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Effects of Dietary Vitamin E and C on the Quality of Pork

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ABSTRACT

Pork quality especially muscle colour is what most consumers look for. The use of a hormone-like group of synthetic chemical substances to improve muscle colour is known to be detrimental to health. This study showed that adding vitamin E 200 ppm (T2) compared with control (T1) in 40–100 kg pigs' diets gave back fat deposit in castrated males higher than in females 1.89 cm ($p < 0.05$). It was similar by adding vitamin E 100 ppm plus vitamin C 500 ppm (T3) compared with control (T1) in 40–100 kg pigs' diets gives back fat deposit in castrated males higher than in females 1.44 cm ($p < 0.05$). T2 tended to gave a higher percentage of muscle in carcasses at Hunter '*a*' value > 5 and > 6 were 92.31% and 69.23% respectively. Whereas T3 tended to give a higher percentage of muscle in carcasses at the same Hunter '*a*' value were 100% and 92.31% compared with T1 at Hunter '*a*' value > 5 and > 6 were 91.66% and 66.66%. At the same time the percentage of pigs in T2 and T3 tended to give drip loss under 3.5% which is higher than T1. That was 53.85%, 46.15% compared with 41.66%, respectively. The pH value in T2 and T3 was not altered. Furthermore, the trend towards higher ADG was shown as 0.614, 0.639 and 0.629 kg/d and the trend of lower FCR was 3.206, 3.127, 3.16 in T1, T2,and T3, respectively

Key words : meat/pork quality, meat/muscle colour, vitamin E, vitamin C,

INTRODUCTION

Today pig farmers in Thailand are trying to find out the substances that claim to " lose the fat, keep the muscle and fresh colour" to substitute for beta adrenergetic agonist which was prohibited to use in feed since Jan, 1999. This experiment tried to find the generally recognized as safe substances that could be substituted for beta adrenergetic agonist.

It is known that the metabolic function of vitamin E are on hormone metabolism and membrane antioxidant while the regulation of steroid synthesis, oxidising and reducing agent could claim from vitamin C (Voet and Voet, 1990). The quality of pork was enhanced by high levels of vitamin E or E+C due to the metabolic function of these two vitamins

Myoglobin is a pigment in the body tissue which gives a purplish red colour to meats. The process of oxygen consumption of body tissue in live animals changes myoglobin into oxymyoglobin giving meat its bright red colour. After slaughtering, an autocatalytic process develops rapidly. The lipid oxidation a free-radical mediated of cell membrane of meats is catalysed myoglobin, oxymyoglobin to

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metmyoglobin then gives brown meat colour (Sheehy,1994). Furthermore, oxidized (unpleasant) flavours aldehydes, ketones, alcohols etc. from the break down of lipid hydroperoxides develop at the same time (Morrissey and Apte, 1988 cited by Sheehy, 1994). The flavour of this mixture is unacceptable to consumers. Oxidation of unsaturated fatty acids and haemoprotein in meats also affects the colour, texture, nutritive value (Sheehy, 1994; Monahan *et al*., 1994) and taste. These changes are slowed considerably by elevated vitamin E in tissue (Baker, 1999). Giving vitamin E 100–200 mg/kg to pigs 4–12 weeks before slaughter improves the oxidative stability of the muscle. The rate of colour fading is lowest ($p < 0.05$) in pork chops of pigs being fed vitamin E 200 mg/kg. Furthermore this reduces drip loss also. (Cheah *et al.*, 1995).

In biological tissues, vitamin E and vitamin C act together to remove the free radicals and gives vitamin E recovered. (Allen and Hamilton, 1994). Rapid reaction with organic free radicals is a property shared by vitamin C and vitamin E (Yen, 1984). Tappel (1968) cited by Yen (1984) has proposed that vitamin C and vitamin E act synergistically in such a fashion that vitamin E serves as the primary antioxidant and vitamin C reductively regenerates vitamin E. Even though nothing is known about the effect of vitamin C supplementation on the status of vitamin E and of selenium and glutathione peroxidase activity in pigs. In rats, vitamin C supplementation has been shown to increase plasma vitamin E concentration, and supplemental vitamin E also increases plasma vitamin C level (Chen *et al.*, 1980 cited by Yen, 1984). The sparing effect of vitamin C on the metabolism of vitamin E during vitamin E deficiency has also been observed in guinea pigs (Chen and Chang, 1978 cited by Yen, 1984). Mahan *et al.* (1991) has improved the colour and lipid stability in beef longissimus with dietary vitamin E 1200 mg/animal/day for 67 days and dip treatment in 1% of vitamin C for 20 second. In the case of dip treatment in 1% of vitamin C for 20 seconds, the results show greater pigment and lipid stability than undipped control during 16 days of display at 4°C. Enhancing vitamin E 50 ppm and selenium at 0.1 ppm from 20–100 kg. body weight and vitamin C 670 ppm from 80-100 kg body weight in pork diets at the same time showed taint and drip loss were reduced but colour, muscle and fat stability increased (Close, 1997).

This experiment aimed to evaluate the validity of earlier reports. Specific goals were to determine the efficacy of vitamin E and vitamin C dietary supplementation in enhancing colour stability and reducing drip loss in fresh pork. Hopefully, it will prove to be a better choice for carcass improvement and could be substituted for beta adrenergetic agonist. Moreover, vitamins are generally recognized as safe substances(GRAS).

MATERIALS AND METHODS

Fifty seven crossbred Largewhite × Landrace pigs (27 castrated males and 30 females) average weight 40 kg were randomly caged individually. There were 9 replicates of castrated males and 10 replicates of females per treatment. The treatment diets are as follows :

1. Corn-rice bran ration used as a control (T1)
2. Control + vitamin E 200 ppm in feed (T2)
3. Control + vitamin E 100 ppm in feed + vitamin C 500 ppm in feed (T3)

Feed and water were available *ad libitum*. Feed composition was shown in Table 1. The slaughter weight was 90–100 kg. The experimental period from 40 kg body weight to slaughter weight was 90–103 days.

Body weight was recorded every 2 weeks

Table 1 Composition of diet (as-fed basis).

Ingredients (%)	Control	Control + E	Control + E + C
Corn meal	48.95	48.95	48.95
Soybean meal	12.80	12.80	12.80
Full fat soybean	2.50	2.50	2.50
Rice bran	20.30	20.30	20.30
Fish meal	4.00	4.00	4.00
Broken rice	7.85	7.80	7.75
Tallow	0.50	0.50	0.50
Premix(vitamins+minerals)[1/]	0.30	0.30	0.30
Vitamin E (ppm)	0	200	100
Vitamin C (ppm)	0	0	500
Calculated composition (%)			
Crude protein	16.00	16.00	16.00
ME , kcal/kg	3063.18	3063.18	3063.18
Fat	5.86	5.86	5.86
Crude Fibre	4.73	4.73	4.73

[1/] 33 ppm vitamin E

from the beginning of the experiment until the pigs reached market weight. The amount of feed intake per pig per day were recorded every day. At the completion of the feeding period, two pigs per treatment that reached slaughter weight (90 kg up) were weighed (every day or alternate days) and feed removed approximately 12 hours before slaughter day. Then they were transported to slaughter at the local abattoir around 10 km from the experimental farm. Pigs were randomly selected from each treatment for meat quality testing. Hot carcass weights were taken immediately after the final wash. Carcasses were separated into wholesale cuts for pork quality determinations. Back fat was measured between rib 9 and rib 10 by back fat probe, meat sample was taken between rib 9 and rib 10 (Jaturasitta, 1999) for measuring colour value as Hunter '*a*' values, which is the measurement of surface redness of fresh muscle (Monahan *et al.*, 1994) by Chroma Meter (Gerdemann, 1996) see in Figure 1 while pH was read from pH meter (Jaturasitta, 1999) and driploss was calculated by Honikel's (1987) method.

The experimental design was 2×3 factorial. Where applicable, significant differences between treatment diets and interactions were analyzed via carcass quality, ADG and FCR by analysis of variance (Cochran and Cox, 1957).

RESULTS AND DISCUSSIONS

Meat quality evaluation

Back fat: Back fat deposits are shown in Table 2. No difference was evident between the treatments but the sexes (M 1.89 cm; F 1.44 cm) showed highly significant differences. Castrated males had higher fat deposits in every treatment group and there was a tendency to be higher fat

deposits on dietary vitamin supplement. However, on the average, dietary vitamin supplementation was unable to decrease back fat deposit. This result is similar to Cannon *et al.*(1996).

Fresh pork colour: Even though there was no difference between treatment groups and sexes (Table 3), in female pigs the vitamin diets had a tendency to increase Hunter '*a*' value were 6.64, 7.33 and 7.72 for T1, T2 and T3, respectively. These finding was similar to those of Monahan *et al.* (1994). In the case of castrated males '*a*' value in T3 (7.65) trend to be higher than in T1 (7.05) and in T2 (6.936) but T2 was lower than T1. This evidence occurred vice versa in females so it is contrary to the work of others and may be caused by laboratory errors. Because in freshly cut meat, the oxidative system is believed to be the dominant factor controlling the rate of metmyoglobin accumulation (Monahan *et al.*, 1994). However, averagely T3 had a tendency to give highest ' a' value and T2 tended to give higher than T1 at 7.68, 7.13 and 6.85 for T3, T2 and T1, respectively. Hundred percent of all colour samples was acceptable (Hunter '*a*' value > 5) as compared with the photograph in Figure 2 (Price and Schweigert, 1971). But the positively effects of dietary vitamin E and vitamin E + C at Hunter '*a*' value > 6 are shown in Table 4. The results showed that dietary 100 ppm vitamin E + 500 ppm vitamin C gave a higher percentage increased in fresh pork surface redness than in dietary 200 ppm vitamin E and control (92.31%, 75% and 70%, respectively).

Acceptable pork colour is shown in Figure 2 (Price and Schweigert, 1971). Lets R is the pig number from 1–60 pigs. The lowest (T1R13, 3.19) and the highest (T1R19, 10.08) of Hunter '*a*' value

Table 2 Effect of vitamin E (T2) and vitamin E+C (T3) on back fat deposit compared with control (T1).

	Back fat in cm		
Treatment	M	F	Avg.
T1	1.7 [a]	1.44 [b]	1.57
T2	2.1 [a]	1.36 [b]	1.73
T3	1.88 [a]	1.54 [b]	1.71
Avg.	1.89 [a]	1.44 [b]	1.67

[a, b] Mean value in a row show a highly significant difference ($p < 0.001$)

Table 3 The average Hunter '*a*' value in dietary vitamin (T2 and T3) supplements compared with control (T1).

Treatment	M	F	Avg.
T1	7.05	6.64	6.847
T2	6.93	7.33	7.13
T3	7.65	7.72	7.68
Avg.	7.2	7.23	

from T_1 are shown in Figure 3. For treatment 2 (200 ppm vitamin E) the lowest (T2R35, 3.85) and the highest (T2R30, 11.28) of Hunter '*a*' value could not be presented because of a mishap in taking a photograph. However, the different Hunter '*a*' value between 5.08 (T2R22) and 7.19 (T2R38) represent treatment 2 (Figure 4). Treatment 3 (200 ppm vitamin E + 500 ppm vitamin C) was similar to treatment 2, the lowest Hunter '*a*' value (5.7) could not be shown here but the highest (9.57) and second lowest (6.34) are shown in Figure 5.

pH value: It has been recognized for many years that living muscle containing little or no lactic acid and has a pH approximately 7.4 or 7.6 in

Figure 1 Using **Chroma Meter** to measure Hunter '*a*' value.

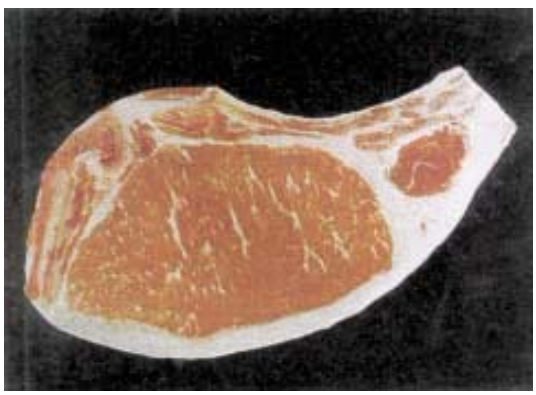

Figure 2 An acceptable pork colour (Price and Schweigert, 1971).

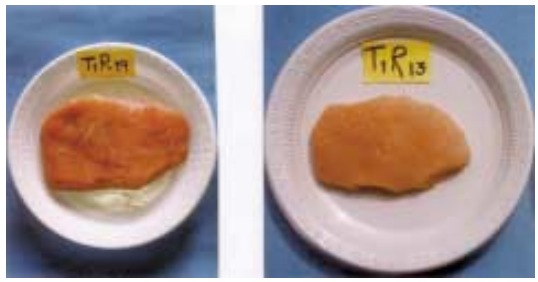

Figure 3 Pork muscle colour in control (T1) 'a' value : 10.08 (T1R19) , 3.19 (T1R13). Lets T means treatment and R means pig number from R1-R60.

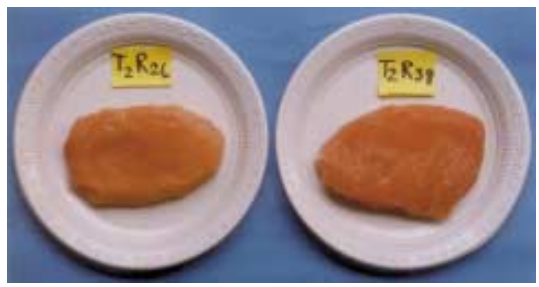

Figure 4 Pork muscle colour in dietary vitamin E (T2) 'a' value: 7.19 (T2R38), 5.64 (T2R26). Lets T means treatment and R means pig number from R1-R60.

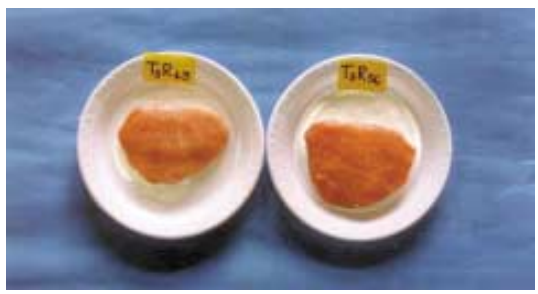

Figure 5 Pork muscle colour in dietary vitamin E + C (T3) 'a' value : 9.57 (T3R56), 6.34 (T3R43). Lets T means treatment and R means pig number from R1-R60.

living rested muscle (Price and Schweigert, 1971). But at post-mortem, pH of meat has a marked effect upon its physical properties, being responsible for dark-firm-dry (DFD) and pale-soft-exudative (PSE) pork muscle. Usually 1% glycogen in muscle is converted into lactic acid, which directly causes a depression in pH values from about 7.4 to about 5.6 (Jay, 1986). High pH value (5.8 up) results in an increase in water binding capacity, giving a darker colour and coarser texture and providing conditions more favourable to spoilage, whereas low pH value (5.5 or less) tends to have the reverse effect (Price and Schweigert, 1971). However, the ultimate pH (pHu) for PSE should not be lower than 5.4 and DFD should not be higher than 6. But for commercial plants different kinds of equipment will give a variation of pH 0.1-.02 units. So the use of pHu alone to separate such extreme quality condition, DFD and PSE condition is questionable (Kauffman and Warner, 1993). Jay (1986) reported pH value range 5.3-6.9 is the lowest and highest in pork muscle, and the approximate pH of ham is 5.9-6.1. Among these contradictory numbers, the results from Table 5 has shown that vitamin E or C did not affect pH value. The highest and lowest pH value of T1, T2 and T3 were 6.25 and 5.75; 6.26 and 5.76; and 6.36 and 5.81, respectively.

Drip loss: Acceptable water loss in carcass weight should not be more than 3.5% (Jaturasitta, 1999). The results in Table 6 show that vitamin E and vitamin E + C in diets could improve the percentage of drip loss ($p < 0.05$) in females but not in castrated males and not different by the average of treatment. Mean difference between sexes was significant ($p < 0.05$). In general, fat content in females is higher than in males and vitamin E is fat soluble vitamin. So by the rule of thumb the total amount of vitamin E content in females carcasses must be higher than in males carcasses. This is also makes the number of carcasses which shows drip loss lower than 3.5% in T2 and T3 12.19% and 4.49% higher respectively compared with the control (Table 7),

General performances

Weight gain: Weight gain is shown in Table 8. No difference of total body weight gain in T1, T2 and T3 (55.8 < 58.88 and 58 kg/hd) but showed a difference between treatments in female 52.9, 58.33 and 58 kg/hd ($p < 0.05$), respectively. Average daily gain (ADG) showed a statistically difference ($p < 0.05$) between castrated males (6.54 kg/d) and females (6.01 kg/d). But this was not affected by dietary vitamin supplements. Although dietary vitamin supplements had a tendency to give higher weight gain in both but maybe this was caused by a higher number of castrated males.

Feed conversion ratio (FCR): There was no difference between treatments and sexes. But the trend in vitamin diets gave lower FCR (Table 9).

Cost-benefit analysis

By the conclusion, the results in Table 10 showed that adding vitamin E 100 ppm + vitamin C 500 ppm (T3) gave highest of total income and vitamin E 200 ppm (T2) also showed higher of total income than the control group. Because the percentage of pig culling in T1 was the highest (10.52%), but T2 and T3 were equal (5.26%). Even though the feed price of control group was lowest 6.34 B/kg as compared with T2 and T3 at 6.79 and 6.59 B/kg, respectively.

CONCLUSION

It seems that this experiment gave satisfactory answers. One interesting point was female pigs showed more response to vitamin supplemented than castrate males.

Even though back fat deposit was not decreased by dietary vitamin and showed no

Table 4 Percentage of pig number at Hunter '*a*' value > 6 and > 5 in vitamin diets (T2 and T3) compared with control (T1).

Treatment	No. of pigs Hunter '*a*' value >6	No. of pigs Hunter '*a*' value >5
T1 (n, 10)	7/10 (70.0 %)	10/10 (100 %)
T2 (n,12)	9/12 (75.0 %)	12/12 (100 %)
T3 (n,13)	12/13 (92.31%)	13/13 (100%)

Table 5 Ultimate pH value in vitamin dietary compared with control.

Treatment	pH_1	pH_2
Control (T1)	6.25	5.75
+ vit. E (T2)	6.26	5.76
+ vit.E+ vit. C (T3)	6.36	5.81

* pH_1 : measured 45 minutes after slaughter, pH_2 : measured 24 hours after slaughter

Table 6 Effect of vitamin diets on drip loss percentage.

Treatment	M (%)	F (%)	Avg (%)
Control (T1)	3.27	6.2^{b}	4.9
+ vit. E (T2)	3.349	4.41^{bc}	3.87
+vit.E + vit.C (T3)	3.429	3.97^{c}	3.78
Avg.	3.34^{a}	4.86^{b}	4.18

^{a,b} Mean difference in rows ($p < .05$) , $^{b, c}$ LSD test significantly difference in columns ($p < .05$)

Table 7 Percentage of pigs in vitamin dietary treatments on drip loss value < 3.5%*.

Treatment	No. of pig (drip loss < 3.5%)*	No. of pig in % (drip loss < 3.5%)*
Control (T1)	5/12	41.66
+ vit. E (T2)	7/13	53.85
+vit.E + vit.C (T3)	6/13	46.15

* acceptable pecentage.

Table 8 Effect of dietary vitamin E and vitamin E+ C on body weight gain and ADG.

Treatment	Avg Tot. Gain (kg/hd.)			Treatment	ADG (kg/d)		
	M	F	Avg		M	F	Avg.
Control (T1)	58.71 (n, 7)	52.9[a] (n,10)	55.8 (n,17)	Control (T1)	0.661 (n,7)	0.567 (n,10)	0.614 (n,17)
+ vit. E (T2)	59.44 (n, 9)	58.33[b] (n,9)	58.88 (n,18)	+ vit. E (T2)	0.656 (n, 9)	0.623 (n, 9)	0.639 (n, 18)
+vit.E+vit. C (T3)	58 (n, 8)	58[b] (n,9)	58 (n,17)	+vit.E+vit. C (T3)	0.645 (n, 8)	0.614 (n, 9)	0.629 (n, 17)
Avg.	58.71	56.41	57.56	Avg.	0.654[c]	0.601[d]	0.627

[a, b] LSD test significantly difference in column ($p<0.05$), [c, d] Mean value in a row are significantly difference ($p <0.05$)

Table 9 Effect of vitamin diets on FCR.

	FCR		
Treatment	M	F	Avg.
Control (T1)	3.015	3.398	3.206
T1+ vit. E (T2)	3.051	3.202	3.127
T1+ vit.E + vit.C (T3)	3.245	3.097	3.16
Avg.	3.10	3.23	3.169

Table 10 Cost-benefit analysis.

Treatment	Avg FCR	Feed price (B/kg) (B/kg)	Live Wt. price culling	(%)
Control (T1)	3.206	6.34	20.32	10.52
T1+ vit. E (T2)	3.127	6.79	21.23	5.26
T1+ vit.E + vit.C (T3)	3.16	6.59	20.82	5.26

difference in fresh pork colour. Fresh pork colour was improved at 'a' value > 6 in T2 (2.63%) and in T3 (25.7%) compared with the control. Also drip loss percentage was improved 12% in T3 and 4.5% in T2. Both results should satisfy the butcher. In the one day retail display, the colour remains fresh, succulent and the flavour unimpaired. Furthermore, the higher level of vitamin E and C in diets did not influence meat pH value. For total income adding higher vitamins E and C gave positive results.

For general performance, females responsded better to high levels of vitamin E and C supplement in diets ($p < 0.05$) giving a higher ADG and thus FCR on the average.

Experience gained from this trial has made our staff aware of meat exposure to the air and made them more careful in measuring scale of drip loss and pH value. The suggestion is that the stability of muscle colour should be tested at several periods during freezing and also tested for rancidity. There was no different between 200 ppm vitamin E and 100 ppm vitamin E + 500 ppm vitamin C supplemented in diets. Supported by the fact that vitamin E and vitamin C act together to remove free radicals and recover vitamin E. (Allen and Hamilton, 1994). The act synergistically in a fashion such that vitamin E serve as the primary antioxidant and vitamin C reductively regenerates vitamin E (Chen and Chang, 1978 cited by Yen, 1984). And because vitamin C could be synthesized by the pig's body (Voet and Voet, 1990), it is suggested that the vitamin C level be reduced to around 200 ppm.

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