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Physiological Responses of Gilt to Supplementation of Selenium and Vitamin E

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Abstract

A completely randomized design (CRD) experiment was conducted to investigate the effects of selenium and vitamin E on the reproductive performance and blood profile of Large White gilts. Three treatments designated T₁, T₂ and T₃ consisting of control, selenium and vitamin E supplemented diets respectively, were used for the study. Twelve nulliparous sows aged 7 to 8 months with an average body weight of 117.63 kg were randomly assigned to the treatments with four gilts per treatment, each gilt served as a replicate. Results of the study showed that PCV (Packed Cell Volume) of the gilts was significantly (P<0.05) lower in the control (T₁ 36.50 %) than selenium treated (T₂ 45.50 %). The vitamin E treated (T₃ 39.00 %) showed no significant difference (P>0.05) between the selenium supplemented group and the control in PCV. Also creatinine of the control (T₁ 1.45 mg/dl) was significantly (P<0.05) lower than those of the treatment groups (T₂ 2.19 mg/dl and T₃ 2.22 mg/dl). The rest of the haematological and biochemical constituents of the gilts showed no significant (P>0.05) differences between the various treatments. The selenium treated was significantly (P<0.05) higher in body weight (T₂ 143.50 kg) during the gestation than the control (T₁ 131.00 kg). There were no significant (P>0.05) differences in body weight between vitamin E (T₃ 139.25 kg) and the other treatments at gestation. The respective litter size at birth and at weaning were significantly (P<0.05) higher in the selenium (7.75 and 5.75) and vitamin E (6.25 and 5.25) treated groups than the control (5.75 and 4.00). The weaning weight was significantly (P<0.05) lower in the selenium (8.31 kg) than control (9.78 kg). There were no significant (P>0.05) differences between T₃ (vitamin E treated; 9.08 kg) and the control (T₁). Also the diet supplemented groups (T₂ and T₃) recorded no significant (P>0.05) differences in the weaning weight of their piglets. The rest of the reproductive characteristics showed no significant (P>0.05) differences among the three treatments. None adverse effects of selenium and vitamin E on the blood parameters of the treated sows indicated that these anti-oxidants are tolerable and well assimilated by the sows. The selenium treated sows exhibited better performance followed by the vitamin E group.

Key words: Haematology, Lactation, Selenium, Serum biochemistry, Vitamin E

Introduction

Dietary trace minerals are widely used as feed supplements to stimulate growth, improve feed efficiency and secure uniform performance¹. Micro/trace minerals and vitamins play roles in cellular metabolism, particularly as component part of

many enzyme systems². They may directly or indirectly affect reproduction. Reproductive functions have been reported to be affected by manganese, zinc, molybdenum and beta-carotene (vitamin A precursor) because all these are involved in steroidogenesis^{3,4,5}. As reported⁴, zinc might act through the pituitary to influence gonadotropic

secretion. Increase in sperm concentration of boar with supplementation of zinc oxide in the diet was reported⁶. Selenium is an essential micronutrient required by animals⁷. It is an integral part of the enzyme glutathione peroxidase and is a potent antioxidant (prevents the oxidation of lipids), that protects the body from damage due to oxidation of free radicals during oxygen metabolism. Several authors have reported that deficiency consequences of selenium include mulberry heart disease⁸; muscle dystrophy⁹; acute respiratory failure¹⁰; non-maintenance of stability and integrity of membranes¹¹. In breeding swine herds, deficiencies of selenium and vitamin E prevail due to feeding of forages and grains which are often produced on leached and depleted soils.

Vitamin E is most often removed from soya beans with the oil in the manufacture of soya bean meal. It was reported that vitamin E (alpha tocopherol) is one of the four essential fat-soluble vitamins required by mammals¹². Natural forms of vitamin E is synthesised in plants and are comprised of a group of related compounds, the tocophreols and tocotrienols, which demonstrate various degrees of biological activities¹³. Vitamin E functions primarily as antioxidant¹⁴. It prevents formation of peroxides and free radicals from cellular lipids by interrupting the initial stages of free radical production, undergoing oxidation itself. Vitamin E has been reported to improve litter size, increase sow milk α -tocopherol and enhance health status of piglets^{15,16}. On the other hand, selenium has been reported to be transferable from sow placenta and mammary tissues to the fetuses and piglets, respectively¹⁷. Milk is produced by the mammary gland and milk yield influences pre-weaning growth in terms of litter weight. Efforts are being made to explore ways of increasing milk production in different farm animal species. This has led to various researches geared towards improvement of feed resources, feed formulation and selection of breeds/species of animal with high milk producing capacity.

Blood conveys nutrients and materials to different parts of the entire body¹⁸. Furthermore, blood is a good indicator of mineral and vitamin status of various animal species¹⁹ and could be used in assessing the physiological status of any animal. A readily available and fast means of assessing nutritional and health status of animals on feeding trials might be the use of blood analysis²⁰. The objective of the study was to determine the impact of selenium and vitamin E on reproductive performance and blood profiles of sow.

Experimental

Experimental location

The experiment was conducted at Chukwuma Livestock Commercial Farm located at Lodu in Umuahia North Local Government Area of Abia State, Nigeria. Chukwuma Livestock Farm has boundary with Ikwuano, Bende and Umuahia. Geographically, the farm is located on latitude of 5° 29' North and longitude of 7° 32' East. It lies on an altitude of about 122 m above sea level. It is situated in the rainforest zone South-Eastern Nigeria²¹ and has an annual rainfall of about 2177 mm, temperature range of 22 to 36°C and relative humidity between 50 to 90%.

Management of experimental animals

The twelve nulliparous Large White breed gilts aged 7 to 8 months with an average weight of 117.63 kg, randomly sampled from a swine herd of 60 pigs were used for this study. They were each identified with a numbered tag and housed singly in pens for ease of identification. The animals were managed in clean environment throughout the study period. They were fed twice daily, morning and evening at the rate of 2.5 kg per sow per day for the first 56 days, 3.5 kg/sow per day during gestation and lactation using the experimental diets (Table 1). Water was also given *ad libitum*.

Breeding/mating of the gilts

Following the second oestrus after puberty, the gilts were introduced to matured boars for service at the ratio of (1:4) one male to four females. All the gilts became pregnant not later than one week interval from each other. They were monitored throughout gestation and all farrowed at the end of their gestation within an interval of 7 to 10 days between groups.

Blood Collection and Analysis

Blood samples were collected from each gilt on the day before mating and during lactation from a femoral vein. Blood was allowed to flow into labelled sterile universal sample bottles. An initial 2.5 ml were collected into the labelled sterile bottles containing ethylene diamine tetra acetic acid (EDTA). This was used to determine the haematological components according to ²². Blood samples for haematology were analyzed within 2 hours of collection for packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC), white blood

Table 1. Composition of experimental diets

Ingredients (kg/100kg)	Treatments		
	T ₁	T ₂	T ₃
Maize offal	50	50	50
Palm kernel cake	33.5	33.5	33.5
Soya bean meal	14	14	14
Oyster shell	0.75	0.75	0.75
Bone meal	1.25	1.25	1.25
Salt	0.25	0.25	0.25
Vitamin mineral premix	0.25	0.25	0.25
Selenium (ppm)	-	-	-
Vitamin E (IU)	-	-	-
Calculated composition of the diet			
Crude protein (%)	16.74	16.74	16.74
DE (kcal/kg)	2546.63	2546.63	2546.63
Methionine (%)	0.28	0.28	0.28
Lysine (%)	0.73	0.73	0.73
Calcium (%)	0.84	0.84	0.84
Cysteine (%)	0.33	0.33	0.33
Total P (%)	0.50	0.50	0.50

cell (WBC). Another 2.5 ml collected into sterile sample bottles without coagulant was used to determine the biochemical components using standard methods²³. The coagulated blood was subjected to standard methods of serum separation and the harvested sera were used for determination of creatinine, serum alanine transaminase (SALT) and serum aspartate transaminase (SAST). Pooled samples per treatment were divided into two. Blood was not collected during gestation period to avoid stressing the animals during pregnancy

Milk Collection and Analysis

Milk samples were collected at weekly interval for eight week. Milk samples were analyzed for lactose, total solids, protein, solids not fat and ash. Lactose content was determined from fresh samples by standard procedure²⁴. Total solids were determined by drying a known gramme of milk sample to a constant weight at 40.56⁰ C for 48 hours. Butterfat was obtained by the Roese-Gottlieb method²⁵. Milk protein (NX6.38) was determined by the semi-micro distillation method using Kjeldahl and Markhamps apparatus. Solids-not-fats were determined as the difference between total solids and butter fat.

Performance characteristics

The gilts were weighed at the beginning of the experiment, 56 days from the feeding of the experimental diets, 28 day of gestation and at

weaning. Records were taken on gestation length, litter size at birth and at weaning, litter weight at birth and at weaning weekly weight gain of piglets.

Experimental design

The experiment was a completely randomized design (CRD) with three treatments. The treatments designated T₂ and T₃ had selenium and vitamin E included in their respective diets while T₁ (control), had neither of these. Twelve Large White gilts were randomly assigned to the 3 treatment groups with 4 gilts per treatment with each gilt serving as a replicate.

Statistical analysis

All the data generated were analyzed using the analysis of variance (ANOVA) procedures appropriate for a Completely Randomized Design²⁶. Significant means were separated using least significant difference (LSD).

Results and Discussion

Blood profile

The haematological and serum biochemistry of the gilt during the study are presented in Tables 2 and 3. The haematological components of the gilts showed that only PCV was significantly (P<0.05) higher in T₂ (45.5 %) than T₁

Table 2. Haematological and biochemical characteristics of experimental animals before breeding

Parameters	Treatments			SEM
	T ₁	T ₂	T ₃	
Haematological				
Erythrocytes (x 10 ⁶ mm ³)	7.50	8.13	13.50	0.65
Haemoglobin (g/dl)	16.93	13.95	13.50	1.03
PCV (%)	36.50 ^b	45.50 ^a	39.00 ^{ab}	2.10
Leucocytes (x 10 ³ mm ³)	16,500.00	16,875.00	16,950.00	1661.00
Neutrophils (%)	44.73	41.60	42.25	4.42
Lymphocytes (%)	45.70	45.80	47.00	4.10
Monocytes (%)	10.00	9.80	8.75	1.20
Eosinophils (%)	11.00	9.23	9.50	1.03
Biochemical				
SALT (IU/L)	23.00	19.8	26.00	1.93
SAST (IU/L)	20.25	22.25	20.25	1.69
Creatinine (mg/dl)	1.45 ^b	2.19 ^a	2.22 ^a	0.20

^{a,b} means with different superscript in the same row are significantly different (p<0.05)

PCV= Packed cell volume, SALT= serum alanine transaminase and SAST = Serum aspartate transaminase; SEM = Standard error of mean

Table 3. Haematological and biochemical characteristics of gilts fed selenium and vitamin E during lactation

Parameters	Treatments			SEM
	T ₁	T ₂	T ₃	
Haematological				
Erythrocytes (x 10 ⁶ mm ³)	6.38	6.50	7.23	0.62
Haemoglobin (g/dl)	10.82	11.30	12.40	0.68
PCV (%)	34.50	36.50	45.20	3.55
Leucocytes (x 10 ³ mm ³)	14475.00	18,400.00	18,050.00	2679.10
Neutrophils (%)	39.00	40.25	40.70	2.61
Lymphocytes (%)	48.50	47.25	47.50	3.55
Monocytes (%)	7.20	5.45	6.63	1.21
Eosinophils (%)	5.00	3.00	3.30	1.17
Biochemical				
SGGT (IU/L)	21.25	20.00	25.00	2.01
SGGTP (IU/L)	21.00	21.25	19.50	1.43
Creatinine (mg/dl)	1.79	1.58	2.00	0.15

(36.50 %) and T₃ (39.00 %) before mating (Table 2). Values obtained in all the haematological parameters in this study agreed with the range (Hb 10 to 16g/dl; PCV 32 to 45 %; RBC 5 to 8 X10⁶mm³; WBC 15 to 20 X10³mm³) reported for pigs²⁷. The normal haemoglobin (Hb) values recorded in the study may have contributed to the sustainable muscular activity of the animal. With the exception of creatinine, the rest of the serum components studied showed no significant (P>0.05) differences among the treatment groups (Tables 2 and 3). The serum creatinine for gilts in T₂ and T₃ exhibited significantly (P<0.05) higher creatinine concentration than the control T₁ prior to mating. The values of haematology recorded for all the

experimental groups fell within the normal range for sows reported previously²⁷. The values of other serum enzymes were within the normal range for sows²⁸. This was an indication that the diet had good quality protein of the die and that it was efficiently utilized by the experimental sows²⁹.

Reproductive performance

The performance of Large White gilt fed selenium and vitamin E supplemented diet is presented in Table 4. Gilt fed selenium diet had significantly (P<0.05) higher live weight at one month of gestation than the control. The weight gain of the gilt during the period of gestation

Table 4. Mean performance characteristics of large white gilts

Parameters	Treatments			SEM
	T ₁	T ₂	T ₃	
GIBW (kg)	118.69	119.00	119.80	2.25
W1MG (kg)	131.00 ^b	143.5 ^a	139.25 ^{ab}	3.02
WAW (kg)	111.25	106.75	109.75	4.19
LS	5.75	7.75	6.25	0.98
PWM (%)	31.54	23.90	18.20	13.83
LSW	4.00	5.75	5.25	0.97
GL (days)	115.50	116.50	115.00	0.71

^{a, b} Means with different superscript in the same row are significantly different ($p < 0.05$).

SEM = Standard error of mean; GIBW = Gilt body weight; W1MG = Weight 1 month of gestation; WAW = Weight at weaning; LS = litter size; PWM = Pre-weaning mortality; LSW = Litter size at weaning and GL = Gestation length.

depends on weight of the foetuses, the foetal fluid, increased growth of the mammary glands and laid down adipose tissues. The initial body weight, and weight at weaning of the gilt, gestation length and pre-weaning mortality of the piglets show no significant ($P > 0.05$) differences among treatment groups. Litter size at birth and at weaning showed significant ($P < 0.05$) differences with T₂ being significantly higher than T₃ and T₁. Also the control had significantly ($P < 0.05$) lower litter size at birth and at weaning than T₃. The litter size obtained from the study compares favourably with average litter size of 6.9 piglets born alive by Large White X Landrace crosses reported by³⁰.

Litter size at weaning is considered a practical index to measure eventual profitability of any animal production. Increasing the number and viability of piglets weaned per sow has a large impact on overall herd productivity and profitability. In this study, it was observed that most deaths occurred by overlying of the piglets by the gilt during the first 3 days of life when the piglets are spending much of their time trying to secure positions along the teats of the udder. The weaning weight of the piglets in the control (9.78 kg) was not significantly ($P > 0.05$) higher than T₃ (9.08 kg) but was significantly ($P < 0.05$) higher than selenium treated (8.31 kg). Conversely, there were no significant ($P > 0.05$) differences between the piglet weaning weights of T₂ and T₃ (treated groups).

Weight gain of the suckling piglets over a period of 2 to 3 weeks, or the litter weaning weight is routinely obtained and commonly recommended as practical method of assessing the lactation performance of sows. The weight gain at the end of lactation (8 weeks) was influenced by milk components and yield.

Milk Composition

Milk composition of the gilt in the different treatments during the lactation period is presented in Table 5. Total solids (%) content of gilt milk showed significant ($P < 0.05$) differences in week one and two of lactation. Milk total solids of T₃ (vitamin E fed gilt) was significantly ($P < 0.05$) higher than T₂ (selenium fed gilt) and the T₁ (control) during the first week of lactation. In week 2, the total solids of the control were significantly lower than the selenium and vitamin E treated groups. Total solids in milk for the rest of the weeks of lactation showed no significant ($P > 0.05$) differences among treatment groups. The total solids recorded in the gilt's milk during the study agree with the values obtained previously^{14,31}. Observations from the study showed that total solids decreased slightly with advancing lactation.

Milk ash (%) content of gilt milk showed significant ($P < 0.05$) differences in week one and eight. In week one, the concentration of the gilt's milk ash of T₁ (0.97%) was significantly ($P < 0.05$) higher than T₂ (0.85%) and T₃ (0.82%). In addition, the ash concentration in week eight of lactation showed that T₃ (0.93%) was significantly ($P < 0.05$) higher than T₂ and T₁ (0.82%).

Milk protein content of gilt's milk showed significant ($P < 0.05$) higher from week four to eight of lactation in the treated groups than the control (Table 5). The decreasing trend from week one could be associated with reduction in casein, lactalbumin and lactoglobulin of protein³² or inability of the gilt to synthesize protein from amino acids they consume in feeds.

Table 5. Milk composition of the different treatments during lactation period

Parameters	Week of Lactation	Treatments			SEM
		T ₁	T ₂	T ₃	
Total solids	1	11.03 ^b	11.13 ^b	12.59 ^a	0.35
	2	10.57 ^b	10.81 ^a	11.29 ^a	0.31
	3	11.03	10.23	10.66	0.28
	4	11.03	10.14	10.94	0.34
	5	10.68	10.26	10.62	0.32
	6	10.83	10.31	10.55	0.38
	7	10.87	10.54	10.82	0.36
	8	11.31	10.02	10.16	0.46
Ash	1	0.97 ^a	0.85 ^b	0.82 ^b	0.33
	2	0.83	0.83	0.87	0.07
	3	0.93	0.83	0.90	0.23
	4	0.78	0.86	0.80	0.07
	5	0.66	0.82	0.87	0.06
	6	0.86	0.88	0.82	0.04
	7	0.87	0.78	0.84	0.04
	8	0.82 ^b	0.82 ^b	0.93 ^a	0.02
Protein	1	6.08	6.09	6.18	0.29
	2	5.52	5.83	5.89	0.22
	3	4.50	5.57	5.19	0.34
	4	3.84 ^b	5.22 ^a	4.47 ^a	0.25
	5	3.54 ^b	4.64 ^a	4.18 ^a	0.18
	6	3.05 ^b	3.82 ^a	3.83 ^a	0.16
	7	2.22 ^b	3.38 ^a	3.36 ^a	0.09
	8	2.05 ^b	3.23 ^a	3.13 ^a	0.07
Butter fat	1	4.71 ^b	4.98 ^{ab}	5.81 ^a	0.34
	2	4.84 ^b	4.90 ^b	5.67 ^a	0.25
	3	4.92 ^a	4.45 ^{ab}	5.35 ^a	0.22
	4	5.74	5.12	5.50	0.38
	5	5.56	5.01	5.89	0.33
	6	5.64	5.13	5.42	0.30
	7	5.45	5.73	5.84	0.36
	8	5.49	4.99	5.73	0.33
Solids-not-fat	1	6.32	6.15	6.79	0.44
	2	5.74	5.91	5.54	0.37
	3	6.11	5.78	5.31	0.40
	4	5.29	5.02	5.43	0.31
	5	5.11	5.25	4.74	0.54
	6	5.19	5.17	5.13	0.36
	7	5.43	4.82	4.99	0.56
	8	5.82 ^a	5.03 ^b	4.43 ^b	0.24
Lactose	1	3.38	3.51	3.41	0.16
	2	3.33	3.56	3.44	0.12
	3	3.64	3.87	3.75	0.11
	4	3.67 ^a	4.25 ^a	3.79 ^b	0.09
	5	3.81 ^c	4.38 ^a	4.16 ^b	0.06
	6	3.99 ^b	4.38 ^a	4.39 ^a	0.06
	7	4.20 ^b	4.48 ^a	4.49 ^a	0.07
	8	4.41	4.48	4.52	0.07
Water	1	88.96	88.87	87.41	0.35
	2	89.43	89.19	88.71	0.31
	3	88.97	89.77	89.35	0.28
	4	90.26	89.87	89.07	0.88
	5	89.33	89.75	89.38	0.32
	6	89.17	89.70	89.45	0.38
	7	89.25	89.46	89.18	0.37
	8	88.69	89.98	89.10	0.65

^{a,b} means with different superscript in the same row are significantly different ($p < 0.05$), SEM=Standard error of mean

Butterfat content of gilt milk were significantly ($P < 0.05$) higher in week one and two with T_3 being higher than T_2 and T_1 (Table 5). On the other hand, butterfat in week three showed significantly ($P < 0.05$) higher value for T_3 (5.35%) than T_1 (4.92%) and T_2 (4.45%). Solids-not-fat content of gilt milk showed significant ($P < 0.05$) difference only in week eight of lactation (T_1 5.82 %; T_2 5.03 %; T_3 4.43 %).

The lactose concentration of sow milk showed significant ($P < 0.05$) differences from week four to seven of lactation. In week 4, T_2 (4.25%) had higher significant value of lactose than T_3 (3.79%) and T_1 (3.67%). From week 5 to 7, the lactose content of the milk of selenium and vitamin E treated groups were significantly higher than the control (Table 5). Milk lactose content in the study exhibited increasing trend from early to end of lactation. Values from the study however are lower than those reported for sows³³. Differences in dietary plane and composition could influence yield and compositions of milk even within animals of the same breed³⁴. In lactating animals, protein, solids-not-fat and lactose concentration in milk are likely to be influenced by diet quality.

Water content of sow milk showed no significant ($P > 0.05$) differences during the weeks of lactation. The values recorded from the study agrees with the range 67-92% reported by³⁵ for different animal species. Values obtained for water content of milk did not follow a particular trend; however, numerical increase was noticed in mid lactation.

Conclusion

None adverse effects of selenium and vitamin E on the blood parameters of the treated gilts indicated that these anti-oxidants are tolerated and well assimilated by the gilts. The weaning weight of the piglets of the experimental groups was within the normal range. Thus significant higher litter size at birth and at weaning of the selenium and vitamin E treated groups is an enhancement on reproductive performance of the treated gilts despite the higher weaning weight of piglets in the control. From the results of the study, the selenium treated group exhibit better performance followed by the vitamin E group. The weight at weaning of all the groups is an indication that milk from the dams was well utilized by the piglets.

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