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Vitamin E Supplementation to Sows and Effects on Fertility Rate and Subsequent Body Development of their Weanling Piglets

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Abstract

The aim of this study was to evaluate the effects of dietary supplementation of vitamin E to sows on sow fertility and serum α-tocopherol, growth and physiological state of their weanling pigs. A total of 60 Large White gilts were randomly allotted to three groups (20 gilts per group) from coitus to lactation phases over a two-parity period to evaluate the effects of dietary vitamin E on fecundity rates and litter size of sows. Each of the three dietary vitamin E treatment combinations involved 0, 40 or 70 IU/kg of dl- α-tocopheryl acetate/kg of diet, and parity 1 and 2. Sow serum α-tocopherol and Selenium (Se) were collected at 30 day *post coitum*, 99 day of gestation and 21 day lactation. Serum α-tocopherol and Se were collected from piglets at 1 day *post natum* and on day 21 (weaning age). Data relating to sow fecundity and litter size were also recorded. Results indicate that body weights and body weight gains of sows and their litters increased significantly ($P < 0.01$) by parity, increasing more from parities 1 to 2, mostly when dietary vitamin E was increased from 40 to 70 IU/kg diet. The highest number of total piglets and number of piglets born alive (12 ± 8.9 vs. 11 ± 0.1) were obtained at parity 2 when dietary vitamin E was increased to 70 IU/kg diet. There was an increase in weights of the piglets when dietary vitamin E was increased in sow's diet. There was a dramatic increase in serum α-tocopherol and Se concentrations following 40 and 70 IU/kg of vitamin E supplementation during the 30 and 99 day gestation and 21 day lactation periods as parity increased. Se concentrations were about 3 fold higher in the 70 IU/kg vitamin E supplemented group in parity 2 compared to the other groups. In both parities, female piglets had higher serum α-tocopherol and Se concentrations at both 2 day *post natum* and on day 21 (weaning) compared to the male piglets. Results from this study suggest that supplementing 70 IU/kg α-tocopheryl acetate in sow's diets appears to enhance growth of their weanling piglets.

Keywords: Litter size, dl- α-tocopheryl acetate, physiological status, pigs, South Africa

1 Introduction

In South Africa like in most parts of the world, swine breeders lack site-specific information on the exact level of vitamin supplements that are to be supplied in sows' diet to

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optimise litter size, and subsequent body development and general wellbeing of weanling pigs. Most estimates on vitamin E supplementation are based on the minimum level required to overcome a deficiency symptom and not necessarily to promote productivity or indeed, to enhance immunity (Umesiobi, 2008). The supplemental level of vitamin E necessary to attain maximum litter size has not yet been ascertained, but it is considered to be within 10 to 22 IU/kg of diet (NRC, 1998). Higher dietary vitamin E levels may be necessary when diets contain high-moisture grain (Prasad and Kalra, 1993; McDowell, 2002) or unsaturated fat (McDowell, 2001). The immense importance of vitamin E in optimising fecundity rates and litter size in sows is demonstrated by the fact that maximal early growth and general wellbeing in weanling pigs, depend amongst other factors, on correct vitamin E supplementation to their sows pre and *post coitum* (Capper *et al.*, 2005). Consequently, when swine diets have been fortified with vitamin E, an increased litter size at birth has generally been demonstrated (Marin-Guzman *et al.*, 2000; Stuart and Kane, 2004).

Dietary supplementation of vitamin E is required during gestation and lactation to prevent reproductive failures (Wolf, 2005; McDowell, 2002; Umesiobi, 2008). Vitamin E is a fat soluble chemical found in the diet in varying amounts. Vitamin E usually refers to all tocol (α, β, γ and δ) and trienol (α, β, γ and δ) derivatives. All these substances are found in plants and have vitamin E activity, but alpha-tocopherol is the most active form of vitamin E. In the animal body, vitamin E is present primarily as alpha tocopherol. Vitamin E is essential for growth and mostly, during critical periods of embryonic development to enhance embryo survival (Stuart and Kane, 2004), it also acts as an intracellular antioxidant (Dufrasne *et al.*, 2000; Umesiobi, 2008). Vitamin E is also a precursor of certain thromboxanes, prostaglandins, leukotrienes and immunoglobulins (Håkansson *et al.*, 2001; Le Dividich *et al.*, 2005).

Vitamin E deficiency has been shown to affect growth development and health status of weanling pigs (Flachowsky, 2000), cattle (McDowell, 2001, 2002; Waller *et al.*, 2007) and several other animal species (Pehrson *et al.*, 2001; McDowell, 2002), resulting in foetal death and resorption (Sivertsen *et al.*, 2007), with a concomitant reduction in profitability of pig husbandry. Consequently, increasing dietary vitamin E intake during gestation or intramuscular injection of vitamin E resulted in an increase in litter size and a reduction of pre-weaning piglet mortality (Allan and Bilkei, 2005; Fragou *et al.*, 2006). However, the optimal level of vitamin E needed to improve the reproductive parameters has not been determined because of several interfering factors such as the composition of the diet, feed consumption, the rate of animal growth and living conditions or stress (Prasad and Kalra, 1993; McDowell, 2001, 2002). Moreover, the way of actions of vitamin E in enhancing litter size in sows and general wellbeing of the weanling pigs is still unclear. According to reports (Capper *et al.*, 2005), antioxidant properties as well as an immuno-modulating effect may be the reasons, and may also be important for the general wellbeing of weanling pigs. Interestingly, vitamin E supplementation during early development has important immediate and short-term effects on growth, body composition and body functions in weanling pigs (Oldfield, 2003; Stuart and Kane, 2004). In addition, various reports by Barker (1994) and

BURRIN (2001) indicate that long-term vitamin E supplementation during critical time periods of development affected later physiological and metabolic processes of weanling pigs, a phenomenon referred to as 'metabolic programming' (BARKER, 1994; BURRIN, 2001).

Since no behaviour or other parameters in relation to this study, were recorded that could be effectively related to the wellbeing of pigs in the South African environment, the aim of this study was to assess the adequacy of present feeding regimes in the South African pig industry with respect to vitamin E status for sows and its effects on litter size and subsequent body development of their weanling piglets.

2 Methodology

2.1 Study area

Large White gilts (n = 60) were obtained and maintained from a private swine farm at Rodenbeck Bleomfontein, South Africa, located at an altitude of 1351 m i.e.l. on latitude 29°06' South and longitude of 26°18' East. These animals were second generation gilts raised under confinement conditions and fed formulated diets composed of corn and soybean meal. They were selected at 30 kg body weight (BW), and reared in groups of 15 per confinement pen. Pre-treatment diets for the gilts consisted of corn-soybean meal admixture formulated to meet the NRC (1998) nutrient requirements with dietary supplementations of 0.1 ppm of Se as sodium selenite and 10 IU of dl- α-tocopheryl acetate/kg of diet. Diets were provided on *ad libitum* basis in feeding stalls from 30 to 130 kg BW.

2.2 Diet compositions and management protocols

At 130 kg BW, gilts were randomly allotted to each of the three dietary vitamin E treatment combinations involving 0, 40 or 70 IU/kg of dl- α-tocopheryl acetate/kg of diet, and parity I and II. These treatment diets were provided during both gestation and lactation phases following the procedures of WURYASTUTI *et al.* (1993); MAHAN (1994); MARIN-GUZMAN *et al.* (2000); UMESIOBI (2008). The litters from all treatment groups were fed a fortified semi-purified creep diet and water *ad libitum* from 2 days *post natum* until the end of the study. The feeders were cleaned daily. The piglets were weaned and weighed at 21 days of age. No supplemental vitamin E or Se was added to both the creep and weaning diets so as to evaluate and deplete the piglets' body reserves of vitamin E or Se. The diets were provided in sequence within each treatment group, meeting the NRC (1998) nutrient requirements for each production phase except for the nutrient being investigated.

2.3 Gilt oestrus induction and artificial insemination

Oestrus was synchronised in the experimental gilts by a single subcutaneous injection of P.G. 600® (400 IU PMSG with 200 IU HCG/5 mL dose/animal; Intervet Inc., Millsboro, DE). Gilts were checked for oestrus twice daily by providing them with fence-line contact with a teaser boar, for a minimum of 15 minutes beginning 12 hours after the injection of PG600. About 72 hours after the P.G. 600®, all gilts were given 1000

Table 1: Percentage composition of experimental diets, on dry matter basis.

Ingredient	*Gestation* [a]	*Lactation* [b]
Corn	75.30	65.90
Soybean meal (45% CP)	20.00	25.00
Lard[c]	-	4.50
Dicalcium phosphate	2.60	2.50
Limestone	0.75	0.75
Se premix[d]	0.15	0.15
Trace minerals[e]	0.50	0.50
Vitamin premix[f]	0.20	0.20
Vitamin E premix[g]	+	+
Antibiotics[h]	0.50	0.50

[a] Calculated analysis: 14% CP, 0.65% lysine, 1.00% Ca, and 0.80% P.

[b] Calculated analysis: 16.5% CP, 0.95% lysine, 1.00% Ca, and 0.80% P.

[c] Animal-vegetable fat admixture obtained from Bloemfontein Abattoir.

[d] Sodium selenite in a limestone carrier provided 0.3 ppm of dietary Se.

[e] Supplied per kilogram of diet: 8 mg Copper, 120 mg Iron, 0.2 mg Iodine, 15 mg Manganese, 120 mg Zinc, and 5.5 g Sodium chloride.

[f] Supplied per kilogram of diet: 4, 000 IU vitamin A, 220 IU vitamin D3, 3 mg vitamin K, 3.5 mg riboflavin, 14.5 mg pantothenic acid, 18 mg niacin, 20 μg vitamin B12, 330 mg of choline, and 0.2 mg biotin.

[g] Vitamin E premix contained 44, 000 IU dl- α-tocopheryl acetate/kg diet and was added at the appropriate level to supply: 30, 60 or 90 IU /kg of dl- α-tocopheryl acetate/kg of diet at the expense of corn.

[h] Supplied per kilogram of diet: 110 mg of chlortetracycline, 110 mg sulfamethazine, and 55 mg penicillin.

IU of HCG (Intervet Inc., Millsboro, DE), to induce ovulation to occur at 40 hours (Willenburg *et al.*, 2003). After the onset of oestrus, gilts of each treatment were artificially inseminated using semen from the same boars and collections. All experimental females received inseminations of 3 $\times$ 109 sperm/80 ml at 12 and 24 hours after onset of oestrus. All females were inseminated using a spirette catheter (Minitube Inc., Verona, WI).

Inseminated gilts were fed 2.0 kg of their diet once daily and individually housed in gestation pens with dwarf walls and concrete floors through the first gestation. The lactation diet was increased by approximately 0.8 kg/d from parturition to 7 d *postpartum*,

on *ad libitum* basis through to 21 days of lactation. Animals were weighed at breeding; 110 days *post coitum*, at parturition and weaning (42 day *postpartum*). Piglets from each treatment groups were weighed at birth and on day 21 *post natum*. In terms of feeding patterns, vitamin E and Se supplementation as well as other management procedures, the second parity was identical to the first parity. The sows were re-bred approximately 32 days post weaning as recommended by UMESIOBI and ILOEJE (1999). During the second parity, sow and litter parameters were evaluated in the same way as in the first parity. In order to minimise feed wastage by both sows and piglets, 2 weeks to weaning the sows were fed a restricted quantity (1 kg/d) of their treatment diet but they remained with their lactation diet and in their pen.

2.4 Serum evaluation

For the evaluation of concentrations of vitamin E and Selenium equivalents in the blood serum, all the sows were bled (8 mL/sow) by puncture of the jugular vein or the anterior Vena cava during both reproductive cycles (parity I and II). Samples were collected at 30 day *post coitum*, the 99 day of gestation and on day 21 of lactation. Four piglets per litter (two males and two females) were bled via cardiac puncture (5 mL) into heparinized vacuum tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ) on days 1 4, and 8 *post natum* and at weaning (day 21) to evaluate haematological (Lymphocytes, Neutrophils and Neutrophil / Lymphocyte ratio) and α-tocopherol concentrations. Blood samples were drawn from the marked pigs in both parities, resulting into $60 \times 2 \times 2 = 240$ samples, and body weights were recorded. Approximately 120 mL of the harvested serum was used for the determination of haematological status of the piglets. Aliquots of the blood samples (lymphocytes and neutrophils) were analyzed with an automated hematology analyzer, ADVIA 120 (Bayer, Tarrytown, USA) using commercial reagent kits (ADVIA® 120 PEROX 1, 2 & 3 reagents, Bayer, USA). The remainder (n = 120 mL serum) was frozen at -25°C for subsequent laboratory analysis of α-tocopherol concentrations. The following parameters were investigated for each litter: the total number of piglets born, the number of piglets born alive, the number of stillborn (defined as the number of piglets which were alive at the initiation of farrowing, but died *intrapartum*), mortality during the lactation period, the litter size at weaning, the average body weight of piglets at birth and at weaning following the procedures of MAHAN (1991), WURYASTUTI *et al.* (1993), UMESIOBI (2004) and UMESIOBI (2008).

Feed and serum were analyzed for vitamin E spectrophotometrically applying with the procedures of MARIN-GUZMAN *et al.* (2000). Selenium level was determined by the method of MAHAN (1994) using a spectrofluorometer. Glutathione peroxidase (GSH-Px) activity was determined as described by MAHAN (1991). Diarrhoea was evaluated only when it occurred, using a 1-5 point scale.

2.5 Statistical analyses

Litter size and serum concentrations of vitamin E and Se were statistically evaluated as a 2×3 factorial treatment in a randomized complete block design with sows in treatment groups between parity as repeated measures. Individual sows or litters, respectively,

were considered the experimental unit. Main effects least squares means of vitamin E levels and parity are presented in the tables. Statistical analyses were performed using the General Linear Model (GLM) procedure (SAS, 2002). Data were reported as least-square means (± s.e.). Differences between treatment means were tested for significance using the procedures of McDonald (2008).

3 Results and Discussion

3.1 Sow and litter weight

Mean sow and litter weight after vitamin E supplementation to sow over a two-parity period are displayed in Tables 2 and 4, respectively. Gilt weights at first breeding averaged 135.3 ± 0.6 kg. The 99-day *post coitum* weights increased dramatically ($P < 0.01$) from parity 1 to 2. Body weight gains increased from parity 1 to 2, with the highest gain recorded at parity 2, following 70 IU/kg of vitamin E supplementation (188.1 ± 0.6 kg). There was a greater lactation weight increase ($P < 0.01$) of sows from parity 1 to 2 as dietary vitamin E level increased from 0 to 70 IU/kg. Sow farrowing and weaning weights increased ($P < 0.01$) from parity 1 to 2 following 70 IU/kg of vitamin E supplementation. Lactation weight increased from parity 1 to 2; the greatest sow weight gain occurred during the second lactation. A significant ($P < 0.01$) sow weight gain was noticed during the first and second lactation period, with the highest sow weight gain observed at parity 1 following 70 IU/kg of vitamin E supplementation ($P < 0.01$).

Table 2: Average weight of sows after vitamin E supplementation over a two-parity period.

Parameters over two parity periods	*Reproductive cycles*						*SEM*
	Parity I Vitamin E (IU/kg)			*Parity II Vitamin E (IU/kg)*			
	0	*40*	*70*	*0*	*40*	*70*	
Body weight at breeding (kg)	135.3^a	135.3^a	135.3^a	165.3^a	172.6^a	188.1^a	0.6
Body weight at 99 day gestation (kg)	181.5^a	200.7^b	215.1^c	182.3^a	208.0^d	211.9^c	2.4
Body weight gain (g/d during 99 days)	16.2^a	35.4^b	49.8^c	16.6^a	42.7^d	46.6^e	0.2
Farrowing weight (kg)	156.5^a	158.4^b	166.5^c	171.2^d	184.9^e	195.1^f	0.8
Weaning weight (kg)	156.9^a	160.2^b	169.5^c	175.8^d	190.1^e	204.3^f	0.3
Body weight gain (g/d, during × days)	0.4^a	1.8^b	3.0^c	4.6^d	5.2^e	9.2^f	0.2

Means with different superscripts within rows ($^{a\ b\ c\ d\ e\ f}$) differ at $P < 0.01$
SEM = Standard error of the means.

Table 3: Mean sow reproductive performance after vitamin E supplementation over a two-parity period.

Parameters over two parity periods	*Reproductive cycles*						*SEM*
	Parity I Vitamin E (IU/kg)			*Parity II Vitamin E (IU/kg)*			
	0	*40*	*70*	*0*	*40*	*70*	
Weaning-to-oestrus interval (days)	5.3^{a}	4.1^{b}	3.2^{c}	5.4^{a}	2.2^{d}	1.0^{e}	0.4
Returns to oestrus per sow (n)	0.3^{a}	0.1^{b}	0.02^{c}	0.3^{d}	0.02^{c}	0.01^{e}	0.04
Farrowing-to-farrowing interval (days)	153^{a}	149^{b}	144^{c}	152^{d}	145^{e}	136^{f}	0.01
Farrowing rate (%)	40.9^{a}	53.1^{b}	67.5	79.1	88.3^{c}	91.5^{c}	4.1
Total piglets born/litter (n)	6^{a}	8^{a}	12^{ab}	8^{a}	10^{c}	12^{d}	4.7
Piglets born alive/litter (n)	4^{a}	6^{b}	10^{c}	5^{d}	9^{e}	11^{f}	0.5
Stillborn piglets/litter (n)	1.7^{a}	0.7^{a}	0.5^{a}	1.4^{a}	0.5^{a}	0.5^{a}	1.02
Litter size at weaning (n)	3.2^{a}	5.9^{b}	9.6^{c}	3.7^{a}	7^{e}	10^{f}	0.7

Means with different superscripts within rows ($^{a\ b\ c\ d\ e\ f}$) differ at P < 0.01
SEM = Standard error of the means.

Table 4: Mean growth, diarrhoea score and haematological characteristics of piglets after vitamin E supplementation of their sows over a two-parity period.

Parameters over two parity periods	*Reproductive cycles*						*SEM*
	Parity I Vitamin E (IU/kg)			*Parity II Vitamin E (IU/kg)*			
	0	*40*	*70*	*0*	*40*	*70*	
Piglet body weight at birth/litter (kg)	1.2^{a}	1.6^{a}	2.1^{b}	1.3^{a}	2.3^{b}	2.5^{b}	0.2
Piglet body weight/litter on day 21, weaning (kg)	7.0^{a}	7.8^{b}	9.5^{c}	7.5^{d}	7.8^{b}	12.5^{e}	0.2
Weight gain (g/d until weaning)	276.2^{a}	295.2^{b}	352.4^{c}	295.2^{b}	262^{d}	476.2^{e}	6.2
Diarrhoea score/litter until weaning (1-5 scale)	5.1^{a}	3.4^{b}	2.0^{c}	5.5^{a}	2.1^{c}	0.7^{d}	0.3
Dead piglets until weaning (n)	1.5^{a}	1.1^{b}	0.8^{c}	1.6^{a}	0.5^{d}	0.5^{d}	0.07
Lymphocytes, %	33.5	30.3	27.5	33.8	29.3	26.3	6.8
Neutrophils, %	59.5	61.8	63.5	61.3	64.5	65.1	3.8

Means with different superscripts within rows ($^{a\ b\ c\ d\ e\ f}$) differ at P < 0.01
SEM = Standard error of the means.

As indicated in Table 4, feeding diets supplemented with vitamin E to sows significantly increased (P<0.01) the weaning body weight gain of piglets compared to the control diet, with the highest body weight (12.5 ± 0.2 kg) and average daily weight gain (476.2 ± 6.2 g) obtained in weanling pigs farrowed by sows receiving 70 IU/kg of vitamin E supplementation. Even though the litter size was higher in the supplemented groups, this did not have a negative effect on the birth weight of the piglets and on their weight at weaning. A considerable increase in birth and weaning weigh is in agreement with the findings of Le Dividich *et al.* (2005). Mahan (1991) and Pehrson *et al.* (2001) reported that increasing the vitamin E level of sow's diet over the generally considered adequate led to increased titers of serum antibodies to *Escherichia coli* bacteria. This reason could be attributed for better survival and birth and weaning weigh gain of the piglets.

3.2 Sow fecundity parameters

The main effects of dietary vitamin E level and parity on sow reproductive performance and litter sizes are presented in Table 3. In this study farrowing rate was determined by percentage of pregnant sows that farrowed litters within the experimental period. There were significant ($P < 0.01$) effects due to parity and dose of vitamin E on weaning-to-oestrus interval, number of returns to oestrus per sow and farrowing-to-farrowing interval. The shortest weaning-to-oestrus interval (1.0 ± 0.4), lowest number of returns to oestrus per sow (0.01 ± 0.04) and shortest farrowing-to-farrowing interval (136 ± 0.01) were obtained at parity 2 following 70 IU/kg of vitamin E supplementation. Additionally, the number of piglets born alive per litter was greater in the groups which received 70 IU/kg of vitamin E and this difference was significant between parities. Similar results were also reported by Flachowsky (2000), Oldfield (2003) and Umesiobi (2008). Research in sows has shown that vitamin E supplementation increases the immunogenic capacity of reproductive sows (Wuryastuti *et al.*, 1993; Moreira and Mahan, 2002) which is important for the embryonic development and survival (Tarín, 2002; Pinelli-Saavedra and Scaife, 2005).

Litter size referred to the total number of piglets born per litter per female. As shown in Table 3, parity and vitamin E supplementation elicited significant differences ($P < 0.01$) in parturition and postnatal litter parameters exemplified by farrowing rate (FR) and litter size (LS) of AI sows. There was a tendency for a higher total number of piglets born to parity 2 groups, especially in the group supplemented with 70 IU/kg of vitamin E (12 ± 4.7). Moreover, the number of piglets born alive was higher ($P < 0.01$) at parity 2 compared with parity 1 and the LS at weaning was found to be higher at parity 2 in the groups treated with 40 and 70 IU/kg of vitamin E respectively, compared with parity 1 groups. However, the supplementation of vitamin E to the sows' diet did not influence ($P > 0.01$) the number of stillborn piglets/litter, although the lowest number of stillborn piglets/litter was obtained with 40 and 70 IU/kg of vitamin E supplementation to sows' diets. The greater number of weaned piglets observed in the group supplemented with 70 IU/kg of vitamin E is probably due to the greater number of piglets born alive per litter. These results are in agreement with those of Pinelli-Saavedra and Scaife

(2005), who reported that although the body weights of piglets at birth and at 21 days of age differed amongst groups, supplementation of vitamin E to sows enhanced the average daily weight gain of piglets/litter.

3.3 Diarrhoea score and haematological characteristics of piglets

As illustrated in Table 4, the diarrhoea score of piglets until weaning was influenced by the supplementation of vitamin E to sows' diet during the two parities, with the highest (best) values obtained when vitamin E was supplemented to the sows' diets at parity 2. On the other hand, no significant treatment differences in blood parameters (concentrations of lymphocytes and neutrophils in blood) were obtained through supplementation of vitamin E to the sows' diet (Table 4). Dietary supplementation of vitamin E to sows' diet may have resulted in the significant reduction ($P < 0.01$) in the diarrhoea score during lactation/litter and in piglet mortality during lactation. These results are in line with findings of Wolf (2005) who observed that supplementation of vitamin E to the diet of sows could alleviate a diarrhoea-like condition and at the same time maintain the growth rate of their piglets. The results on lymphocyte and neutrophil concentrations in blood of piglets compare favourably to those obtained by Wuryastuti *et al.* (1993) who reported that vitamin E restriction affected both neutrophils and lymphocytes profile, and hence, if gestating sows do not obtain adequate vitamin E, they and their piglets will be more susceptible to disease processes in the *peripartum* period.

3.4 Sow and piglet serum compositions

Tables 5 and 6 highlight the mean serum α-tocopherol concentrations (μg/mL) of the sows and litters after vitamin E supplementation of sows over a two-parity period. There were significant effects ($P < 0.05$) due to supplementation of vitamin E at the two parities. Serum α-tocopherol at 30 and 99 day *post coitus* increased ($P < 0.05$) as dietary vitamin E increased during first and second parity. There was a dramatic increase in serum α-tocopherol concentration following 40 or 70 IU/kg of vitamin E supplementation during the 30 and 99 day gestation and 21 day lactation periods from parity 1 to parity 2. Serum α-tocopherol levels during gestation and lactation were substantially higher when sows were fed diets containing 70 IU/kg of vitamin E supplements. Serum Se concentrations were significantly affected ($P < 0.05$) by the dietary vitamin E level. On day 30 and 99 of gestation and day 21 of lactation, Se concentrations were about 3 fold higher in 70 IU/kg vitamin E supplemented sows in parity 2 compared to parity 1 and control groups, respectively. In all treatment groups, the highest Se concentrations were noticed on day 21 of lactation. Certainly, a positive correlation between nutritional intake of vitamin E and serum vitamin E levels has been established (Capper *et al.*, 2005), and a relationship between dietary levels of vitamin E and its concentrations in the liver has been shown (Brigelius-Flohé and Traber, 1999; Yoon and McMillan, 2006). According to Stuart and Kane (2004) a slight increase in the levels of α-tocopherol in the blood of animals that received supplemental vitamin E could be enough to show beneficial effects during critical periods of embryonic development, thus enhancing embryo survival. Results from this current study conducted over 2 parity periods indicated that dietary supplementation of vitamin E influences serum levels of α-

tocopherol and thus have a beneficial effect on some important reproductive parameters in sows and subsequent improvements in growth of their weanling pigs.

Table 5: Average serum parameters of sows with and without vitamin E supplementation over a two-parity period.

Parameters over two parity periods	*Reproductive cycles*						*SEM*
	Parity I			*Parity II*			
	Vitamin E (IU/kg)			*Vitamin E (IU/kg)*			
	0	*40*	*70*	*0*	*40*	*70*	
Serum α-tocopherol concentrations (μg/mL):							
Day 30 *post coitus*	0.11^a	0.35^b	1.51^c	0.11^a	2.73^d	4.04^e	0.2
Day 99 of gestation	0.13^a	0.25^b	1.84^c	0.12^a	3.01^d	4.17^e	0.2
Day 21 of lactation	0.33^a	0.52^b	2.55^c	0.38^a	4.55^d	5.05^e	0.3
Serum Se concentrations (ppm):							
Day 30 *post coitus*	0^a	0.44^b	0.62^c	0^d	0.47^e	0.68^f	0.02
Day 99 gestation	0.35^a	0.41^b	0.40^b	0.38^b	0.54^c	0.62^d	0.03
Day 21 of lactation	0.31^a	0.28^b	0.45^c	0.32^a	0.35^d	0.55^e	0.03

Means with different superscripts within rows ($^{a\ b\ c\ d\ e\ f}$) differ at P < 0.01
SEM = Standard error of the means.

Piglets' serum α-tocopherol concentrations on day 2 and 21 were significantly influenced (P < 0.05) by parity and level of vitamin E supplementation. Female piglets had higher serum α-tocopherol concentrations at both day 2 and day 21 compared to the male piglets. These differences were more pronounced at parity 2 with 70 IU/kg of vitamin E supplementation. On day 2 and day 21, serum Se concentrations of piglets were also affected (P < 0.05) by dietary vitamin E levels fed to the sows. Serum Se contents increased from parities 1 to 2, with highest values observed at 70 IU/kg of vitamin E supplemented in parity 2. Also, female piglets had higher serum Se concentrations on day 2 and day 21 compared to the male piglets. The significant increases noticed in the serum α-tocopherol concentrations in 2-day old and weanling pigs support the reports by Marin-Guzman *et al.* (2000) and Tao *et al.* (2004) who indicated that concentrations of plasma α-tocopherol were higher in piglets born from gilts fed vitamin E supplemented diets. This implies that piglets from nursing sows fed higher dietary vitamin E levels received more α-tocopherol during the latter part of lactation and thus were in a better vitamin E status at weaning than pigs from sows fed the lower dietary level. The activity of the selenium-dependent enzyme glutathione peroxidase in the serum of piglets was very low on day 2 *post natum* in both groups despite the fact that the sows' feed had been supplemented with 0.15 mg selenium/kg. This indicates that the selenium status of newborn piglets might be more critical for their health than their vitamin E status. However, no behavioural parameters were recorded in this study that could be effectively related to the wellbeing of the piglets of vitamin E supplemented sows in the South African environment.

Table 6: Average concentrations of α-tocopherol and Se in piglets' serum as influenced by vitamin E supplementation of their sows over a two-parity period.

Parameters over two parity periods	*Reproductive cycles*						*SEM*
	Parity I			*Parity II*			
	Vitamin E (IU/kg)			*Vitamin E (IU/kg)*			
	0	*40*	*70*	*0*	*40*	*70*	
Piglets' serum α-tocopherol concentrations (μg/mL):							
Male piglets							
Day 2 *post natum*	0.42^{a}	1.81^{b}	3.43^{c}	0.71^{d}	3.85^{e}	5.35^{f}	0.4
Day 21 (weaning age)	0.95^{a}	1.36^{b}	3.09^{c}	1.25^{b}	4.61^{d}	5.35^{e}	0.4
Female piglets							
Day 2 *post natum*	1.17^{a}	1.85^{b}	3.51^{c}	1.32^{d}	4.81^{e}	5.81^{f}	0.1
Day 21 (weaning age)	1.40^{a}	1.91^{b}	4.15^{c}	1.88^{b}	5.55^{d}	6.26^{e}	0.3
Piglets' serum Se concentrations (ppm):							
Male piglets							
Day 2 *post natum*	0.055^{a}	0.065^{b}	0.071^{c}	0.058^{d}	0.074^{c}	0.085^{e}	0.004
Day 21 (weaning age)	0.059^{a}	0.073^{b}	0.075^{b}	0.061^{c}	0.078^{b}	0.092^{d}	0.003
Female piglets							
Day 2 *post natum*	0.057^{a}	0.070^{b}	0.079^{c}	0.062^{d}	0.075^{e}	0.085^{f}	0.003
Day 21 (weaning age)	0.063^{a}	0.077^{b}	0.082^{c}	0.065^{d}	0.083^{c}	0.095^{e}	0.003

Means with different superscripts within rows ($^{a\ b\ c\ d\ e\ f}$) differ at $P < 0.01$
SEM = Standard error of the means.

4 Conclusion and Recommendation

Based on the results of the present study on improved body weight gains of vitamin E supplemented sows and their weanling piglets, improved sow fertility parameters, piglet survival and haematological status of sows and piglets, it is concluded that supplementing sows' diets with 70 IU/kg α-tocopheryl acetate appears to be most beneficial. It seems that the vitamin E requirements of reproducing sows are higher than currently recommended and that the progeny of animals fed higher dietary levels of vitamin E are in a better vitamin E status at weaning. Therefore following concrete recommendations are made:

- Gestation and lactation diets of sows should be supplemented with at least 70 IU/kg α-tocopheryl acetate so as to enhance litter size and subsequent body development of the piglets.

- There should be a routine check on the activity of the selenium-dependent enzyme glutathione peroxidase in the serum of piglets, during the first two days after birth. This seems imperative since the selenium status of newborn piglets might be more critical for their health than their vitamin E status.

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