2, G4 and G6). While, Mn content was ranged from 4.85 to 5.98 mg/100g DM. The Co content was varied according to the supplemental groups (G5 and G6), and was higher due to supplementation.

Table 6 showed that all groups were in positive Ca, P, Mg, K, Zn and Mn balance, while Cu balance was negative except for G2, G5 and G6, which were positive related to high Cu intake. While, cobalt balance was negative with all groups except the supplemental groups G5 and G6.

These results could be due to poor absorption and consequently rapid binding of Co by microorganisms. Also, absorption is reduced since Co is converted into non-vitamin $B_{12}$ compounds that can not be absorbed or used. McDowell (1992) mention that high Mn fix Co in un-available form “Cobaltized” therefore, the use of vitamin $B_{12}$ may warranted where stress, disease or parasites, low intake, reduce intestinal absorption were noticed.

The high level of Ca and P in diet of G6 affected Mn requirements, which interference with Mn absorption, but additional Mn (nearly 50 ppm) tented counteract the excess of Ca. The same results obtained by Cook and Crenshaw (1983). While high Ca with low P level, reduced Cu and Zn absorption (G3). Kincaid (1979) reported that elevated amount of dietary Ca as ground limestone, reduced absorption of Zn in rats fed soy protein.

**Table 6: Minerals balance of tested diets with rabbits at 8 weeks of age.**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| DMI (g/h/d) | 80.20 | 68.78 | 86.61 | 74.48 | 80.85 | 99.31 |
| **Ca (mg/h/d)** | | | | | | |
| Intake | 778.0 | 866.0 | 993.0 | 782.0 | 828.0 | 1065.0 |
| Balance | 404.0 | 588.0 | 636.0 | 428.0 | 533.0 | 558.0 |
| Balance % | 51.93 | 67.90 | 64.05 | 54.73 | 64.37 | 52.39 |
| **P (mg/h/d)** | | | | | | |
| Intake | 330.0 | 302.0 | 364.0 | 346.0 | 327.0 | 439.0 |
| Balance | 73.0 | 84.0 | 100.0 | 98.0 | 87.0 | 136.0 |
| Balance % | 22.12 | 27.81 | 27.47 | 28.32 | 26.61 | 30.98 |
| **Mg (mg/h/d)** | | | | | | |
| Intake | 363.0 | 247.0 | 404.0 | 287.0 | 336.0 | 335.0 |
| Balance | 102.0 | 86.0 | 141.0 | 99.0 | 113.0 | 143.0 |
| Balance % | 28.10 | 34.82 | 34.90 | 34.49 | 33.63 | 42.69 |
| **K (mg/h/d)** | | | | | | |
| Intake | 1075.0 | 846.0 | 1204.0 | 793.0 | 946.0 | 1460.0 |
| Balance | 514.0 | 402.0 | 592.0 | 406.0 | 462.0 | 686.0 |
| Balance % | 47.81 | 47.52 | 49.17 | 51.20 | 48.84 | 46.99 |
| **Cu (mg/h/d)** | | | | | | |
| Intake | 1.31 | 1.75 | 1.38 | 1.26 | 1.46 | 1.57 |
| Balance | -0.25 | 0.23 | -0.31 | -0.16 | 0.32 | 0.16 |
| Balance % | -19.08 | 13.14 | -22.46 | -12.70 | 21.92 | 10.19 |
| **Zn (mg/h/d)** | | | | | | |
| Intake | 4.54 | 3.89 | 5.40 | 5.59 | 5.37 | 7.20 |
| Balance | 0.80 | 1.25 | 1.66 | 1.48 | 1.74 | 3.53 |
| Balance % | 17.62 | 32.13 | 30.74 | 26.48 | 32.40 | 49.02 |
| **Mn (mg/h/d)** | | | | | | |
| Intake | 3.89 | 3.71 | 5.02 | 4.45 | 4.31 | 5.48 |
| Balance | 0.87 | 1.04 | 1.07 | 1.16 | 1.39 | 1.92 |
| Balance % | 22.37 | 28.03 | 21.31 | 26.07 | 32.25 | 35.04 |
| **Co (mg/h/d)** | | | | | | |
| Intake | 0.13 | 0.14 | 0.25 | 0.21 | 0.32 | 0.36 |
| Balance | -0.02 | -0.03 | -0.08 | -0.04 | 0.05 | 0.04 |
| Balance % | -15.38 | -21.43 | -32.00 | -19.05 | 15.63 | 11.11 |

The high and low intake of Mg affected negatively on Cu and Co absorption (G3 and G4, respectively). Increasing of K intake with low Co reduce Zn balances (G1) and the low level of Cu in diets affected negatively on Co absorption and vs. (G1, G3 and G5). Similar results obtained by McDowell (1992).

It could be recommended that supplemented the rabbit’s diets with Di-calcium phosphate plus Zn and Co increased digestibility of nutrients, feed units, N-balances and improved minerals balance than supplementation with mineral premix.

**Digestibility and feed units (at 12 weeks of age)**

Data in Table 7 showed that the digestibility of DM and OM had no significantly differences among groups, while CP digestibility was significantly lower ($P<0.05$) for group G1. These results might be due to low intake of DM.

The NFE showed that groups G2, G4, G5 and G6 had the high significantly differences (P<0.05) than G1 and G3.

**Table 7: Digestibility, feeding values, daily intake and N-balances of rabbits fed the tested rations at 12 weeks of age.**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| **Digestion coefficients, %** | | | | | | |
| DM | 65.31±4.57 | 73.14±1.93 | 67.63±1.49 | 68.10±1.57 | 70.40±2.32 | 69.13±3.46 |
| OM | 64.96±4.58 | 73.11±1.96 | 67.11±1.46 | 68.72±1.43 | 68.64±3.10 | 69.18±3.32 |
| CP | 67.46±4.78 c | 77.70±1.49 a | 70.52±1.73 b | 66.93±0.96 c | 74.23±3.27 ab | 74.60±4.39 a |
| CF | 23.17±9.06 b | 36.37±4.24 a | 26.85±3.18 b | 28.46±5.14 b | 29.19±4.92 b | 28.51±7.70 b |
| EE | 72.60±5.55 b | 77.41±6.38 b | 88.80±1.13 a | 75.57±5.82 b | 80.07±3.80 b | 86.12±1.89 a |
| NFE | 66.43±4.20 c | 81.91±3.47 a | 74.48±0.98 b | 77.31±0.86 ab | 77.01±1.54 ab | 77.44±1.57 ab |
| **Feeding values, %** | | | | | | |
| TDN | 57.17±4.25 c | 67.36±1.63 a | 62.88±1.24 b | 62.90±1.17 b | 61.65±1.85 b | 64.68±2.27 ab |
| DCP | 12.41±0.82 ab | 13.76±0.26 a | 12.88±0.31 a | 11.28±0.16 b | 12.67±0.55 ab | 12.65±0.74 ab |
| **Daily intakes (g/h/d)** | | | | | | |
| DM | 71.29±4.57 c | 75.27±2.04 c | 96.40±4.33 a | 61.37±1.29 d | 88.55±1.56 b | 74.21±2.42 c |
| TDN | 40.38±0.74 d | 50.76±2.52 bc | 60.60±2.73 a | 38.57±0.25 d | 54.65±1.77 b | 48.04±2.74 c |
| DCP | 8.77±0.03 d | 10.62±0.50 bc | 12.42±0.62 a | 6.92±0.15 e | 11.23±0.57 ab | 9.42±0.79 cd |
| **Daily N-balances (g/h/d)** | | | | | | |
| NI | 2.10±0.13 c | 2.19±0.05 bc | 2.78±0.15 a | 1.65±0.03 d | 2.48±0.06 ab | 2.01±0.06 c |
| FN | 0.69±0.13 b | 0.49±0.02 c | 0.83±0.06 a | 0.54±0.02 bc | 0.62±0.07 b | 0.37±0.19 d |
| UN | 0.21±0.00 b | 0.50±0.05 a | 0.16±0.06 b | 0.09±0.02 c | 0.17±0.01 b | 0.28±0.10 b |
| NB | 1.19±0.01 cd | 1.19±0.03 cd | 1.82±0.09 a | 1.01±0.03 d | 1.63±0.20 ab | 1.35±0.11 bc |
| NB% | 57.14±3.61 cd | 54.59±0.96 d | 64.5±0.83 b | 61.07±0.75 c | 67.21±7.62 a | 67.17±3.96 a |

**a, b, c, d and e : Means not followed by the same letter in the same row are significantly differ at (P<0.05).**

Generally, G2, G5 and G6 had the higher digestibility for all nutrients. The TDN value was significantly higher (P<0.05) for G2 and G6 without significant difference, while it was than other groups. Lowest value was recorded by G1 which did not containing any supplementation. DCP values were comparable among groups.

The daily intake (g/h/d) from DM, TDN and DCP was higher for group supplemented with Di-calcium phosphate alone (G3) followed by G5, G2 and G3 respectively. It could be concluded that G2, G3, G5 and G6 were similar in all nutrients digestibility and feeding values, therefore it could be used Di-calcium phosphate with Zn or with cobalt alone or both together in rabbits diet at the finishing period, which was better than other combination.

### Nitrogen balance (at 12 weeks of age)

The daily nitrogen intake was affected by dietary intake of DM and N-contents in the diets (Table 7), whereas, G1, G4 and G6 recorded the lowest N-intake. Fecal and urinary-N are varied among groups, while the N-balance as a percentage of intakes for all groups were not affected except G2, which showed the lowest. Meanwhile, the highly absolute figures of N-balances were noted with G5 and G6 followed by G3. It could be concluded from these results that addition of Di-calcium phosphate alone or with Zn or Co when combined could be better and can resulted in improving digestibility, feeding values and N-balance than using premix alone.

**Minerals balance (at 12 weeks of age)**

Data in Table 8 showed that Ca, P, Mg, K, Zn and Mn were in a positive balances in all groups, while Cu balance was negative with all groups except G2, which was positive balance. It might be due to high Cu intake of G2 than the other groups.

**Table 8: Minerals balance of tested ration using rabbits (at12 weeks).**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| DMI (g/h/d) | 71.29 | 75.27 | 96.40 | 61.37 | 88.55 | 74.21 |
| **Ca (mg/h/d)** | | | | | | |
| Intake | 692.0 | 948.0 | 1106.0 | 644.0 | 907.0 | 796.0 |
| Balance | 449.0 | 614.0 | 758.0 | 403.0 | 576.0 | 537.0 |
| Balance % | 64.88 | 64.77 | 68.54 | 62.58 | 63.51 | 67.46 |
| **P (mg/h/d)** | | | | | | |
| Intake | 294.0 | 330.0 | 405.0 | 285.0 | 358.0 | 328.0 |
| Balance | 84.0 | 95.0 | 142.0 | 88.0 | 97.0 | 103.0 |
| Balance % | 28.57 | 28.79 | 35.06 | 30.88 | 27.09 | 31.40 |
| **Mg (mg/h/d)** | | | | | | |
| Intake | 323.0 | 270.0 | 450.0 | 237.0 | 368.0 | 250.0 |
| Balance | 106.0 | 84.0 | 156.0 | 79.0 | 124.0 | 102.0 |
| Balance % | 32.82 | 31.11 | 34.67 | 33.33 | 33.70 | 40.80 |
| **K (mg/h/d)** | | | | | | |
| Intake | 955.0 | 926.0 | 1340.0 | 654.0 | 1036.0 | 1091.0 |
| Balance | 521.0 | 506.0 | 611.0 | 371.0 | 528.0 | 556.0 |
| Balance % | 54.55 | 54.64 | 45.60 | 56.73 | 50.97 | 50.96 |
| **Cu (mg/h/d)** | | | | | | |
| Intake | 1.16 | 1.92 | 1.53 | 1.04 | 1.59 | 1.17 |
| Balance | -0.22 | 0.28 | -0.38 | -0.32 | -0.26 | -0.29 |
| Balance % | -18.97 | 14.58 | -24.84 | -30.77 | -16.35 | -24.79 |
| **Zn (mg/h/d)** | | | | | | |
| Intake | 4.04 | 4.26 | 6.02 | 4.60 | 5.88 | 5.38 |
| Balance | 0.42 | 1.18 | 1.83 | 1.63 | 1.81 | 2.59 |
| Balance % | 10.40 | 27.70 | 30.40 | 35.43 | 30.78 | 48.14 |
| **Mn (mg/h/d)** | | | | | | |
| Intake | 3.46 | 4.06 | 5.59 | 3.67 | 4.72 | 4.10 |
| Balance | 0.79 | 1.19 | 1.83 | 1.09 | 1.49 | 1.88 |
| Balance % | 22.83 | 29.31 | 32.74 | 29.70 | 31.57 | 45.85 |
| **Co (mg/h/d)** | | | | | | |
| Intake | 0.11 | 0.15 | 0.28 | 0.17 | 0.35 | 0.27 |
| Balance | -0.01 | -0.02 | -0.08 | -0.03 | 0.05 | 0.05 |
| Balance % | -9.09 | -13.33 | -28.57 | -17.65 | 14.29 | 18.52 |

Cobalt balance was in a negative balance in all groups except G5 and G6, which showed positive balance, related to supplementation of cobalt. These results may be related to poor absorption of Co and its necessary to increase the requirements of Co than the recommended allowance of NRC, (1977) for rabbits.

High levels of Ca and P in the diets affected Mn requirements and its needed to supply the rabbit's diet with more than 45 ppm Mn to tend the counteract excess of Ca and P in the diets. The same results were obtained to those reported by Cook and Crenshaw (1983).

Negative Cu balance was affected by highly level of Zn intake, similar results was reported by McDowell, (1992). But, Zn is more protective against Cu toxicity for monogastric species. Suttle and Peter (1984) have suggested that intake of Fe depress Cu status in intestinal. The metabolism of Zn may influence by interaction with other elements like Ca, Cu and Mn as well as type and level of protein (Strain and Pories 1970 and Miller *et al*. 1979).

Generally, many diets could contain adequate amount of elements, but naturally only small amount of element seem to be available to animals. The precentage absorption from different dietary source may varies due to some factors such as form of element in diet, interaction with other elements, age of animal, species, animal status before which can caused a reduction of elements absorption or impair their utilization in the animal feeding (Underwood, 1979).

**Performance of rabbits (at 8 weeks of age)**

Table 9 showed that the initial body weight (IBW) and final body weight (FBW) were similar with no significantly differences among males or females groups. The average body weight gains (BWG) had no significantly differences among males groups, but was significantly higher in respective of females groups. However, groups 2 and 3 had showed more BWG either for males or females. These were matched with nutrients digestibility, higher feeding values (DCP) and better N-utilization for such groups. Concerning minerals balance, G2 was needed to add Co in their diets and G3 and G4 are also needed to supply with Co and Cu to rectify their balances. Therefore, G3 showed that it is the cheapest one than the other combination.

It could be concluded that supplemented rabbit's diets with Di-calcium phosphate alone or with Zn plus Co improved the body weight gains and feed efficiency (FE) for males and females rabbits during the growing period (from 35 days to 8 weeks of age).

**Performance of rabbits (at 12 weeks of age)**

Data in Table 9 indicated that no significantly differences were found among males and females groups for IBW, FBW and BWG, but the absolute values of BWG for males or females were higher in the same order with G2, G3, G5 and G6. The BWG was in concordance to nutrients digestibility, feeding values and N-balance. Mineral balance at this stage showed that all groups are needed to add Cu in their diets except G2, while G1, G2, G3 and G4 are needed to be supply with Co. It could be recommended that supplementing rabbits diets with Di-calcium phosphate alone or with Zn plus Co to improve nutrients digestibility, feeding values and nitrogen and minerals balance which reflected on BWG and cost of diets at finishing period (up to 12 weeks of age).

However, 100, 81.82, 64.24, 41.82 and 24.24% increased supplementation cost from the point of view for G1, G3, G4, G5 and G6, respectively (Table 10).

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**Table 10: Cost supplementation of 100 kg diet.**

| Group | Supplementation | L.E | Increasing rate(%) |
|---|---|---|---|
| G1 | Non | -- | 100.00 |
| G2 | Premix | 1.65 | 00.00 |
| G3 | Di-Ca-P | 0.30 | 81.82 |
| G4 | Di-Ca-P + Zn | 0.59 | 64.24 |
| G5 | Di-Ca-P + Co | 0.96 | 41.82 |
| G6 | Di-Ca-P + Zn + Co | 1.25 | 24.24 |

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# تأثير إضافة بعض الأملاح المعدنية في علائق الأرانب على القيم الهضمية والموازين الغذائية والكفاءة التحويلية للغذاء.

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**معهد بحوث الإنتاج الحيواني – مركز البحوث الزراعية – وزارة الزراعة- الدقى – الجيزة -مصر**

استخدم في هذه الدراسة ٩٦ أرنب نيوزيلندي أبيض عمر ٣٥ يوم (٤٨ ذكور و ٤٨ إناث) قسم كل جنس إلى ستة معاملات ، كل معاملة بها ٨ أرانب في أقفاص من الآستنلستيل تم إجراء تجربتين هضم خلال فترة التجربة (١٢ أسبوع) إحداها عند عمر ٨ أسبوع والثانية عند عمر ١٢ أسبوع من بدء التجربة. شملت كل معاملة على ثلاث أرانب وضعت في صناديق هضم وغذيت على عليقه تغطى الاحتياجات الحافظة طبقاً لمقررات المجلس القومي للبحوث الأمريكية (١٩٧٧) وكانت المعاملات كالآتي:-

مجموعة ١ : عليقة أساسية تحتوى على ١٦% بروتين و ٢٦٥٠ كيلو كالورى طاقة مهضومة لكل كجم من المادة الجافة وبدون إضافة.

مجموعة ٢ : تماثل عليقة المجموعة ١ مضاف إليها ٠,٣% مخلوط معدني.

مجموعة ٣ : تماثل عليقة المجموعة ١ مضافاً إليها ٠,٣ % فوسفات ثنائي كالسيوم.

مجموعة ٤ : تماثل عليقة المجموعة ٣ مضافاً إليها ١٢٢,٧ جزء في المليون كبريتات زنك.

مجموعة ٥ : تماثل عليقة مجموعة ٣ مضاف إليها ٢٠,٢ جزء في المليون كلوريد كوبلت.

مجموعة ٦ : تماثل عليقة مجموعة ٤ مضاف إليها ٢٠,٢ جزء في المليون كلوريد كوبلت.

كان معاملات الهضم وميزان الآزوت والمأكول من المادة الجافة ووحدات الغذاء عالية معنوياً بالنسبة للمجموعة السادسة ثم تلتها المجموعة الثانية عند عمر ٨ أسابيع بينما كانت هذه القيم متغيرة عند عمر ١٢ أسبوع.

كان ميزان العناصر المعدنية للمجموعة ٥ و ٦ إيجابيا لكل من الكالسيوم ، الفسفور ، الماغنسيوم ، البوتاسيوم ، النحاس ، الزنك ، المنجنيز ، الكوبلت بينما كان الميزان سالباً للنحاس للمعاملة ١، ٣،٤ وسالباً مع الكوبلت فى المجموعة ١،٢،٣،٤ عند عمر ٨ أسابيع بينما كان الميزان موجبا لجميع الأرانب عند عمر ١٢ أسبوع فيما عدا النحاس فكان سالباً مع المجاميع ١،٣،٤،٥،٦ وسالبا للكوبلت مع المجاميع ١،٢،٣،٤ و كانت قيمة الزيادة في وزن جسم الأرانب للمجاميع ٢،٣،٦ كبيرة عند عمر ٨ أسابيع بينما كانت هذه الزيادة عند عمر ١٢ أسبوع كبيرة في المجاميع ٢، ٣، ٥، ٦.

من هذه الدراسة يمكن استنتاج أن تزويد عليقة الأرانب بفوسفات ثنائي الكالسيوم منفرداً أو مع الزنك والكوبلت يحسن معاملات الهضم والقيمة الغذائية مما تنعكس بالزيادة في معدل نمو الأرانب خلال الفترة من عمر الفطام (٣٥ يوم) وحتى ١٢ أسبوع من العمر مع تقليل تكلفة تكوين العلائق.

**Table 9: Performance of rabbits during the two experimental periods.**

| Item | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|
| **Performance of male from 35 days-8 weeks** | | | | | | |
| IBW (g) | 769.78+22.6 | 747.7+24.5 | 733.7+27.8 | 772.8+39.9 | 755.2+33.6 | 755.7+29.1 |
| FBW (g) | 1812.13+51.5 | 1879.5+79.1 | 1854.3+78.8 | 1781.8+74.5 | 1773.0+22.1 | 1814.9+61.4 |
| BWG (g) | 1042.25+42.4 | 1131.8+73.0 | 1120.7+59.4 | 1009.0+63.5 | 1017.8+19.3 | 1059.1+39.5 |
| FC (g)** | 4339.13+87.4 | 4417.3+85.0 | 4449.3+135.6 | 4377.8+157.9 | 4553.8+85.9 | 4627.7+30.5 |
| FE | 0.24+0.01 | 0.26+0.2 | 0.25+0.01 | 0.23+0.0 | 0.23+0.01 | 0.23+0.01 |
| **Performance of female from 35 days-8 weeks** | | | | | | |
| *IBW (g) | 771.0+24.3 | 686.5+31.0 | 678.7+35.8 | 711.8+33.2 | 679.2+27.9 | 714.7+43.1 |
| FBW (g) | 1682.0+79.7 | 1856.2+88.5 | 1804.6+24.7 | 1715.7+63.4 | 1773.4+50.2 | 1792.7+76.7 |
| BWG (g) | 911.0+99.1 b | 1169.7+70.7 a | 1125.9+44.5 a | 1003.8+68.7 ab | 1094.2+30.4 ab | 1078.0+65.1 ab |
| FC (g) | 4284.0+120.2 a | 4344.8+57.2 a | 3987.0+90.6 ab | 3905.3+125.1 b | 4102.6+126.6 ab | 4243.3+138.5 ab |
| FE | 0.21+0.02 b | 0.27+0.02 a | 0.28+0.01 a | 0.25+0.02 ab | 0.26+0.01 a | 0.25+0.01 ab |
| **Performance of male from 8-12 weeks.** | | | | | | |
| IBW (g) | 1812.13+51.5 | 1854.33+78.7 | 1773.00+22.1 | 1879.50+79.1 | 1814.84+61.4 | 1781.80+74.5 |
| FBW (g) | 2144.13+99.5 | 2247.83+105.1 | 2145.60+83.9 | 2213.17+97.8 | 2163.00+86.7 | 2099.80+117.9 |
| BWG (g) | 333.00+53.6 | 393.50+57.0 | 372.60+76.6 | 333.66+28.1 | 348.14+36.4 | 318.00+54.1 |
| FC (g) | 3750.38+156.8 | 4053.17+166.5 | 3808.40+93.3 | 3623.50+200.4 | 3824.57+79.0 | 4037.00+215.5 |
| FE | 0.087+0.01 | 0.096+0.01 | 0.100+0.02 | 0.093+0.01 | 0.091+0.01 | 0.078+0.01 |
| **Performance of female from 8-12 weeks.** | | | | | | |
| IBW (g) | 1856.17+88.5 | 1715.67+63.4 | 1682.00+79.7 | 1804.57+24.7 | 1792.67+76.7 | 1773.40+50.2 |
| FBW (g) | 2135.17+91.2 | 2125.67+50.6 | 2087.60+87.5 | 2080.86+50.6 | 2194.33+87.2 | 2125.80+38.6 |
| BWG (g) | 279.00+69.3 | 410.00+48.1 | 405.66+41.1 | 276.28+60.7 | 401.66+30.1 | 352.40+14.8 |
| FC (g) | 3784.67+63.4 | 3787.00+125.4 | 3712.00+198.8 | 3503.43+105.0 | 3729.50+149.1 | 3807.20+123.0 |
| FE | 0.07+0.02 | 0.11+0.01 | 0.11+0.01 | 0.078+0.02 | 0.10+0.01 | 0.094+0.01 |

**a and b : Means not followed by the same letter in the same row are significantly differ at (P<0.05)**

**** FC : Feed consumption.**