

## RELATIVE BIOLOGICAL AVAILABILITY OF MANGANESE FROM SOME INORGANIC SOURCES FOR CHICKS

M.A.M. Sayed; M.Y. Attia; M.H.Abdel-samad and M.A.Abdel-Galil

Animal Prod Res Inst, Agric Res Center, Dokki, Cairo, Egypt.

Received: 12/04/2009

Accepted: 25/05/2009

**Abstract:** *An experiment was conducted to estimate the relative biological availability of manganese (Mn) from some inorganic sources compared with that from reagent grade Mn sulfate.*

*Three hundred developed local strain "Golden Montazah" male chicks 4 weeks old were used. They were randomly distributed into 10 groups (3 replicates / group) (10 male chicks / replicate) according to the average replicate body weight. Chicks were fed 10 experimental diets: the basal diet (without supplemental Mn) and 9 dietary treatments consisted of 3 supplemental Mn levels (100, 200 or 300 mg Mn/Kg basal diet) provided from each of three Mn sources: Mn sulfate, Mn oxide or Mn chloride. The experiment extended 12 weeks in 3 intervals of 4 weeks each. At the end of each 4 weeks interval, parameters of growth performance were calculated. At the end of the experiment, manganese concentration in tibia bones and livers were determined.*

*Main results obtained can be summarized as follow:*

- *Analysis of Mn in tissues revealed a linear relationship between bone or liver Mn concentration and dietary Mn for all three Mn sources. Also, Regression analysis indicated a linear Mn uptake of bone and liver as dietary Mn increased among all sources.*
- *An average values of relative biological availability were 86.58 and 75.17% for Mn oxide and Mn chloride, respectively, when Mn sulfate was set as 100%, biological availability.*
- *Manganese sulfate was the most available followed by Mn oxide and Mn chloride.*

## INTRODUCTION

Manganese (Mn) is essential for bone formation, enzyme function, and amino acid metabolism in poultry (Scott *et al.*, 1976). The utilization of Mn has become an increasing concern because of the extremely rapid growth rate of commercial broiler strains, which puts additional stress on bone structure. Several studies reported that organic Mn sources are more available than inorganic sources (Fly *et al.*, 1989; Henry *et al.*, 1989; Lu *et al.*, 2006),

Ji *et al.*, 2006 reported that the ileum was the main site of Mn absorption for broilers. Also, they indicated that organic Mn was more efficiently absorbed than inorganic Mn.

Manganese is distributed widely throughout the body, although it is generally higher in bones (Underwood, 1977) and tissues rich in mitochondria (Maynard and Cotzias, 1955).

The preferred sources of Mn for supplementation are based on some considerations such as biological availability and cost (Smith *et al.*, 1995). Biological availability of manganese sources is of practical concern when feed ingredients that are low in Mn constitute a large percentage of diets used for poultry. In addition, ingredients including corn, soybean meal, wheat bran and fish meal have been reported to reduce the utilization of dietary inorganic Mn (Halpin *et al.*, 1986; Halpain and Baker, 1986).

Dietary supplementation of Mn is especially important for poultry because diets based on corn and soybean meal are deficient in Mn unless supplemented with inorganic sources or with feedstuffs rich in Mn. Cereal grains and their by-products are vary greatly in Mn concentrations (Mertz, 1987). Corn is very low in Mn (7ppm) and soybean 29 to 43 ppm Mn depending on the method of processing (NRC, 1994).

The linear uptake of Mn by liver and bone make these tissues useful measures of biological availability that are more precisely measured than leg bone deformity scores (Watson *et al.*, 1970, 1971; Black *et al.*, 1984 a,b).

The relationship between high dietary Mn levels and the uptake of Mn by several tissues as a measure of bioavailability of Mn sources has been investigated (Southern and Baker, 1983b; Black *et al.*, 1984a). These studies indicated that tissue Mn uptake in response to dietary Mn is linear and provides a suitable method for determining relative biological availability of Mn sources. Tissue Mn uptake and chick performance were also used as measures of Mn bioavailability (Watson *et al.*, 1970; Southern and Baker, 1983a ; Black *et al.*, 1984a, b).

The following study was conducted to estimate the relative biological bioavailability of Mn obtained from some inorganic sources compared with that from reagent grade Mn Sulfate.

## MATERIALS AND METHODS

The present study was carried out at Seds Research Station, Beny Suif, Animal Production Research Institute, Agricultural Research Center, Egypt. The study involved one experiment designed to evaluate the relative biological availability of manganese obtained from different inorganic sources using the developed local strains "Golden Montazah".

Three hundred developed local strain "Golden Montazah" (Rod Island Red × Dokki4) male chicks 4 weeks old were used. Chicks were housed in chicks battery brooders wire screen floors. They were randomly distributed into 30 battery brooder compartments (10 male chicks/compartment) according to the average group body weight.

Chicks were fed 10 experimental diets: The basal diet (control, T1) and 9 dietary treatments. The basal diet (Table 1) was a corn-soybean meal diet (without supplemental manganese), it was formulated to meet the nutrient requirements of chicks according to Ministerial Decree No 1498, 1996. Treatments consisted of three supplemental Mn levels (100, 200 or 300 mg Mn/ Kg basal diet) provided by each of three Mn sources, Mn sulphate (MnSO<sub>4</sub>. H<sub>2</sub>O), (T2, T3 and T4), Mn oxide (Mn<sub>3</sub>O<sub>4</sub>) (T5, T6 and T7) and Mn chloride ( MnCl<sub>2</sub>.4H<sub>2</sub>O), ( T8, T9 and T10). Chicks were allowed ad libitum access to feed and water for 24 hours photoperiod. The experiment extended 12 weeks in 3 intervals, of 4 weeks each.

At the end of each 4 weeks interval, parameters of growth performance including body weight (FBW), and feed intake (FI) were recorded and body weight gain (BWG) and feed conversion values (FC) were calculated. Also, the relative body weight gain (RWG) and relative feed conversion (RFC) were calculated.

At the end of 12 weeks period, six chicks from each treatment were taken randomly for slaughtering. Right tibia bones were removed, then moisture and ash content were determined according to A.O.A.C., (2000) procedures. Also, livers were removed to determine manganese concentration. Manganese in tibia bones and livers was determined by flame atomic absorption spectrophotometry.

Data obtained for growth performance, tibia bones and livers analysis were analyzed statistically by analysis of variance and linear regression (Duncan, 1955 and SAS, 1990).

## RESULTS AND DISCUSSION

### **Effect of dietary manganese source and level on growth performance of chicks.**

The effect of dietary manganese on growth source and level performance of Golden Montazah male chicks is shown in (Table 2). Results showed that chicks fed the basal diet (T1) ( without Mn supplementation) gave 963 g., 762 g., 4225 g., and 5.54 as final body weight (FBW), body weight gain (BWG), feed intake (FI) and feed conversion (FC), respectively for overall period (5-16 weeks).

Differences in (FBW)between chicks fed on the basal diet and all treatments for the three periods were significant. A significant differences were found between (T2) and all treatments in (FBW) for the second and third periods. There were insignificant differences between T3 and T6, also, between T6 and T9 in (FBW) for the first and third periods. Differences between T7 and T10 in (FBW) for the three periods were insignificant.

According to the results of (BWG), there were a significant differences between chicks fed the basal diet and all treatments during the three periods and for the overall period. There were a significant differences between all treatments in (BWG) for the first and second periods. Insignificant differences were found between T5 and T8, also, between T3 and T6 for the third and overall periods. Differences between T7 and T10 in (BWG) during the third and overall periods were insignificant.

Concerning the results of feed intake (FI), the differences between chicks fed the basal diet and all treatments during the three periods and overall period were significant. There were an insignificant differences between T6 and T7 for the first and overall period also, between T4 and T10 during the second and overall periods.

A significant differences were found between chicks fed the basal diet and all treatments in feed conversion (FC) during the three experimental periods and overall period. Differences between all treatments for the first and second periods were significant. Insignificant differences were found between T3 and T6, also, between T7 and T10 during the third and overall periods.

The results showed that the differences between chicks fed the basal diet and all treatments in final body weight (FBW), body weight gain (BWG) and feed conversion (FC) were significant. These results are in agreement with those of (Black *et al.*, 1984 a,b ; Henry *et al .*, 1989 , Ghazalah *et al .*, 1991 and Attia *et al .*, 2004).

Birds fed diets supplemented with Mn (as Mn sulfate) recorded significantly higher values of FBW and BWG, also, gave the best FC values. These results agreed with those obtained by (Ghazalah *et al.*, 1991 and Attia *et al.*, 2004).

**The effect of dietary manganese source and level on tibia bone:**

The effect of supplementing Golden Montazah chicks diet with different sources and levels of manganese on tibia bone weight and ash is shown in (Table 3).

Chicks fed the basal diet gave 3.91 g., 0.406 %, 42.52% and 1.66% as dried tibia bone weight (DTW), dried tibia bone weight as percentage of live body weigh (DTL), tibia bone ash (TA) and tibia bone ash as percentage of dried tibia bone weight (TAT), respectively.

Insignificant differences were observed between chicks fed the basal diet (T1) and (T2, T5, T6, T8, T9 and T10) in dried tibia bone weight (DTW). Whereas, the differences between (T1) and (T3, T4 and T7) in (DTW) were significant .

Differences between chicks fed the basal diet and all treatments in dried tibia bone weight as percentage of live body weight (DTL) were insignificant.

Concerning the tibia bone ash percentage (TA), the results showed that there were a significant differences between chicks fed the basal diet (T1) and (T2,T3,T4, T6,T7,T9 and T10).While, the differences between T1 and (T5 and T8) were insignificant.

Results of tibia bone ash percentage (TA) showed that T2, T3, T4, T5, T6, T7, T8, T9 and T10 caused 1.93, 5.01, 7.93, 0.49, 4.33, 5.34, 0.24, 3.50 and 5.02 % increase, respectively, as compared to the basal diet (T1).

The results showed that differences between chicks fed the basal diet (T1) and (T2, T3, T4, T5, T6, T7, T9 and T10) in tibia bone ash percentage of DTW (TAT) were significant. But the differences between T1 and T8 were insignificant.

The results showed that tibia bone ash were increased by increasing the dietary Mn from all Mn sources. These results is in agreement with those obtained by (Ghazalah *et al.*, 1991 and Attia *et al.*, 2004).

### **The effect of dietary manganese source and level on manganese concentration of tibia bone and liver**

The effect of dietary Mn source and level on Mn concentration of tibia bone and liver are summarized in Table 4. Chicks fed the basal diet gave 10.5 ppm and 9.3 ppm of Mn in tibia bone and liver , respectively.

Chicks fed the basal diet supplemented with 100, 200 and 300 ppm Mn (as Mn sulphate ) had average tibia bone Mn concentration of 15.8, 25.5 and 35.2 ppm, respectively. While, the chicks fed the basal diet supplemented with 100, 200 and 300 ppm Mn (as Mn oxide) gave 13.1, 21.5 and 30.1 ppm Mn for tibia bone , respectively. However, the chicks fed the basal diet supplemented with 100, 200 and 300 ppm (as Mn Chloride) had an average of tibia bone Mn concentration of 12.9,20.4 and 27.9 ppm, respectively.

Results showed that chicks fed the basal diet supplemented with 100, 200, and 300 Mn (as Mn sulphate ) had an average of liver Mn concentration of 13.5, 22.3 and 31.1 ppm, respectively. Chicks fed the basal diet supplemented with 100, 200, and 300ppm Mn (as Mn oxide) gave 11.2,18.5 and 25.9 ppm Mn for liver Mn concentration , respectively. However, chicks fed basal diet supplemented with 100, 200 and 300 ppm Mn ( as Mn chloride) had an average of liver Mn concentration of 10.6, 17.1 and 23.7 ppm, respectively.

The results showed that the Mn concentration of tibia bone increased linearly with increasing the dietary Mn from all Mn sources which is in agreement with previous studies of (Watson *et al.*, 1970, 1971; Southern and Baker , 1983b ; Black *et al.*, 1984a,b; Henry *et al.* , 1986; Wong-Valle *et al.* , 1989 ; Smith *et al.*, 1995 and Attia *et al.* , 2004).

Manganese concentration in liver followed the same trend as did the tibia bone Mn concentration. The results indicated that liver Mn concentration increased as dietary Mn increased. These results agreed with those obtained by (Watson *et al.*, 1970, 1971; Southern and Baker 1983b; Black *et al.*, 1984 a,b, 1985; Henry *et al.* , 1986; Ghazalah *et al.*, 1991 and Attia *et al.*, 2004).

#### **Relative biological values of manganese sources:**

Linear regression analysis of tibia bone ash Mn concentration and liver Mn concentration as related to dietary Mn levels yields the equations which are shown in Table (5).

Regression analysis indicated a linear uptake of Mn by bone as dietary Mn increased with all tested sources (Fig.1). Also, liver Mn increased in a linear manner as dietary Mn increased regardless of Mn sources (Fig.2).

Relative biological availability values were obtained by a ratio of the slopes from the linear regression equations for bone and liver Mn concentrations (Table 6). When the slope of Mn sulfate was set equal 100%, relative biological availability values of 88.19 and 78.13% were obtained for Mn oxide and Mn chloride, respectively, based on bone Mn concentrations. Availability of Mn from Mn oxide and Mn chloride was 84.96 and 72.20%, respectively, that from Mn sulfate based on liver Mn concentrations. When these values were averaged and Mn sulfate was set at 100%, relative biological values were 86.58 and 75.17% for Mn oxide and Mn chloride, respectively.

The bone Mn had the greatest slope and best of data followed by liver Mn. This result is in agreement with Black *et al.*, (1984a, b) and Henry *et al.*, (1986) who reported also that bone was the most sensitive tissue to changes in dietary Mn followed by liver.

Regression analysis indicated a linear uptake of Mn by bone as dietary Mn increased with all sources. These results agreed with those obtained by Watson *et al.*, (1970); Southern and Baker (1983b); Black *et al.*, (1984a,b), (1985); Henry *et al.*, (1986) and Smith *et al.*, (1995). Also, regression analysis indicated that Mn in liver had been shown to increase linearly with increasing dietary Mn levels regardless of Mn source. This result is in agreement with previous studies (Southern and Baker, 1983a; Black *et al.*, 1984a, b, 1985 and Henry *et al.*, 1986).

Manganese sulfate was the most available followed by Mn oxide and then by Mn chloride, which is in agreement with Black *et al.*, (1984b).

**Table1.** Composition and calculated analysis of the basal diet.

<b>Ingredient</b>	<b>%</b>
Yellow corn	64.00
Soybean meal 44%	32.10
Dicalcium phosphate	1.80
Limestone	1.40
Salt (NaCl)	0.30
Vitamin and mineral mixture*	0.30
DL-Methionine	0.10
<b>Total</b>	<b>100</b>
Calculated chemical analysis**	
Crude protein %	19.10
Metabolizable energy Kcal/Kg	2863
Calcium %	1.06
Available phosphorus %	0.47
Lysine %	1.09
Methionine %	0.43
Methionine+Cystine %	0.75
Manganese mg/kg	19.18

\*Formulated to be free of manganese, each 3 kg of vit. and min. mix. Contains:12000000 IU vit A, 2500000 IU vit.D3 , 30000mg vit. E, 2000 mg vit K3, 1000 mg vit.B1, 5000 mg vit.B2, 1500 vit.B6, 30000 mg Niacin, 15000 mg Pantothenic acid, 1500 mg Folic acid, 50 mg Biotin, 12 mg vit. B12, 300000 mg Choline, 50000 mg Zinc, 30000 mg Iron, 4000 mg Copper, 1000 mg Iodine, 100 mg Selenium and100 mg Cobalt.

\*\* Calculated according to (NRC, 1994).

**Table 2.** The effect of feeding chicks diets supplemented with different manganese sources and levels on growth performance of chicks.

Item	Treatments	Cont.	Sulphate			Oxide			Chloride		
			100	200	300	100	200	300	100	200	300
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Initial body weight, g (IBM)		201	201	200	202	199	199	201	200	201	198
Final body weight, g (FBW):											
At 8 weeks		425 <sup>e</sup>	432 <sup>d</sup>	439 <sup>c</sup>	449 <sup>a</sup>	428 <sup>de</sup>	436 <sup>c</sup>	447 <sup>ab</sup>	430 <sup>d</sup>	439 <sup>c</sup>	445 <sup>b</sup>
At 12 weeks		685 <sup>l</sup>	714 <sup>l</sup>	739 <sup>c</sup>	758 <sup>a</sup>	704 <sup>h</sup>	728 <sup>e</sup>	749 <sup>b</sup>	710 <sup>g</sup>	735 <sup>d</sup>	750 <sup>b</sup>
At 16 weeks		963 <sup>g</sup>	1009 <sup>e</sup>	1052 <sup>c</sup>	1079 <sup>a</sup>	994 <sup>l</sup>	1046 <sup>cd</sup>	1066 <sup>b</sup>	997 <sup>l</sup>	1041 <sup>d</sup>	1065 <sup>b</sup>
Body weight gain, g (BWG):											
5-8 weeks		224 <sup>l</sup>	231 <sup>g</sup>	239 <sup>d</sup>	247 <sup>a</sup>	229 <sup>l</sup>	237 <sup>l</sup>	246 <sup>c</sup>	230 <sup>h</sup>	238 <sup>e</sup>	246 <sup>b</sup>
9-12 weeks		260 <sup>l</sup>	282 <sup>g</sup>	300 <sup>d</sup>	309 <sup>a</sup>	276 <sup>l</sup>	292 <sup>l</sup>	302 <sup>c</sup>	280 <sup>h</sup>	296 <sup>e</sup>	305 <sup>b</sup>
13-16 weeks		278 <sup>d</sup>	295 <sup>c</sup>	313 <sup>ab</sup>	321 <sup>a</sup>	290 <sup>c</sup>	318 <sup>a</sup>	317 <sup>a</sup>	287 <sup>c</sup>	306 <sup>b</sup>	315 <sup>ab</sup>
5-16 weeks		762 <sup>g</sup>	808 <sup>e</sup>	852 <sup>c</sup>	877 <sup>a</sup>	795 <sup>l</sup>	847 <sup>cd</sup>	865 <sup>b</sup>	797 <sup>l</sup>	840 <sup>d</sup>	866 <sup>b</sup>
Relative bodyweight gain%(RWG)		100	106	112	115	104	111	114	105	110	114
Feed intake, g (FI):											
5-8 weeks		1251 <sup>a</sup>	1166 <sup>c</sup>	1134 <sup>e</sup>	1109 <sup>g</sup>	1168 <sup>c</sup>	1134 <sup>e</sup>	1138 <sup>e</sup>	1190 <sup>b</sup>	1157 <sup>d</sup>	1124 <sup>l</sup>
9-12 weeks		1353 <sup>a</sup>	1301 <sup>l</sup>	1315 <sup>d</sup>	1303 <sup>ef</sup>	1288 <sup>h</sup>	1296 <sup>g</sup>	1307 <sup>e</sup>	1320 <sup>c</sup>	1338 <sup>b</sup>	1305 <sup>ef</sup>
13-16 weeks		1621 <sup>a</sup>	1543 <sup>c</sup>	1512 <sup>e</sup>	1487 <sup>g</sup>	1537 <sup>d</sup>	1513 <sup>e</sup>	1504 <sup>l</sup>	1548 <sup>b</sup>	1513 <sup>e</sup>	1478 <sup>h</sup>
5-16 weeks		4225 <sup>a</sup>	4010 <sup>c</sup>	3961 <sup>e</sup>	3899 <sup>g</sup>	3993 <sup>d</sup>	3943 <sup>l</sup>	3949 <sup>l</sup>	4058 <sup>b</sup>	4008 <sup>c</sup>	3907 <sup>g</sup>
Feed conversion (FC) (FI/BWG):											
5-8 weeks		5.58 <sup>a</sup>	5.05 <sup>d</sup>	4.74 <sup>g</sup>	4.49 <sup>l</sup>	5.10 <sup>c</sup>	4.78 <sup>l</sup>	4.63 <sup>h</sup>	5.17 <sup>b</sup>	4.86 <sup>e</sup>	4.57 <sup>l</sup>
9-12 weeks		5.20 <sup>a</sup>	4.61 <sup>d</sup>	4.38 <sup>g</sup>	4.22 <sup>l</sup>	4.67 <sup>c</sup>	4.44 <sup>l</sup>	4.33 <sup>h</sup>	4.71 <sup>b</sup>	4.52 <sup>e</sup>	4.28 <sup>l</sup>
13-16 weeks		5.83 <sup>a</sup>	5.23 <sup>b</sup>	4.83 <sup>cd</sup>	4.63 <sup>e</sup>	5.29 <sup>b</sup>	4.76 <sup>de</sup>	4.74 <sup>de</sup>	5.39 <sup>b</sup>	4.94 <sup>c</sup>	4.69 <sup>de</sup>
5-16 weeks		5.54 <sup>a</sup>	4.96 <sup>d</sup>	4.65 <sup>f</sup>	4.45 <sup>h</sup>	5.02 <sup>c</sup>	4.66 <sup>f</sup>	4.57 <sup>g</sup>	5.09 <sup>b</sup>	4.77 <sup>e</sup>	4.51 <sup>g</sup>
Relative feed conversion %(RFC)		100	110	116	120	109	116	118	108	114	119

Means having different superscripts in the same row are significantly different (P<0.05).

**Table 3.** The effect of feeding Golden Montazah chick diets supplemented With different sources and levels of manganese on tibia bone.

Treatments	Contr.	Sulphate			Oxide			Chloride		
		100	200	300	100	200	300	100	200	300
Item	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Live body weight ,g (LBW)	963d	1009 <sup>c</sup>	1052 <sup>ab</sup>	1075 <sup>a</sup>	1001 <sup>c</sup>	1044 <sup>b</sup>	1066 <sup>ab</sup>	994 <sup>c</sup>	1040 <sup>b</sup>	1064 <sup>ab</sup>
Tibia bone weight, g (TW)	5.70e	6.02 <sup>bcde</sup>	6.26 <sup>abc</sup>	6.62 <sup>a</sup>	5.90 <sup>cde</sup>	6.13 <sup>bcd</sup>	6.61 <sup>a</sup>	5.85de	6.09 <sup>bcde</sup>	6.32 <sup>ab</sup>
Tibia bone weight as % of LBW (TWL)	0.592 <sup>ab</sup>	0.597 <sup>ab</sup>	0.595 <sup>ab</sup>	0.616 <sup>a</sup>	0.589 <sup>b</sup>	0.587 <sup>b</sup>	0.620 <sup>a</sup>	0.588 <sup>b</sup>	0.586 <sup>b</sup>	0.594 <sup>ab</sup>
Dried tibia bone weight ,g (DTW)	3.91d	4.17 <sup>bcd</sup>	4.34 <sup>abc</sup>	4.44 <sup>ab</sup>	3.98d	4.12 <sup>cd</sup>	4.58 <sup>a</sup>	3.95d	4.22 <sup>bcd</sup>	4.20 <sup>bcd</sup>
Dried tibia bone weight as % of LBW (DTL)	0.406 <sup>ab</sup>	0.413 <sup>ab</sup>	0.412 <sup>ab</sup>	0.413 <sup>ab</sup>	0.398 <sup>ab</sup>	0.395 <sup>b</sup>	0.430 <sup>a</sup>	0.397 <sup>ab</sup>	0.405 <sup>ab</sup>	0.395 <sup>b</sup>
Tibia bone ash% (TA)	42.52e	43.34d	44.65 <sup>b</sup>	45.89 <sup>a</sup>	42.73de	44.36 <sup>bc</sup>	44.79 <sup>b</sup>	42.62e	44.01 <sup>c</sup>	44.73 <sup>b</sup>
Tibia bone ash% as % of DTW (TAT)	1.66 <sup>c</sup>	1.81 <sup>b</sup>	1.94 <sup>b</sup>	2.04 <sup>a</sup>	1.70 <sup>b</sup>	1.83 <sup>b</sup>	2.05 <sup>a</sup>	1.68 <sup>c</sup>	1.86 <sup>b</sup>	1.88 <sup>b</sup>

Means having different superscripts in the same row are significantly different (P<0.05).

**Table 4.** The effect of dietary manganese sources and levels on tibia bone and liver Mn concentration of Golden Montazah chicks.

Treatment	Mn source	Supplemental Mn level, ppm	Tibia bone Mn (ash basis) ppm	Liver Mn (dry basis) ppm
1	Control	0	10.5	9.3
2	Sulphate	100	15.8	13.5
3		200	25.5	22.3
4		300	35.2	31.1
5	Oxide	100	13.1	11.2
6		200	21.5	18.5
7		300	30.1	25.9
8	Chloride	100	12.9	10.6
9		200	20.4	17.1
10		300	27.9	23.7

**Table 5.** Linear regression analysis of tibia bone and liver manganese with respect to dietary manganese.

Manganese source	Regression equation
<b>Tibia bone*</b>	
Sulphate	$Y = 6.23 + 0.0965X$
Oxide	$Y = 4.57 + 0.0851X$
Chloride	$Y = 5.36 + 0.0754X$
<b>Liver*</b>	
Sulphate	$Y = 4.87 + 0.0871X$
Oxide	$Y = 3.73 + 0.0740X$
Chloride	$Y = 4.03 + 0.0655X$

\*Where: Y = tibia bone Mn, ppm or liver Mn, ppm  
X = dietary Mn, ppm.

**Table 6.** Relative biological availability of manganese source based on linear regression.

Manganese source	Linear regression slope	Relative value %
<b>Tibia bone</b>		
Sulphate	0.0965	100.00
Oxide	0.0851	88.19
Chloride	0.0754	78.13
<b>Liver</b>		
Sulphate	0.0871	100.00
Oxide	0.0740	84.96
Chloride	0.0655	72.20

Fig.1. Effect of Mn source and level on tibia bone Mn concentration.

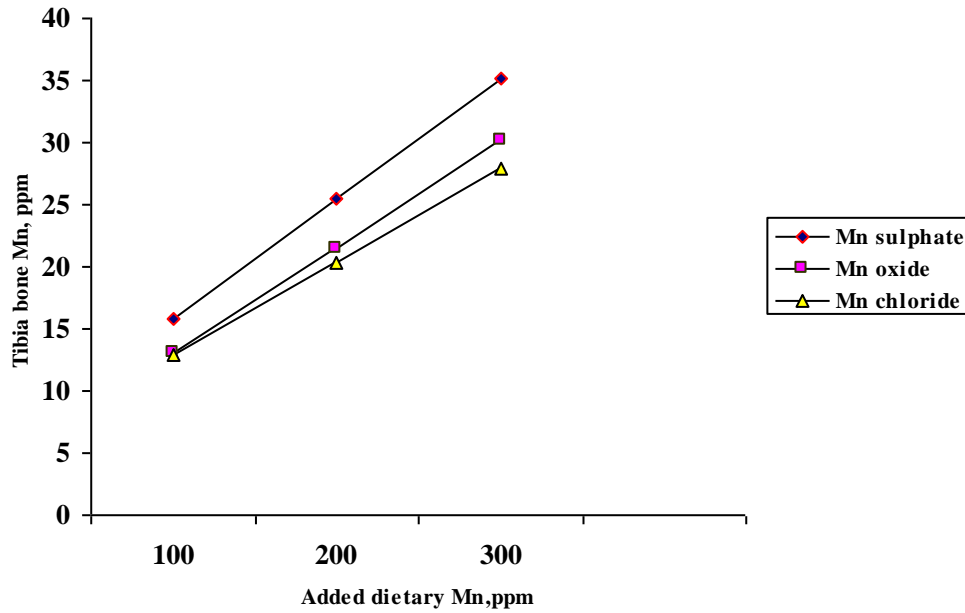
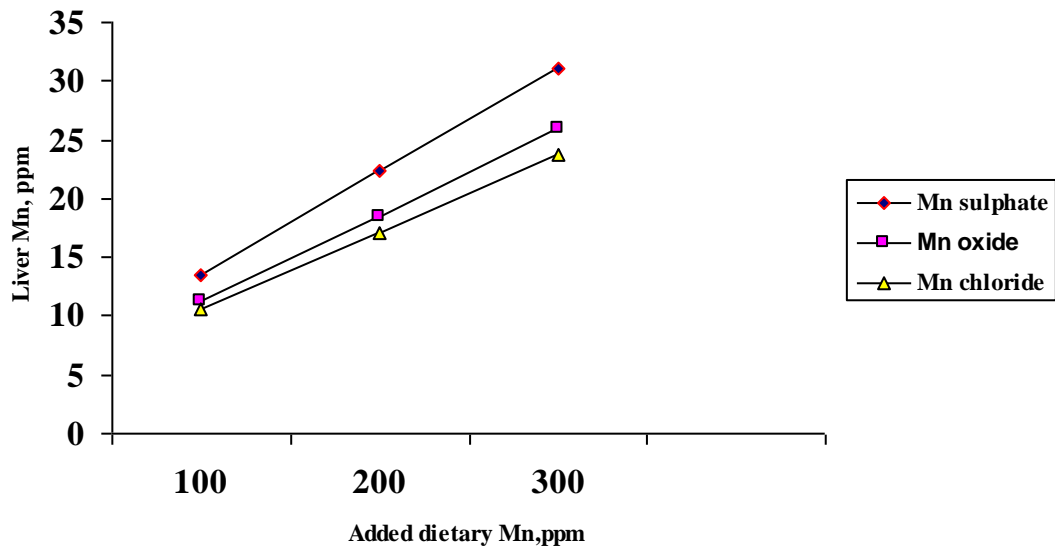


Fig.2. Effect of Mn source and level on liver Mn concentration.



## REFERENCES

- Association of Official Analytical Chemists, (A.O.A.C), (2000).** *Official Methods of Analysis. 17<sup>th</sup> ed., Association of Official Analytical Chemists, Washington, DC.*
- Attia, M.Y.; M.A.M. Sayed; M.A. Abdel-Galil and M.H. Abdel- Samad, (2004).** *Manganese requirement of Dokki 4 and Dandarawi growing chicks. Egypt. J. Appl. Sci., 19(3B):426-442.*
- Black, J.R.; C.B. Ammerman; P.R. Henry and R.D. Miles, (1984) a.** *Biological availability of manganese sources and effects of high dietary manganese on tissue mineral composition of broiler-type chicks. Poultry Sci., 63: 1999-2006.*
- Black, J.R.; C.B. Ammerman; P.R. Henry and R.D. Miles, (1984) b.** *Tissue manganese uptake as a measure of manganese bioavailability. Nutr. Rep. Int., 29: 807-814.*
- Black, J.R.; C.B. Ammerman; P.R. Henry and R.D. Miles, (1985).** *Effect of dietary manganese and age on tissue trace mineral composition of broiler-type chicks as a bioassay of manganese sources. Poultry Sci., 64: 688-693.*
- Duncan, D.B., 1955. Multiple range and multiple F-Test. Biometrics 11: 1-42.**
- Fly, A.D.; O.A. Izquierdo; K.R. Lowry and D.H. Baker, (1989).** *Manganese bioavailability in a methionine chelate. Nutr. Res., 9:901-910.*
- Ghazalah, A.A.; A.F. Soliman and S.S. El-Gazzar, (1991).** *Biological availability of manganese sources as measured by tissue uptake of manganese and performance of broiler chicks. Egypt. Poultry Sci., 11: 245- 265.*
- Halpin, K.M. and D.H. Baker, (1986).** *Manganese utilization in the chick: effects of corn, soybean meal, fish meal, wheat bran and rice bran on tissue uptake of manganese. Poultry Sci., 65: 995-1003.*
- Halpin, K.M.; D.G. Chausow and D. H. Baker, (1986).** *Efficiency of manganese absorption in chicks fed corn-soy and casein diets. J. Nutr., 116: 1747-1751.*
- Henry, P. R.; C. B. Ammerman and R. D. Miles, (1986).** *Bioavailability of manganese sulfate and manganese monoxide in chicks as measured by tissue uptake of manganese from conventional dietary levels. Poultry Sci., 65: 983-986.*

- Henry, P. R.; C. B. Ammerman and R. D. Miles, (1989).** *Relative bioavailability of manganese in a manganese–methionine complex for broiler chicks. Poultry Sci., 68: 107-112.*
- Ji, F.; X. G. Luo; L. Lu; B. Liu and S. X. Yu, (2006).** *Effect of manganese source on manganese absorption by the intestine of broilers. Poultry Sci., 85: 1947-1952.*
- Lu, L.; C. Ji; X.G. Luo and S.X. Yu, (2006).** *The effect of supplemental manganese in broilers diets on abdominal fat deposition and meat quality. Anim. Feed Sci. and Technol., 129: 49-59.*
- Maynard, L. S. and G. C. Cotzias, (1955).** *The partition of manganese among organs and intracellular organelles of the rat. J. Biol. Chem., 214: 489-495.*
- Mertz, W., (1987).** *"Manganese" Pages 185-223 in : Trace elements in Human and Animal Nutrition. 5<sup>th</sup> ed., Academic Press. New York, NY.*
- Ministry of Agriculture, (1996).** *The ministerial decree No.1498, of feed manufacturing and quality control. (In Arabic)*
- National Research Council, NRC, (1994).** *Nutrient requirements of poultry. 9<sup>th</sup> rev. ed., National Academy of Science, Washington, D.C.*
- SAS Institute (1990).** *SAS® institute User's Guide: Statistics. Version 5 Edition. SAS Institute Inc., Cary, NC.*
- Scott, M.L.; M.C. Nesheim and R.J.Young, (1976).** *Nutrition of the chicken. M.L. Scott of Ithica, NY.*
- Smith, M.O.; I. L. Sherman; L.C. Miller and K. R. Robbins, (1995).** *Relative biological availability of manganese from manganese proteinate, manganese sulfate and manganese monoxide in broilers reared at elevated temperatures. Poultry Sci., 74: 702-707.*
- Southern, L. L. and D. H. Baker, (1983)a.** *Emeria acervulina infection in chicks fed deficient or excess levels of manganese. J. Nutr., 113: 172-177.*
- Southern, L. L. and D. H. Baker, (1983)b.** *Excess manganese ingestion in the chicks. Poultry Sci., 62: 642-646.*
- Underwood, E.J., (1977).** *Pages 170-195 in :Trace Elements in Human and Animal Nutrition, 4<sup>th</sup> ed., Academic Press, New York, NY.*
- Watson, L.T.; C.B. Ammerman; S.M. Miller and R.H. Harms, (1970).** *Biological assay of inorganic manganese for chicks . Poultry Sci., 49: 1548-1554.*

**Watson, L.T.; C.B. Ammerman; S.M. Miller and R.H. Harms, (1971).**  
*Biological availability to chicks from different inorganic sources .*  
*Poultry Sci., 50: 1693-1700.*

**Wong-Valle, J.; C.B. Ammerman; P.R. Henry; P.V. Rao and R.D. Miles, (1989).**  
*Bioavailability of manganese from feed grade manganese oxides for broiler chicks. Poultry Sci., 63: 1368 -1373.*

### الملخص العربي

#### الإتاحة البيولوجية لعنصر المنجنيز في بعض مصادره غير العضوية للكتاكيت

محمد أحمد محمد سيد- مصطفى يوسف عطية-محمود حسن عبدالصمد-محمد عبدالعزيز عبدالجليل

معهد بحوث الأنتاج الحيواني- مركز البحوث الزراعية- الدقى-القاهرة- مصر

تهدف هذه الدراسة إلى تقدير الإتاحة البيولوجية لعنصر المنجنيز في بعض مصادره غير العضوية بالمقارنة بكبريتات المنجنيز. تم استخدام 300 كتكوت (ذكور) من السلالة المحلية "المنتزه الذهبى" عمر 4 أسابيع. تم تقسيمها عشوائياً إلى 10 مجاميع ( 3 مكررات/ مجموعة) بواقع (10كتاكيت ذكور/ مكرر) وتم تقسيمها تبعاً لمتوسط وزن كل مكرر . غذيت الطيور على 10 علائق تجريبية تعتمد على عليقة (أذرة-صويا) : العليقة الأساسية (بدون إضافة عنصر المنجنيز ) بالإضافة إلى 9 علائق تجريبية تتكون من العليقة الأساسية مضاف إليها 3 مستويات من عنصر المنجنيز (100، 200 أو 300 ملليجرام منجنيز/ كيلوجرام عليقة أساسية) من أحد ثلاث مصادر للمنجنيز وهى (كبريتات المنجنيز أو أكسيد المنجنيز أو كلوريد المنجنيز). إستمرت التجربة لمدة 12 أسبوع على 3 فترات كل منها 4 أسابيع. تم أخذ قياسات النمو كل 4 أسابيع وفى نهاية التجربة تم تقدير نسبة المنجنيز فى الكبد وعظام الساق.

وفيما يلى أهم النتائج المتحصل عليها:

يوجد علاقة خطية بين نسبة المنجنيز فى الكبد أو عظام الساق ونسبة المنجنيز فى العليقة التجريبية بغض النظر عن مصدر المنجنيز. وقد تأكد ذلك من تقدير نسبة المنجنيز فى الكبد وعظام الساق وكذلك حساب معامل الانحدار.

- أوضحت النتائج أن متوسط قيمة الإتاحة البيولوجية هى 86.58 و 75.17 % لكل من اكسيد المنجنيز وكلوريد المنجنيز على التوالى وذلك باعتبار الإتاحة البيولوجية لكبريتات المنجنيز تساوى 100 %.

- تعتبر كبريتات المنجنيز الأكثر إتاحة بيولوجية يليها أكسيد المنجنيز ثم كلوريد المنجنيز.