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Effect of Different Zinc Sources on Milk Production and Reproductive Performance of Friesian Cows

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This study was conducted to evaluate the influence of dietary supplementation of inorganic or organic zinc on milk production and reproductive performance of dairy cows. A 30 Friesian cows were divided into three groups. Cows in the 1st group (control group, G1) were fed a concentrated feed mixture (CFM), corn silage, fresh berseem and rice straw, while cows in G2 were fed CFM supplemented with inorganic zinc (2.4g/day/cow) and cows in G3 were fed CFM supplemented with organic chelated zinc (2.4g/day/cow). Monthly milk production in G2 and G3 was significantly increased during 2, 5 and 6 months of lactation, as compared with G1. Moreover, G3 increased milk production during 1, 3 and 4 months of lactation than G1 and G2. Milk of fat and protein percentages were significantly ($P<0.05$) increased in G2 and G3 than G1. The G3 had significantly higher protein, albumin, globulin concentrations as compared with G1 and G2. However, G2 and G3 decreased lipid, cholesterol, urea-N concentrations, and increased zinc concentration than G1.Number of estrus cases and ovulatory cycles per cow were decreased in G2 and G3 than in G1. Progesterone (P4) concentration and its peak during the ovulatory cycles in G2 and G3 were significantly increased as compared with G1. The postpartum first estrus and service interval and days open were shorter in G3 than others. The conception rate was significantly higher in G2 and G3 than G1. These findings suggested that supplemented organic zinc improved milk production, reproductive performance and blood metabolites in Friesian cows.

Keywords: Friesian cows, Inorganic zinc, Organic zinc, Milk yield, Reproductive.

Introduction

Despite trace minerals accounting for less than 0.01% of an organism's total mass, they are critical for the production and health of dairy cows [1]. The amounts of trace elements in the animal's bodies and products are influenced by the feeds they consume [2]. Trace minerals such as copper, zinc, and manganese, are essential for protein synthesis, connective tissue formation, immune response, and vitamins metabolism in dairy cows [3], antioxidant properties, maintenance of health, and enhancement of nutritive value and production efficiency in cows [4,5] and their deficiencies in cattle cause health problems. Organic (chelated) minerals are identical to the ones found in natural tissues for plants and animals. These are intended to be absorbed selectively from the intestine [6]. Organic minerals have more bioavailability and retention than inorganic minerals in the digestive tract [7,8]

Zinc is a trace mineral that is required for DNA and RNA synthesis, as well as cell proliferation [9]. The National Research Council [1] suggested that nursing dairy cows should receive 40–60 mg of zinc per kg of body weight in their diet. As a component of metalloenzymes and metalloproteinase, zinc is broadly dispersed throughout the body [10]. The role of zinc was as a cofactor in superoxide dismutase

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enzymes. High dietary Zn intake has the potential to contaminate the environment due to excessive zinc excretion in the faeces and may affect how other nutrients in the diet are digested, absorbed, and used [11,12]. Based on increased bioavailability of Zn compared to inorganic salts, organic mineral formulations in animal feed supplements have gained significant interest from animal producers as a strategy to improve animal performance and health [13,14]. Cows fed organic zinc produced more milk with high fat contents and improved lactation performance and udder health [15].

The objective of this study was to investigate the effects of dietary supplementation of inorganic or organic zinc on milk yield and its compassion, blood metabolites and reproductive performance of Friesian cows.

Materials and Methods

The current study was conducted in collaboration with the Animal Production Department of the Faculty of Agriculture at Tanta University at the Sakha Animal Production Research Station, the belonged to Animal Production Research Institute, Agricultural Research Centre, and Ministry of Agriculture.

Experimental animals

A total of 30 Friesian early postpartum cows weighed 488.7±20.3 kg and aged 3-6 years at 2^{nd} and 3^{rd} parity were used. Animals were randomly divided into three similar groups (n = 10/group) according to live body weight (LBW), milk production, parity and age. Cows of the first group (G1, control) were fed a concentrated feed mixture, those in G2 were fed a concentrated feed mixture supplemented with inorganic zinc (Zinc sulphate, Zn So4) 2.4 g/ day/cow, and those of G3 were fed concentrated feed mixture supplemented with organic zinc 2.4 g/ day/cow during 10 days postpartum up to 180 days of lactation. The source of organic zinc was zinc chelate of glycine hydrate, cupric chelate of glycine hydrate. These supplementations were bought from Biochem (Germany). Cows were maintained in groups under semi-sheds and appeared to be in good health.

Management and feeding system

The concentrate feed mixture (CFM) contained 39% yellow corn, 39%, corn gluten 14%, soybean meal 20%, wheat bran 23%, molasses 2%, premix 0.5% and common salt 1.5%. Cows were fed equal quantities of the diet containing CFM, corn silage**,** fresh berseem and rice straw according to the recommendations of the Animal Production Research Institute [16] for Friesian cows based on their body weight, milk production and fat percentage. Fresh water was supplied throughout the day, and the animals were fed twice a day at 8 a.m. and 2 p.m. The approved procedures of the A.O.A.C. [17] were used to analyse the chemical composition of typical monthly samples of foodstuffs in Table 1.

TABLE 1. Chemical composition of feedstuff

Feed stuff	DM%	OM	CP	CF	EE	NFE	Ash
Concentrate mixture	91.1	91.5	16.5	8.41	2.48	64.11	8.50
Fresh berseem	16.67	84.51	17.43	20.62	3.36	43.10	15.44
Corn silage	33.30	90.91	9.52	17.21	2.56	61.62	9.09
Rice	90.10	84.51	2.53	31.82	1.10	49.06	15.49

Experimental procedure

Body weight

Animals monthly weighted throughout the experimental period.

Milk yield and composition

Farm management standards, at 6:00 and 17:00 h, cows were milked by machine twice daily. Separate daily milk outputs were recorded for morning and evening milking throughout the first 6 months (10 to 180 days) of lactation. Individual milk samples were obtained monthly to measure the milk composition using a Milko-Scan (Model 133B). The fat corrected milk (FCM) content was determined as follows: 4% FCM = 0.4 × Kg milk + 15 × Kg fat [18].

Blood sampling

From 10 days after calving until conception and up to 120 days postpartum, monthly blood samples were taken from the jugular vein and placed in simple test tubes. The obtained blood was centrifuged at 3000 rpm for 10 minutes to remove the serum, and the serum was then kept frozen at -20 °C pending chemical tests.

Chemical assays

Using commercial kits from Diagnostic System Laboratories, In the USA, the concentrations of total protein, albumin, cholesterol, urea-N, glucose, and fat in serum were measured. According to the procedure described by Smith et al. [19], zinc concentrations in serum were measured using an atomic absorption spectrophotometer (Philips, Pug 100, wave length: 213.9 nm, flam type: air-acetylene).

Progesterone assay

The direct radioimmunoassay method (RIA), in accordance with the manufacturer's instructions, was used to determine the P4 concentration in blood serum using a ready antibody coated tube kit from Diagnostic Systems Laboratories (Texas, USA).

The manufacturer states that the P4 antibody's cross reactivity (50 percent binding) was 100 percent with P4 and 6, 2, 50, 1, 20, 0, 80, 0, 48, and 0.10% with 5-pregnone-3, 20-dione 11-Deoxycorticosterone, 17-Hydroxyprogesterone, and 5-pregnone-3, 20-dione 11-Deoxycortisol. The standard curve for P4 ranged from 0.0 to 40.0 ng/ml. The sensitivity value, according to reports, was 0.12 ng/ml. The intra- and inter-assay coefficients of variation were 8.1% and 13.1%, respectively.

Detection of oestrus and insemination

An infertile bull (teaser) was introduced to cows in each group three times a day for 20 minutes each (at 6 a.m., 12 p.m., and 3 p.m.) in order to track the commencement of the first estrus. Cows that responded well to teasers and stayed still for mounting by the teaser were found to be in estrus. They suckled cows that were in heat.

From calving till conception, the quantity and length of estrous cycles were observed. During the estrous cycle, the average P4 concentration, P4 peak, and interval to P4 peak were calculated. First estrus, first postpartum ovulation, intervals post-treatment, number of services per conception (NS/C), conception rate (CR%), and days open (DO) were also noted. Rectal palpation led to pregnancy on day 60 after insemination.

Statistical analysis

The obtained results were statistically analysed [20] as follows using SAS [21] in a one-way complete design. Duncan's [22] Multiple Range Test Duncan was used to test for substantial discrepancies between means.

For digestibility coefficients and nutritive values as well as all different parameters were used and the statistical model was: $Y_{ij} = U + A_i + e_{ij}$.

Where: Y_{ij} = Observed values, U = Overall mean, A_i = Experimental groups and $\mathbf{e_{ij}}$ **=** Random error

Results and Discussion

Changes in live body weight

Live body weights (LBW) and changes in LBW of Friesian cows in control and treated groups at a different stage of lactation are presented in Table (2). The present results revealed that at 2 to 6 months of age studied, LBWs of cows were insignificantly different (Table 2), is almost the highest in cows fed on diets containing organic zinc (chelated, G3) as compared with that fed inorganic zinc (G2) and control diets (Table 2).

TABLE 2. Average and Changes in live body weight of treated and controlled Friesian cows at different lactation stage intervals.

Lactation stage (month)	Experimental groups		
	G1	G2	G3
Average live body weight:			
0 at calving	492±24	481±21	493±16
1	480±22	472±10	485±18
2	488±15	480±25	495±21
3	493±16	486±12	499±0.13
4	497±21	495±23	509±23
5	504±19	498±15	511±29
6	512±19	511±15	527±29
Changes in live body weight:			
0 ~ 1	-12	- 9	- 8
0 ~ 2	- 4	- 1	2
0 ~ 3	1^b	5^a	6^a
0~ 4	5^b	14^a	10^a
0 ~ 5	12^b	17^a	18^a
0 ~ 6	24^b	30^a	34^a

G1: control group, G2 and G3: supplemented with inorganic and organic zinc 2.4 g per day each cow, respectively. $^{a\ and\ b}$ Within the same row, group means marked by the same superscripts are not substantially different at (P<0.01).

The changes in LBW were loss in the first month increased in all groups. But, from the second month, compensation and increase of LBW was higher in G3 compared with those in G1 and G2 groups compared with the G3 were the positive of LBW. The results for BW parameters are consistent with those by Hackbart *et al*. [23], who found no benefit of treated but increased BW loss in cows fed with zinc in addition to amino acid complexes during the first month of lactation. The present results revealed that at 0 ~ 3 to 0 ~ 6 months of ages studied, changes LBW of cows were significantly (P<0.05) different (Table 6), being almost the highest in cows fed on diets containing organic zinc (chelated, G3) and fed inorganic zinc (G2) as compared with those control diets (Table 2). The results agree with Huerta, *et al* [24] found that addition of 200 ppm zinc from zinc sulfate or zinc-methionine with diets of beef heifer improved average daily gains were highest for higher fed zinc methionine diet than controls.

The results are in the same line with Gorlov, et al. [25], who found that the organic treatment calves had increased significantly daily gain compared with the control. The volume and quality of mineral nutrition, which supports the development of lean tissue in the body, especially at a young age, is a significant determinant in the creation of beef production in calves during ontogenesis [26,27]. The foundation of feeding entails enhancing feed efficiency as a result of the diet's maximum amount of nutrients and mineral components, which boost the animals' ability to produce meat.

Biochemical parameters in blood plasma

The effects of treatments on total protein and albumin concentrations in blood plasma of cows were higher significantly (P<0.05) in G3 than in the G1 and G2 groups (Table 3). The results agree with Gorlov et al. [25] who found those albumins high in the blood are presumably linked with the enhanced protein activity and their exchange that is typical for growing animals. In treatment calves, proteins and albumin levels were higher by 7.7-7.8% and 3.4%, respectively compared with the control group.

TABLE 3. Means and standard errors of biochemical parameters of treated and controlled Friesian cows at different lactation stage intervals.

Its	Experimental groups		
	G1	G2	G3
Total protein (g/dl)	7.33 ± 0.19^{b}	7.86 ± 0.13^{ab}	7.96 ± 0.09^{a}
Albumin (g/dl)	3.84 ± 0.09^{b}	4.02 ± 0.09^{ab}	4.27 ± 0.07^{a}
Globulin (g/dl)	3.49 ± 0.08^{b}	3.90 ± 0.08^{a}	3.79 ± 0.07^{a}
Glucose (mg/dl)	52.97±1.25	55.70±0.95	57.27±0.81
Lipid (mg/dl)	234.3 ± 3.36^{a}	193.0 ± 3.60^{b}	191.7 ± 3.82^{b}
Cholesterol(mg/dl)	164.7 ± 1.25^{a}	151.0 ± 1.7^{b}	149.0 ± 3.1^{b}
Urea-N (mg/dl)	29.67 ± 0.55^{a}	25.57 ± 0.45^{b}	24.4 ± 0.44^{b}
Plasma Zinc (μmol/L)	14.60 ± 0.43^{b}	15.70 ± 0.46^{ab}	16.53 ± 0.51^{a}

G1: control group, G2 and G3: supplemented with inorganic and organic zinc 2.4 g per day each cow, respectively. [a and b] Within the same row, group means marked by the same superscripts are not substantially different at (P<0.01).

In cows received 100% inorganic (G2) and organic zinc (chelated) in G3 increased insignificant glucose concentration during the 180 days of lactation, as compared with the control (G1). The results agree with Bakhshizadeh et al.[28] who found that concentrations of glucose had no effects. Also, Sobhanirad et al. [29] found no effects of organic and inorganic Zn on metabolic status.

In cows received 100% inorganic (G2) and organic zinc (chelated) in G3 significantly (P<0.05) decreased lipid, cholesterol and urea-N concentrations in the plasma of cows during the 180 days of lactation, as compared with the control (G1) group. These findings are in line with those made by Shakweer *et al*. [30], and Bakhshizadeh *et al*. [28], who discovered that Friesen calves whose meals included zinc sulphate or zinc methionine at 45 mg/kg DMI had lower blood urea concentrations. However, neither organic nor inorganic Zn supplementation had any influence on markers of metabolic state [29]. The lack of treatment effects on these parameters suggests that animal protein and fat metabolism is unaffected by zinc supplementation [9].

In cows received 100% inorganic (G2) and organic zinc (chelated) in G3 significantly (P<0.05) increased plasma Zinc concentration of cows during the 180 days of lactation, as compared with the control (G1) group. The results agree with Huerta *et al.* [24] found that addition of 200 ppm zinc from zinc sulphate or zinc-methionine with diets of beef heifer improved serum zinc concentrations than controls. Additionally, Alimohamady *et al.* [31] discovered that supplementing 30 mg Zn/kg DM from organic or inorganic to the diet of growing lambs containing 19.72 mg Zn/kg DM might increase plasma Zn concentration. They did this by comparing the higher plasma Zn levels in the zinc supplemented groups to control animals. Previous research, which supports our findings, showed that Zn supplementation might raise the plasma Zn content in lambs [32, 33, 34]. Animals supplemented with organically chelated minerals had higher blood plasma Zn levels than those given inorganic (sulphate) minerals, [35, 36, 34] in male goats. Their findings agree with the information gathered for the current investigation. Increased Zn concentration in the blood may thus be considered a useful indicator of Zn overload because blood Zn concentration is a frequent Zn index in the therapeutic area [28].

Milk yield

Results presented in Table (4) show that the effect of supplemented inorganic and organic trace minerals Zinc significantly (P<0.05) increased average daily milk yield during the 180 days of lactation compared with the control. In cows were resaved organic trace minerals (chelated) in G3 significantly (P<0.05) increased average monthly milk production during 1, 3 and 4 months of lactation than in the G1 and G2 groups. However, cows in G2 and G3 significantly (P<0.05) increased average monthly milk yield during 2, 5 and 6 months of lactation as compared with the control (Fig.1). Organic or inorganic zinc improved milk yield. Even when 100% of the minerals were replaced with organic and inorganic forms, milk yield was increased compared with the control groups. The results in Table 4 show that organic (chelated) and inorganic trace minerals in G2 and G3 significantly (P<0.05) increased monthly milk yield and total milk production during the 180 days of lactation compared with control groups (Fig.1).

TABLE 4. Actual milk yield and compassion of cows in experimental groups

Items	Experimental groups		
	G1	G2	G3
Actual milk yield (kg/day)	20.70±0.92^{b}	22.50±0.83^{ab}	23.25±0.84^{a}
Fat corrected milk yield (kg):	18.84±0.632^{b}	20.99±0.65^{ab}	22.46±0.67^{a}
Monthly milk yield (kg):	621.0±16.3^{b}	675.0±17.25^{a}	697.5±15.9^{a}
Total (180 days)	**3726.0±45.7^{b}**	**4050.0±84.6^{a}**	**4185.0±43.1^{a}**
Compassion milk yield (%)			
Fat	3.42±0.05^{b}	3.55±0.05^{a}	3.65±0.06^{a}
Protein	2.55±0.05^{b}	2.78±0.04^{a}	2.82±0.04^{a}
Lactose	4.07±0.07	4.11±0.08	4.14±0.08
Total solids	11.35±0.24	11.69±0.27	11.78±0.31
Solids not fat	7.33±0.33	7.49±0.25	7.84±0.28

G1: control group, G2 and G3: supplemented with inorganic and organic zinc 2.4 g per day each cow, respectively. [a and b] Within the same row, group means marked by the same superscripts are not substantially different at (P<0.01).

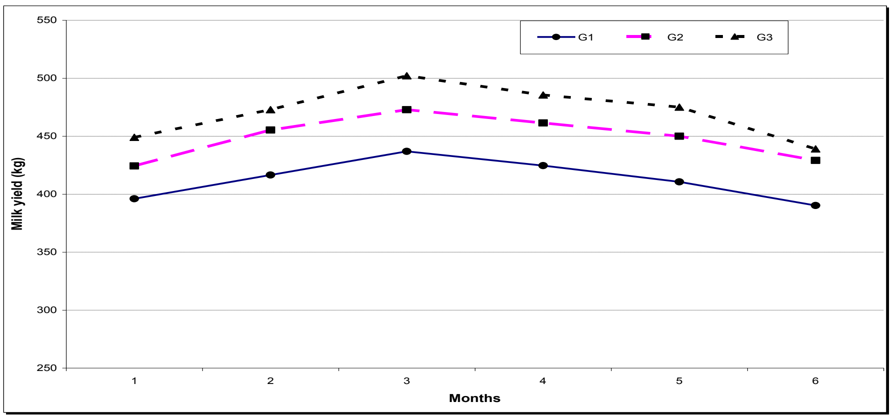

Fig. 1. The effect of inorganic and organic zinc on the monthly milk production of Friesian cows

In cows received inorganic and organic trace minerals (chelated) in G2 and G3 significantly (P<0.05) increased average daily milk yield during the 180 days of lactation, in terms of actual milk yield by 11.58 and 14.74% and 4% fat corrected milk yield (FCMY) by 14.07 and 20.0% as compared with the control (G1) and inorganic (G2) groups. Organic minerals were an improvement in milk yield (Table 4 and Fig.1).

It is of interest to note that inorganic and organic trace minerals treatment in G2 and G3 significantly (P<0.05) increased fat and protein percentages as compared with G1 about by about 5.55 and 3.0, respectively (Table 4). However, lactose and total solid percentages insignificantly increased in G2 and G3 than in G1 about by 3.22 and 2.97%, respectively. All treatments had no effect on lactose and total solid percentage. The obtained increase in AMY and percentages of fat and protein in treated groups (G3) were reflected in significant (P<0.05) higher yields of protein and fat in G3 than in the control group (Table 2). On the other hand, fat yields were increased significantly in treated groups than in the control one, but protein and total solid yields increased in G3 than in G1 about by 10.59 and 3.79%, respectively. The results agree with Michael *et al.* [37] who found that feeding cows a combination of zinc complex, manganese, copper and cobalt to lactating dairy resulted in 0.05 kg/d more milk fat, 0.02 kg/d more milk protein and 0.07 kg/d more milk solids. Also, Tmlinson, [38] found that lactating Holstein cows fed on 14 g/hd/d 4-plex contained 360 mg zinc methionine and 200 mg manganese methionine from 21 days prepartum through 150 days postpartum on lactation resulting in increased production of fat, energy corrected milk and protein production with increasing levels of 4-plex supplementation. As a result, mineral supplementation from organic sources is effective in resolving ruminant reproductive issues. Organic zinc is beneficial in increasing mastitis resistance due to zinc's alleged function in skin integrity and the keratin lining of the vaginal canal [39]. By supplementing organic mineral sources, it is possible to improve udder health by lowering the herd's somatic cell count [40]. Organic minerals have several beneficial effects such as production enhancer, and increasing quality of milk yield in ruminants [4, 23]. In cows, supplementing organic trace minerals increased milk yield and milk fat levels more than in inorganic minerals[4, 41, 23]. Also, (Cope *et al*. [42] reported a considerable increase in milk output when organic Zn was used to replace inorganic Zn (ZnO).

When compared to inorganic Zn diets, milk production and fat corrected milk (FCM) were considerably higher (P 0.05) for both ZnMet meals. 15 mg Zn (ZnMet) and 25 mg Zn (ZnMet) rations improved average daily milk output by 12.32 present and 9.78 present, respectively, above 25 mg of Zn (ZnSO4) diet [39]. Zinc supplementation increased the amount of milk produced by ewes [43]. Previously, when dairy cows were fed with chelated minerals, similar outcomes were documented [7].

The effects of various forms of trace mineral supplementation on milk output have previously been observed to be inconsistent. Dairy cows' milk output was increased by giving diets containing organically complexed minerals or a combination of inorganic and organically complexed minerals [35, 42]. However, in keeping with the findings of the present study, some authors [44, 45] discovered that the type of supplementary Zn did not influence milk output. The results of the current investigation confirm the findings of some studies [42, 41] where the various forms of Zn in the diet had no effect on milk composition. Zinc concentration in milk was unaffected by the type of zinc. With different quantities of dietary Zn, the content of Zn in milk was likewise shown to be constant [42]. It's been claimed that Zn flux in dairy cows' mammary glands is tightly controlled to ensure that the neonate gets enough Zn [46]. When compared to inorganic sources, chelated sources of Zn, Mn, and Cu resulted in greater milk output, milk fat, and protein percentages in cows [47]. In comparison to an inorganic zinc sulphate source, Hassan *et al*. [39] found that supplementing ewes with 40 present less Zn from chelated sources enhanced milk output by 12 present, as well as 26 present and 31 present increases in protein and fat synthesis. When compared to 100% inorganic minerals, reduced mineral supplementation to a tone of 40% from chelated sources resulted in a 4% improvement in milk yields in late lactation cows [48]. In terms of average daily growth and feed intake in steers, developing kids and calves, as well as milk production in goats and cattle, organic zinc supplementation outperformed inorganic versions [49]. Zinc supplementation may alter the fatty acid composition of milk, but it has no discernible effect on amino acids [50].

Ovarian activity

Results in Table (5) showed that inorganic and organic zinc (chelated) treatment in G2 and G3 decreased (P<0.05) average number of estrus cases and ovulatory cycles per cow during the ovulatory cycles compared with the control group. On the other hand, average number of total ovulations, and ovulatory cycle length were not significant. Average Pg and Pg peak concentrations during the ovulatory cycles in G2 and G3 were significantly (P<0.05) increased as compared with G1. However, P4 concentration significantly (P<0.05) decreased prior to estrus incidence in G2 and G3 as compared with G1. But, the interval to P4 peak was not significant (Table 5).

TBLE 5. Postpartum ovarian activity of cows

Item	Experimental groups		
	G1	G2	G3
Number of ovulatory cycles/cow	4.5±0.21^{a}	3.00±0.25^{b}	2.50±0.23^{b}
Number of ovulations /cow	4.00±0.25^{a}	3.75±0.28^{ab}	3.00±0.27^{b}
Ovulatory cycle length (day)	21.85±2.5	22.32±2.8	20.95±1.9
Average of P4 prior to estrus activity[1]	0.489±0.03^{a}	0.298±0.04^{b}	0.342±0.04^{b}
Average Pg concentration (ng/ml)*	2.795±0.15^{b}	3.902±0.17^{a}	3.867±0.18^{a}
Pg peak (ng/ml)*	7.391±0.35^{b}	8.635±0.41^{a}	9.568±0.46^{a}
Interval to Pg peak (day)**	11.45±1.2	10.92±1.3	11.25±1.4

G1: control group, G2 and G3: supplemented with inorganic and organic zinc 2.4 g per day each cow, respectively. [1] From the time of treatment to estrus incidence. *During ovulatory cycles, **from the beginning of the ovulatory cycle.[a and b] Within the same row, group means marked by the same superscripts are not substantially different at (P<0.01).

Reproductive performance

The average postpartum first estrus interval of cows is shown to have a marked effect of dietary treatment, being significantly (P<0.05) shorter for organic zinc cows supplemented than those in the control group. However, the differences between organic zinc (chelated) and inorganic or inorganic and control groups were not significant. This means that postpartum first estrus interval of cows that received organic zinc (chelated) was earlier by about 6.25 and 10.91 days than those of the inorganic and control groups, respectively (Table 6). The present results for average postpartum first estrus interval of cows agree with Abu El-Hamd *et al*. [51]**,** who observed an improvement in reproductive performance occurred either in the first service.

The present results showed that resumption of the postpartum ovarian activity, particularly estrous activity, was significantly earlier in cows with resaved organic zinc (chelated), which may indicate beneficial effect of zinc supplementation on the incidence of the first estrus in cows. Results revealed a significant (P<0.01) effect of dietary treatment on postpartum first service interval, being shorter for cows in organic zinc (chelated) and inorganic zinc than those in the control group. However, cows in organic zinc (chelated) are shorter significantly than those in inorganic zinc. This means the earlier postpartum first service interval of cows resaved organic zinc (chelated) by about 8.2 and 29.2 days than those of the inorganic zinc and control groups, respectively (Table 6).

TABLE 6. Reproductive performance of cows fed different dietary treatments.

Item	Experimental groups		
	G1	G2	G3
Postpartum first estrus interval (day)	42.53±2.27^{a}	36.25±2.11^{ab}	31.62±1.82^{b}
Postpartum first service interval (day)	80.7±3.4^{a}	72.5±2.6^{b}	51.5±3.5^{c}
Service period length (SPL, day)	21.8±3.1^{a}	17.7±2.7^{ab}	10.83±1.8^{b}
NS/C	2.00±0.16^{a}	1.75±0.13^{a}	1.4±0.12^{b}
Days open (DO, day)	102.5±9.85^{a}	90.2±8.15^{a}	62.67±6.86^{b}
Conception rate (%)	60.00	80.00	100.00

G1: control group, G2 and G3: supplemented with inorganic and organic zinc 2.4 g per day each cow, respectively. [a and b] Group means denoted with the same superscripts within the same row are not significantly different at (P≥0.05).

The present results for PFSI agree with Griffiths *et al*. [4] and Hackbart *et al*. [23 who found that organic minerals have several beneficial effects such as production enhancer, increasing quality of milk yield and also improving reproductive efficiency in ruminants. Data showed that the service period length(SPL) in cows was affected significantly (P<0.01) by dietary treatment. As a result of conceiving most cows in the organic zinc (chelated) group after the 1st service (60%), SP length was

10.83 days, being significantly ($P<0.05$) than the control and inorganic zinc groups. The corresponding SP was 21.8 and 17.7 days in the control and inorganic zinc group, respectively (Table 6).These results indicated a good impact of feeding cows on diets supplemented with organic zinc (chelated) than with inorganic zinc on the service period length (10.83 vs. 17.7 days). On the other hand, feeding cows with inorganic zinc showed somewhat improvement in SP length as compared with the control animals (17.7 vs 21.8 days). Results revealed that NS/C of cows was affected significantly ($P<0.01$) by dietary treatment (Table 6), whereas 60% of cows resaved organic zinc (chelated) supplemented conceived from the 1st service, and NS/C was 1.4 services. The corresponding values were 1.72 and 2.00 services for inorganic zinc cows and control groups, respectively. The low average of NS/C for cows obtained in treatment groups in this study (1.0 - 1.6 services) agreed with that reported by Hegazy *et al*. [52].

In this study, the introducing male to females in all experimental groups to heat detection may be the reason for reducing the number of services required per conception. These results indicated a good impact of feeding cows on diets supplemented with organic zinc (chelated) than those fed diets supplemented with inorganic zinc on NS/C (1.4 vs. 1.75). On the other hand, feeding cows in the treatment group showed somewhat improvement in NS/C (1.4, 1.75 vs. 2.00 NS/C) as compared with the control animals. Cows fed organic zinc (chelated) significantly ($P<0.05$) showed the shortest DO (62.67 d), while Do for cows fed inorganic zinc and control diets were nearly similar, being 90.2 and 102.5 days, respectively (Table 5). Conception rates (CR) at successive postpartum days of cows were higher significantly ($P<0.05$) at 100% and 80% of cows in organic zinc (chelated) and inorganic zinc diet, respectively than 60% of cows in the control group during this period (Table 6). The current results for CR are consistent with numerous studies that have suggested that organic trace minerals improve a variety of manifestations of reproduction in cows, including an increase in pregnancy percentage [41,53], a decrease in open days and NS/C [15] and a decrease in days to first postpartum oestrus [44]. When compared to supplementing with inorganic mineral sources, amino acid chelated sources of minerals might reduce the open days by 42 days and NS/C by 42% because they raise the concentration of certain minerals in their uterine tissue [41, 44].

Therefore, supplementation of minerals through organic sources is effective in ameliorating the reproductive problems in ruminants. Abu El-Hamd *et al.* [51] observed an improvement in reproductive performance occurred either in first service, conception rate or in the overall conception per pregnancy rate. Also, minerals have been examined for their potential to increase fertility during breastfeeding in the months before insemination. When organic vs inorganic Cu, Zn, Mn, and Se were compared, Boland *et al*. [54] found improvements in conception rates and days to the first service.

Conclusion

Results of these findings concluded that supplemented organic zinc (chelated) in Friesian cows improved reproductive performance with higher values in pregnancy rate in Friesian cows, progesterone levels and shorter days open. As well as evaluation indicated that improved average daily milk production during the 180 days of lactation in Friesian cows. Also, improvement in some blood metabolites were as increasing total protein, albumin, globulin and zinc but decreasing lipid, cholesterol and urea-N concentrations in the blood plasma of cows.

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Conflict of Interest:

None

Author`s contributions

All authors contributed to the study’s conception, and design. Data collection, examination and experimental study were performed by GMO, SHS, AAB and MAA. All biochemical analysis and data analysis were performed by MAA, GMO and ShAG. MSS, AAB, ShAG and AHG drafted and corrected the manuscript; MAA and MSS revised the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References

1. NRC, *Nutrient requirements of dairy cattle*. 7th rev. ed., Natl. Acad. Press, Washington, DC. (2001).
2. Goldman, C.R. *Micronutrient elements* (Co, Mo, Mn, Zn, Cu). Chapter, Encyclopedia of Inland Waterson. pp. 52–56 (2009).
3. Miller, J.K., Ramsey, N. and Madsen, F.C. *The trace elements* In: Church D.C. The Ruminant Animal: Digestive Physiology and Nutrition. Prentice-Hall, Englewood Cliffs, NJ 988: 342-400 (1988).
4. Griffiths, L.M., Loefller, S.H., Socha, M.T., Tomlinson, D.J. and Johnson, A.B. Effects of supplementing complexed zinc, manganese, copper and cobalt on lactation and reproductive performance of intensively grazed lactating dairy cattle on the South Island of New Zealand. *Animal Feed Science Technol*., **137**, 69-83 (2007).
5. Faulkner, M. J. and Weiss, W. P. Effect of source of trace minerals in either forage- or by-product–based diets fed to dairy cows: 1. Production and macronutrient digestibility. *Journal of Dairy Science*, **100**, 5358–5367 (2017).
6. Webb, K.E., Wong E.A., Pan YX, Chen H., Poole C.A., Van L. and Klang J.E. The role of peptides in absorption pathways. *Redefining Mineral Nutrition*. pp: **197**-225 (2005).
7. Formigoni, A., Parisini, P. and Corradi, F. The Use of Amino Acid Chelates in High Production Milk Cows," In: H. D. Ashmead, Ed., The Roles of Amino Acid Chelates in Animal Nutrition, Noyes, Park Ridge, NJ, 170-186 (1993).
8. Predieri, G., Tegoni, M., Cinti, E., Leonardi, G. and Ferruzza, S. Metal chelates of 2-hydroxy-4-methylthiobutanoic acid in animal feeding: preliminary investigations on stability and bioavailability. *Journal of Inorganic Biochemistry*, **95**, 221-224 (2003).
9. Cortinhas, C.S., Botaro, B.G. and Sucupira, M.C.A. Antioxidant enzymes and somatic cell count in dairy cows fed with organic source of zinc, copper and selenium. *Journal of Livestock Science,* **127**, 84-87 (2012).
10. Valleem B.L. and Falchuk, K.H. The biochemical basis of zinc physiology. *Physiological Research*, **73**,79-118 (1993).
11. Bao, Y.M., Choct, M., Iji P.A. and Bruerton, K. Effect of organically complexed copper, iron, manganese, and zinc on broiler performance, mineral excretion, and accumulation in tissues. *Journal of Applied Poultry Research,* **16**,448–455 (2007).
12. Mohanta, R.K. and Garg, A.K. REVIEW: Organic Trace Minerals: Immunity, Health, Production and Reproduction in Farm Animals. *Indian Journal of Animal Nutrition*, **31**(3), 203-221 (2014).
13. Ammerman, C.B., Baker, D.P. and Lewis, A.J. Bioavailability of nutrients for animals: amino acids, minerals, vitamins. In: Academic press. San Diego, California (1995).
14. Spears, J.W. Trace mineral bioavailability in ruminants. *Journal of Nutrition*, **133**,1506–1509 (2003).
15. Kellogg, D.W., Tomlinson, D.J., Socha, M.T. and Johnson, A.B. Review: Effects of zinc methionine complex on milk production and somatic cell count of dairy cows: twelve trial summary. *The Professional Animal Scientist*, **20**,295-301 (2004).
16. APRI. Recommendation of the Animal Production Research Institute (2002).
17. AOAC. *Official Methods of Analysis*, Association of Official Chemists, Washington, USA (1995).
18. Abou-Raya, A.K. *Animal and Poultry Nutrition*. Dar-El-Maarif, Cairo, (Arabic Textbook) (1967).
19. Smith, J.C., Butrimovitz, G.P. and Purdy, W.C. Direct measurement of zinc in plasma by atomic absorption spectroscopy. *Clinical Chemistry*, **25** (8), 1487–1491 (1979).
20. Snedecor, G.W. and Cochran, W.G. *Statistical methods*. 7th ed. Allied Pacific, Bomobay (1980).
21. SAS. SAS/*STAT User's Guide*: Volumes 1-7. SAS Institute Inc., Cary, North Carolina (2004).
22. Duncan, D.B. *Multiple range and multiple F-tests*. *Biomrtrics,* **11**,1-42 (1955).
23. Hackbart, K.S., Ferreira, R.M., Dietsche, A.A., Socha, M.T., Shaver, R.D., Wiltbank, M.C. and Fricke, P.M. Effect of dietary organic zinc, manganese, copper, and cobalt supplementation on milk production, follicular growth, embryo quality, and tissue mineral concentrations in dairy cows. *Journal of Animal Science*, **88** (12), 3856-3870 (2010).
24. Huerta, M., Kincid, R.L., Cronrach, J.D., Busboom, J., Johnson, A.B. and Swenson, C.K. Interaction of dietary zinc and growth implants on weight gain, carcass traits and zinc in tissues of growing beef steers and heifers. *Animal Feed Science Technol*., **95**, 15-32 (2002).
25. Gorlov, I.F., Levakhin, V.I., Radchikov, V.F., Tsai, V.P. and Bozhkova, S.E. Effect of feeding with organic microelement complex on blood composition and beef production of young cattle. *Modern Applied Science*, **9** (10), 8-16 (2015).

26. Gorlov, I.F, New approaches to the use of dietary supplements and growth-stimulating agents in beef production: monograph. The Ministry of Agriculture of the Russian Federation, Department of Science and Technology Policy and Education, VPO Volgograd State Agricultural University, Volgograd, Russian Federation (2012).

27. Popov, V.V., Sirazetdinovm F.K.h., Kalashnikov, V.V., Gorlov, I.F. and Azhmuldinov, E.A. New techniques for highly efficient beef production: monograph. All-Russian Research Institute of Agricultural Sciences of beef cattle, Bashkir Institute of retraining and advanced training of AIC. Moscow, Russian Federation (2011).

28. Bakhshizadeh, S., Mirzaei Aghjehgheshlagh, F., Taghizadeh, A., Seifdavati, J. and Navidshad, B. Effect of zinc sources on milk yield, milk composition and plasma concentration of metabolites in dairy cows. *South African Journal of Animal Science*, **49** (5), 884-891 (2019).

29. Sobhanirad, S., Carlson, D. and Bahari Kashani, R. Effect of zinc methionine or zinc sulfate supplementation on milk production and composition of milk in lactating dairy cows. *Biological Trace Element Research*, **136**, 48-54 (2010).

30. Shakweer, A.A., El-Mekassm M. and EL-Nahas, H.M. Effect of zinc supplementation as zinc sulfate or zinc methionine on Friesian calf performance. *Egyptian Journal of Animal Production*, **47**(1),23-36 (2010).

31. Alimohamady, R., Aliarabi, H., Bruckmaier, R.M. and Christensen R.G. Effect of Different Sources of Supplemental Zinc on Performance, Nutrient Digestibility, and Antioxidant Enzyme Activities in Lambs. *Biological Trace Element Research*, **189**(1),75-84 (2019).

32. Mallaki, M., Norouzian, M.A. and Khadem, A.A. Effect of organic zinc supplementation on growth, nutrient utilization, and plasma zinc status in lambs. *Turk. Journal of Veterinary Animal Science*, **39**, 75–80 (2015).

33. Aliarabi, H., Fadayifar, A., Tabatabaei, M.M., Zamani, P., Bahari, A., Farahavar, A. and Dezfoulian, A.H. Effect of zinc source on hematological, metabolic parameters and mineral balance in lambs. *Biological Trace Element Research*, **168**, 82–90 (2015).

34. Jia, W., Xiaoping, Z.H., Wei, Z.H., Jianbo, C.H., Cuihua, G. and Zhiha, I.J. Effects of source of supplemental zinc on performance, nutrient digestibility and plasma mineral profile in cashmere goats. *Asian-Australas Journal of Animal Science*, **22**,1648–1653 (2009).

35. Kinal, S., Korniewiez, A., Jamroz, D., Zieminski, R. and Slupezynska, M. Dietary effects of zinc, copper and manganese chelates and sulphates on dairy cows. *Journal of Food Agricultural Environmental*, **3**, 168-172 (2005).

36. Spears, J.W. and Weiss, W P. Role of antioxidants and trace elements in health and immunity of transition dairy cows. *The Veterinary Journal*, **176**(1),70-76 (2008).

37. Michael, T., S., Tomlinson, A. and Tomlinson, J.S. Trace minerals recognized as important components in two days dairy rations. TB-D-4008 August 22 (2001).

38. Tomlinson, J. Cows fed higher levels of 4-plex show improved reproduction and milk production. TB-D-4028. April 2 (2001).

39. Hassan, A.A., Ashry, G.M.E. and Soliman, S.M. Effect of Supplementation of Chelated Zinc on Milk Production in Ewes. *Food and Nutrition Science*, **2** (07), 706–713 (2011).

40. Cao, J., Henry, P.R., Guo, R., Holwerda, R.A., Toth, J.P., Littell, R.C., Miles, R.D. and Ammerman, C.B. Chemical characteristics and relative bioavailability of supplemental organic zinc sources for poultry and ruminants. *Journal of Animal Science*, **78**(8), 2039–2054 (2000).

41. Nocek, J.E., Socha, M.T. and Tomlinson, D.J. The effect of trace mineral fortification level and source on performance of dairy cattle. *Journal of Dairy Science*, **89**, 2679-2693 (2006).

42. Cope, C.M., MacKenzie, A.M., Wilde, D. and Sinclair, L.A. Effects of level and form of dietary zinc on dairy cow performance and health. *Journal of Dairy Science*, **92**(5), 2128–2135 (2009).

43. Hatfield, P.G., Snowder, G.D., Head, W.A.J., Glimp H.A., Stobart R.H. and Besser, T. Production by Ewes Rearing Single or Twin Lambs: Effects of Dietary Crude Protein Percentage and Supplemental Zinc Methionine. *Journal of Animal Science*, **73**(5), 1227-1238 (1995).

44. Campbell, M.H., Miller, J.K. and Schrick, F.N. Effect of additional cobalt, copper, manganese and zinc on reproduction and milk yield of lactating dairy cows receiving bovine somatotropin. *Journal of Dairy Science*, **82**, 1019–1025 (1999).
45. Uchida, K., Mandebvu, P., Ballard, C.S., Sniffen, C.J. and Carter, M.P. Effect of feeding a combination of zinc, manganese and copper amino acid complexes, and cobalt glucoheptonate on performance of early lactation high producing dairy cows. *Journal of Animal Feed Science Technol*., **93**,193-203 (2001).
46. Kelleher, S.L. and Lönnerdal, B. Molecular regulations of milk trace mineral homeostasis. *Journal of Aspect. Medicine*, **26**, 328-339 (2005).
47. El Ashry, G.M., Hassan, A.A.M. and Soliman, S.M. Effect of feeding a combination of Zinc, Manganese and Copper Methionine chelates of early lactation high producing dairy cow. *Food and Nutrition Science*, **3**, 1084-1091 (2012).
48. Somkuwar, A.P., Kadam A.S., Kumar, S. and Radhakrishna, P.M. Efficacy study of metho-chelated organic minerals preparation feeding on milk production and fat percentage in dairy cows. *Veterinary World*, **4** (1), 19-21 (2011)
49. Ashmead, H.D. and Samford, R.A. Effects of metal amino acid chelates or inorganic minerals on three successive lactations in dairy cows. *International Journal of Applied Research Veterinary Medicine*, **2**(3), 181-188 (2004).
50. Faulkner, M.J. Effects of trace mineral supplementation in lactating dairy cattle. Dissertation. The Ohio State University (2016).
51. Abu El-Hamd, M.A., Sayah, M.S., Tag El-Dein, M.A., Salama, A.M.A. and Ibrahim, S.A. Effect of dietary supplementation of zinc, copper and selenium pre- or post-partum on reproductive performance of Friesian cows. *Journal of Animal and Poultry Prod., Mansoura University,* **2** (8), 291- 301 (2011).
52. Hegazy, A.M., Nosir, W.M.B. and EL-Ekhnawy, K.E. The effect of L-carnitine supplementation on reproductive performance of buffalo cows. *Journal of the Egyptian Veterinary Medical Association*, **62**(5) 107-114 (2002).
53. Defrain, J.M., Socha, M.T., Tomlinson, D.J. and Kluth, D. Effect of complexed trace minerals on the performance of lactating dairy cows on a commercial dairy. *The Professional Animal Scientist*, **25**, 709-715 (2009).

تأثير مصادر الزنك المختلفة علي إنتاج اللبن والكفاءة التناسلية في الابقار الفريزيان

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أجريت هذه الدراسه لتقييم تأثير إضافة الزنك المعدني أو العضوي على إنتاج اللبن وتركيبه والأداء التناسلي للأبقار الحلابة. استخدم في الدراسة 30 بقرة فريزيان تتراوح أعمارهم بين 3-6 سنوات وموسم الولادة مابين الثاني والثالث والوزن 488.7 كجم وقسمت عشوائيًا إلى ثلاث مجموعات وفقًا لوزن الجسم الحي وإنتاج اللبن وموسم الولادة والعمر. تمت تغذية الأبقار في المجموعة الأولى (المجموعة الضابطة، G1) بخليط علف مركز، بينما تمت تغذية الأبقار في المجموعة الثانية بخليط علف مركز مضاف إليه الزنك المعدني (2.4 جم/يوم/بقرة) وتم تغذية الأبقار في المجموعة الثالثة بخليط علف مركز مضافا اليه الزنك المخلّبي العضوي (2.4 جم/يوم/بقرة) واستمرت الدراسة من اليوم 10 بعد الولادة وحتى 180 يومًا من الحليب. وادت النتائج إلي زيادة إنتاج اللبن الشهري في المجموعة الثانية والثالثة بشكل ملحوظ خلال الأشهر 2 و5 و6 من الحليب مقارنة بالمجموعة الأولى. علاوة على ذلك، أظهرت المجموعتين الثانية الثالثة زيادة معنوية في إنتاج الحليب الشهري خلال الأشهر الأولى والثالثة والرابعة من الحليب مقارنة مع المجموعة الأولى. أدت إضافة الزنك المعدني والعضوي في المجموعتين الثانية والثالثة إلي زيادة نسبة الدهن والبروتين في اللبن مقارنا بالمجموعة الأولي. أظهرت المجموعة الثالثة زيادة أعلى بكثير في تركيزات كل من البروتين والألبومين والجلوبيولين مقارنة بـالمجموعتين الأولي والثانية. ومع ذلك، أظهر المجموعتين الثانية والثالثة انخفاضًا ملحوظًا في تركيزات الدهون والكوليسترول وأزوت اليوريا، وزيادة ملحوظة في تركيز الزنك مقارنة بالمجموعة الأولي. انخفض عدد حالات الشبق ودورات الشياع لكل بقرة في المجموعتين الثانية والثالثة مقارنة بـالمجموعة الأولي. أدت الاضافة إلي زيادة تركيز البروجسترون (P4) وذروته خلال دورات الشياع في المجموعتين الثانية والثالثة مقارنة بالمجموعة الأولي. انخفض مستوى P4 بشكل ملحوظ قبل حدوث الشبق في المجموعتين الثانية والثالثة بالمقارنة بالمجموعة الأولي تكون فترة الشبق والشياع الأول بعد الولادة أقصر في G1 من غيرها. أظهرت G1 أيامًا مفتوحة أقصر بكثير من المجموعات الأخرى. وكان معدل الحمل أعلى بكثير في المجموعة الثانية (100%) والمجموعة الثالثة (80%) مقابل (60%) في المجموعة الأولي. ومن هذه النتائج يتضح أن إضافة الزنك العضوي (المخلبي) في أبقار الفريزيان أدت إلى تحسين الأداء التناسلي وبعض خصائص الدم. وكذلك أشارت النتائج إلى تحسن متوسط إنتاج الحليب اليومي خلال 180 يوم من الحلب في أبقار الفريزيان.

الكلمات الدالة: أبقار الفريزيان، الزنك المعدني، الزنك العضوي، انتاج اللبن، التناسل.