The Effect of EconomasE® as a Vitamin E Replacer on Performance, Meat Quality and Organ Weights of Broiler Birds

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ABSTRACT: This study was conducted to investigate the effect of supplementing EconomasE®(EcoE) as a vitamin E replacer on performance and meat quality of broilers. A total of 300 one-d-old male broilers were randomly assigned into 6 treatments. Each treatment comprised 5 replicates of 10 broilers each. Broilers were allocated to 1 of 6 diets and were fed for 42 d in a complete randomized design (CRD). The dietary treatments included four concentrations of EconomasE® (150 g, 200 g, 250 g and 300 g /ton) and a 100 IU vitamin E/kg level. The control group was fed with basal diet only. During 42-d growth period, all test diets increased the weight gain of broilers compared to the control ($p<0.05$). EcoE at 200g/ton (T3) diet fed birds had the highest weight gain (53.6 g/d) with the lowest feed conversion ratio (FCR) (1.71) ($p< 0.05$). Three birds from each replicate were sacrificed at the end of experiment to evaluate relative weights of organs and small intestine of broilers, water holding capacity (WHC), cooking loss, and sensory properties of broiler breast meat. The lowest cook loss (14.1%), highest water holding capacity (63.1%) and higher juiciness of breast meat were recorded from 200 g/ton EconomasE® fed birds ($p<0.05$). The higher relative weights of bursa, spleen, gizzard, duodenum and jejunum were recorded by EcoE fed broilers ($p<0.05$). In conclusion, dietary supplementation of EconomasE® has the same or better effects on performance, meat quality and organ weights of broilers compared with dietary supplementation of 100 IU vitamin E/kg.

Keywords: Broilers, EconomasE®, FCR, vitamin E, water holding capacity

INTRODUCTION

The success of broiler production which depends on maximum weight gain within minimum period is fulfilled by proper nutritional and management practices. In order to increase the growth performance of birds, various nutrients are to be incorporated in the diet.

Vitamin E (VE) is well known feed additive used for antioxidant properties (Halliwell and Gutteridge, 2000). It protects cells from the toxic effect of oxygen radicals and associated lipid peroxidation. One of the primary functions of VE is to maintain membrane integrity, which is done by preventing oxidation of polyunsaturated fatty acids (PUFA) in membrane phospholipids (Gropper *et al.*, 2009). Among α-, β-, γ- and δ-tocopherols, and α-, β-, γ- and δ-tocotrienols naturally occurring substances that have been found to display VE activity is α-tocopherol (α-T) which shows the highest antioxidant activity (Halliwell and Gutteridge,

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2000). Moreover, the beneficial effects of dietary VE on meat quality such as diminishing the lipid oxidation and off flavor development, increasing the concentration of vitamin E in meat, stabilizing the red colour of meat, reducing the drip losses and cook losses, improving the water holding capacity and increasing the shelf life of meat have been reported by many researchers (Buckley & Morrissey, 1992; Ahn *et al.*, 1998, Grau *et al.*, 2001; Ryu *et al.,* 2005).

However, synthetic antioxidants are scrutinized due to the usage at high doses and also due to potential carcinogenic and/or mutagenic effects (Kahl and Kaplus, 1993). In addition, the increase of prices of VE, which adds to the rising cost of raw materials and the potential environmental impact related to the manufacturing of VE also are reliable reasons to develop the demand for functional antioxidant in the feed industry (Feed Info News Service, 2008, 2009). Furthermore, VE is subjected to availability fluctuations with the time. Therefore, these factors ensure the necessity of research on cheaper but functionally equivalent product to replace VE to fulfill all the above requirements for the betterment of poultry industry.

Alltech Nutrigenomic Centre, USA has investigated a proprietary blend of nutritional mixture called EconomasE® to replace VE for poultry. It is a mixture of ingredients such as selenium yeast, brewer's dried yeast, dried sea weed meal, *Aspergillus niger* fermentation extracts, and ascorbic acid. Even though this particular feed additive is available in the market, the functionality of the EconomasE® is ambiguous among the stakeholders in Sri Lanka. The present study was designed to investigate the feasibility of using this ingredient mixture to maximize the performance and meat quality of broilers as well as the influence on organ weights of broilers in Sri Lanka.

Objectives of this investigation were to determine the best effective level of EconomasE® for local broilers and effect of EconomasE® as a VE replacer on the performance, meat quality and relative organs weights of broilers.

METHODOLOGY

Location

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Animals and Experimental Design

A total of 300 day-old male broiler chicks were randomly assigned into 6 treatments. Each treatment comprised of 5 replicates of 10 broiler chicks. Birds were allocated to 1 of 6 diets and were fed for 42 d in a complete randomized design (CRD). The dietary treatments included four concentrations of EconomasE® (150, 200, 250 and 300 g/ton) and a 100 IU VE/kg level. The control group was fed only with basal diet which consists of maize-soybean meal basal feed in mash form formulated to meet the nutrient requirements for broilers (NRC, 1994).The treatment groups are listed in Table 1.

Table1. Treatment groups of experiment

Treatment group	Description
T0	Basal diet (control)
T1	Basal diet+100 IU vitamin E/kg
T2	Basal diet+150 g EconomasE®/ton
T3	Basal diet+200 g EconomasE®/ton
T4	Basal diet+250 g EconomasE®/ton
T5	Basal diet+300 g EconomasE®/ton

Management of Birds

The birds were placed in floor pens (1.2 m × 0.9 m) in an open sided house under natural conditions with an average temperature of 28 °C and artificially lighting for 24 h during the first two weeks. Then, the similar conditions with 12 h light/12 h dark cycle (07:00-19:00) was provided. The birds had free access to ad-libitum feed and water. The feeding trial consisted of growing and finishing periods (0 to 21 d and 22 to 42 d, respectively). The composition of the experimental diet is presented in Tables 2 & 3. Average live weights of birds and pen feed consumption were measured weekly, and the feed conversion ratio (FCR) was determined. All the birds were vaccinated against infectious bursal disease at 7, 14 and 21 d by adding the vaccine in to drinking water.

Table 2. Composition of ingredients and calculated composition of broiler starter and finisher rations

Ingredients	Broiler starter (%)	Broiler finisher (%)
Maize	49.00	40.00
Rice polish	08.28	21.75
Fish meal	04.85	02.00
Soybean meal	27.70	19.00
Coconut poonac	05.00	10.00
Shell grit powder	01.08	02.00
Dicalcium phosphate	00.50	00.40
Lysine HCl	00.10	00.50
DL-Methionine	00.20	00.40
Coconut oil	02.00	03.40
Salt	00.25	00.25
Coccidiostat	00.02	00.00
Broiler Premix*	00.30	00.30
Total	100.00	100.00
Calculated composition (g/kg)		
ME (MJ/kg)	12.70	13.30
Lysine	12.90	11.20
Methionine	5.30	5.50
Methionine+ cystine	9.70	8.90
Available phosphorus	4.60	3.80

Table 3. Nutritional composition of starter and finisher rations used in the experiment

	Analyzed Composition (%)					
Starter ration	**DM**	**Ash**	**Fat**	**Protein**	**Crude fiber**	**Gross Energy (MJ/kg)**
Basal diet(T0)	92.47	16.88	3.73	26.79	3.89	17.32
Basal diet+100 IU vitamin E /kg(T1)	92.35	19.99	2.98	26.85	3.78	17.09
Basaldiet+150 g EconomasE®/ton (T2)	90.63	18.95	2.91	25.4	3.00	16.90
Basal diet+200 g EconomasE®/ton (T3)	92.63	19.75	3.11	25.43	3.04	17.39
Basal diet+250 g EconomasE®/ton (T4)	91.70	19.78	3.10	25.00	3.12	17.10
Basal diet+300 g EconomasE®/ton (T5)	90.66	19.80	3.08	25.33	3.04	17.76
Finisher ration	**DM**	**Ash**	**Fat**	**Protein**	**Crude fiber**	**Gross Energy (MJ/kg)**
Basal diet (T0)	91.71	12.29	6.68	21.09	3.69	18.76
Basal diet+100 IU vitamin E /kg (T1)	92.01	11.35	6.41	20.36	3.60	18.47
Basal diet+150g EconomasE®/ton (T2)	91.33	18.62	2.98	24.34	3.07	18.37
Basal diet+200g EconomasE®/ton (T3)	91.63	11.94	7.11	21.63	3.65	18.47
Basal diet+250g EconomasE®/ton (T4)	92.83	12.20	7.22	21.68	3.47	17.9
Basal diet+300g EconomasE®/ton (T5)	90.09	12.04	7.27	21.33	3.55	18.3

Sample Preparation

On day 7, 14, 21, 28, 35 and 42 of the experiment, the average body weight and feed intake per pen were recorded to calculate the average daily gain, average daily feed intake and the FCR. Mortality was recorded daily and adjusted the total number of birds in order to determine the total feed intake per bird. At 14 d, two birds from each replicate were randomly sacrificed by cervical dislocation, organ weights and weights of small intestine parts were measured. At 42 d, the chickens were fasted for 12 hours, three birds from each replicate were randomly selected for slaughter by cervical dislocation. Bowels were excised and weights and lengths of different organs and small intestine parts were measured. The breast part of each carcass was separated, skin was removed and divided in to two halves as left and right, and left half was further dissected in to splits for the analysis of cook loss % and water holding capacity (WHC) of broiler meat and the right halves were vacuum packaged in sterile polythene food bags and stored under frozen (-18 °C) condition for sensory evaluation. All the samples were stored under refrigerated (1-5 °C) or frozen condition (-18 °C) until further analysis.

Data Collection

Determination of Organs Weights and Small Intestine Segments

On 14 d (two birds from each replicate) and 42 d of the experiment the parts of digestive tract (proventriculus, gizzard, duodenum, jejunum, ileum, ceca) and associated organs (heart, liver, pancreas, spleen and bursa) were collected and weights were measured. The small intestine was divided into three segments, namely duodenum (from gizzard outlet to the end of the duodenal loop), jejunum (from the pancreatic loop to Meckel's diverticulum), and ileum (from Meckel's diverticulum to the caecal junction). Each segment was emptied by gentle pressure and the lengths and weights were recorded. Relative weights of organs were calculated according to the following formula.

$$Relative\ weight\ of\ organ = \frac{fresh\ organ\ weight}{live\ weight\ of\ bird} \times 100$$

Analysis of WHC of Breast Meat

The WHC was measured as described by AOAC (1995) using below given formula;

$$WHC\% = \left(\frac{(Weight\ of\ sample\ after\ centrifuging - Weight\ of\ sample\ after\ drying)}{Initial\ weight\ of\ sample}\right) \times 100$$

Analysis of Cook Loss of Breast Meat

The cook loss of breast meat was measured as described by Honikle (1998). The cooking loss is expressed as a percentage of the initial sample weight.

$$Cook\ loss\ \% = \left(\frac{Initial\ weight\ of\ meat\ sample - Weight\ of\ meat\ sample\ after\ cooking}{Initial\ weight\ of\ meat\ sample}\right) \times 100$$

Analysis of Sensory Qualities of Breast Meat

The breast muscles were thawed 24 h, wrapped in aluminum foil and cooked in electric oven until the tissue core temperature reached 85 °C. Thirty untrained panelists were used to evaluate the acceptability of chicken breast meat. At each session, panelists were presented with one sample from each treatment and requested to rate appearance, juiciness, odor, and chicken flavor intensity. The sensory analysis was done according to the Meilgaard *et al.* (1999). Samples from different treatments were offered to panelists one at a time and the panelists were requested to have unsalted crackers, and to rinse the mouth with water, and to pause for 20 seconds between samples to clear the palate. Five point hedonic scale was used to assess breast meat samples. Just-About Right (JAR) scale was used to assess the intensity of appearance (1-Extremly light, 2-Moderately light, 3-Niether light nor dark, 4-Moderately dark, 5-Extremly dark), the intensity of odor (1-Extremely weak, 2-Moderately weak, 3-Niether weak nor strong, 4-Moderately strong, 5-Extremly strong), the intensity of juiciness (1-Extremly dry, 2-Moderately dry, 3-Niether juicy nor dry, 4-Moderately juicy, 5-Extremely juicy), the intensity of flavor (1-Extremely weak, 2-Moderately weak, 3-Niether weak nor strong, 4-Moderately strong, 5-Extremly strong) and the overall acceptability (1-

Extremly like, 2-Moderately like, 3-Neither like nor dislike, 4-Moderately dislike, 5-Extremely dislike) of broiler breast meat. Sample order was randomized to account for sampling order bias.

Statistical Analysis

Data were analyzed using the General Linear Model (GLM) of ANOVA procedure of SAS software (SAS Institute, 2002) considering replicates as experimental units for completely randomized design (CRD). Statistical significance of differences among treatments was assessed using Duncan's multiple range test (Duncan, 1955). A probability level of $P<0.05$ was used to determine statistical significance of differences among the dietary treatments.

RESULTS AND DISCUSSION

Performances and Meat Quality of Broiler Birds

The birds fed with EconomasE® at 200 g/ton had the highest overall daily weight gain with the lowest overall FCR value ($p<0.05$). Although, all the experimental diets were formulated according to the NRC (1994) recommendations, weight gain and FCR in birds fed on diets containing EconomasE® were superior to those fed with the basal diet (Table 4).

The difference of daily weight gain between the best treatment and the control was 28% and it may be due to the effect of Sel-plex included in EconomasE® and the contribution of dried yeast for the muscle development of broilers. Feed to gain ratio improved by 20% over the basal diet by the best level of EconomasE® (200 g EcoE/ton) which agrees with the findings of Ignacio (1995) and Onifade *et al.* (1998) who revealed that feeding yeast to chicks improved body weight (BW) gain and feed/gain ratio.

Table 4. Effect of EconomasE® and Vitamin E in diet on performance and meat quality of broilers (Mean ± SE)

Treatment	Weight gain (g/day)	Feed intake (g/day)	FCR	Cook loss (%)	WHC (%)
T0	$41.88^{d}\pm2.8$	$93.78^{bc}\pm8.9$	$2.15^{a}\pm0.2$	$19.1^{a}\pm0.9$	$54^{d}\pm1.3$
T1	$43.79^{d}\pm2.9$	$93.94^{bc}\pm8.8$	$2.06^{a}\pm0.1$	$20.1^{a}\pm0.8$	$57^{cd}\pm0.4$
T2	$50.18^{b}\pm3.4$	$99.17^{a}\pm8.5$	$1.90^{b}\pm0.1$	$14.9^{b}\pm0.5$	$61^{a}\pm0.8$
T3	$53.65^{a}\pm3.7$	$96.40^{ab}\pm8.3$	$1.71^{c}\pm0.05$	$14.1^{b}\pm0.3$	$63^{a}\pm0.3$
T4	$47.76^{c}\pm3.3$	$93.67^{bc}\pm8.4$	$1.90^{b}\pm0.1$	$18.4^{a}\pm0.4$	$60^{ab}\pm1.4$
T5	$46.13^{c}\pm3.1$	$91.34^{c}\pm7.8$	$1.92^{b}\pm0.1$	$18.7^{a}\pm0.4$	$57^{bc}\pm1$
CV	8.54	9.28	13.20	10.16	4.40
p-value	<0.0001	<0.0001	<0.0001	0.0009	0.0002

*Means within the same column with different superscripts differ significantly ($p<0.05$)

The present study revealed that increasing the selenium content in the diet in the form of EconomasE® has improved the FCR of broilers. This improvement is a result of reduction of feed intake in EconomasE® treatments. Choct *et al.* (2004) explained that organic selenium supplementation improves feather scores due to the role of selenocysteine in feather formation. Whereas, Arthur (1992) demonstrated that selenium enhances the metabolism of thyroid hormones, which are important for normal growth and development. Therefore, feather coverage of birds observed in the present study would have helped to reduce the maintenance energy requirement of birds as in turn reserved more energy for meat production. The thyroid hormone activation was increased by organic selenium availability in the diet consisted with EconomasE®, and lead to improve feed conversion efficiency at the same time and combination of those factors might have contributed to improve the meat yield in EconomasE® treated birds.

In the present study, the lowest cook loss (26%) and the highest water holding capacity (14% improvement) of broiler breast meat were exhibited by 200 g/ton of EconomasE® supplemented group (T3) compared to the control group ($p<0.05$) (Table 5). These results indicated that the mixture of antioxidants (Selenomethionine and ascorbic acid) in EconomasE® supplementation of broiler diets have being able to decrease the cook loss of breast meat ($p<0.05$). This is in agreement with the findings of Kohrle *et al.* (2000), who explained that organic selenium, as a part of selenoenzyme (cytosolic GPx) which works as an antioxidant maintained antioxidant defenses, and thereby prevent damages to tissues and prevent cook loss of muscle tissues. According to the explanation of Kohrle *et al.* (2000) GSH-Px activity in EconomasE® treated breast muscle was enhanced by organic selenium incorporated EconomasE® and H_2O_2, and organic peroxides were reduced to water and corresponding alcohols by preventing the production of reactive oxygen radicals. Thereby, breast muscle membrane integrity was improved at the EconomasE® treated birds. Incidentally, cook loss power has been reduced and the ability of water holding capacity of breast muscle has been improved.

Sensory Qualities of Broiler Breast Meat

Breast meat sample treated with VE was moderately darker in appearance when oven cooked than the control and EconomasE® treated samples ($P<0.05$). The breast meat of the EconomasE® treated birds showed better juiciness than that of the shown the control and VE groups after one month of storage period ($P<0.05$). Cole (2000), explained that selenium supplement in diet improved meat juiciness and softness, reduces the content of fat and water loss and odour. Similarly, Choct *et al.* (2004) confirmed that organic selenium reduces water loss in meat.

The lowest cook loss and the highest water holding capacity may be reason for showing the high juiciness of EconomasE® treated samples in the present study. According to Lyon *et al.* (2004), juiciness is an important contributor for eating quality of meat and also responsible for the relationship between juiciness and physical and chemical properties of meat. There were no differences observed among treatments in breast meat odor ($P>0.05$). Whereas, flavor of the breast meat was changed but not according to the treatment difference ($P>0.05$). The moderately strong meat flavor development was observed in VE and the highest level of EconomasE® treated breast meat samples compared to other treatments ($P<0.05$). There were no differences among the treatments in breast meat for overall acceptability ($P>0.05$). Miezeliene *et al.* (2011) and Hussain *et al.* (2012) also reported that the odor, flavor and acceptability of chicken breast meat did not change with the Se sources, levels, and storage period, but showed a significant influence on juiciness during the 12 days of storage.

As a result of the involvement of selenium in membrane integrity and cell viability, the supplementation of organic selenium (selenium yeast) incorporated EconomasE® might have improved meat quality and shelf life by reducing drip loss and improving juiciness of broiler breast meat.

Table 5. Effect of EconomasE® and Vitamin E in diet on broiler breast meat sensory qualities (Mean ± SE)

Treatments	Appearance	Odor	Juiciness	Flavor	Overall acceptability
T0	$3.07^{b}\pm0.15$	$3.10^{a}\pm0.20$	$2.40^{c}\pm0.20$	$2.80^{ab}\pm0.20$	$2.83^{a}\pm0.16$
T1	$3.73^{a}\pm0.19$	$2.70^{a}\pm0.30$	$2.68^{c}\pm0.20$	$3.30^{a}\pm0.20$	$2.77^{a}\pm0.17$
T2	$3.33^{ab}\pm0.15$	$2.40^{a}\pm0.20$	$2.87^{bc}\pm0.20$	$2.83^{ab}\pm0.20$	$2.93^{a}\pm0.15$
T3	$3.23^{b}\pm0.16$	$2.90^{a}\pm0.20$	$3.23^{b}\pm0.20$	$2.57^{b}\pm0.20$	$3.17^{a}\pm0.18$
T4	$3.47^{ab}\pm0.12$	$2.87^{a}\pm0.20$	$4.17^{a}\pm0.20$	$2.58^{b}\pm0.20$	$3.19^{a}\pm0.18$
T5	$3.30^{ab}\pm0.17$	$2.94^{a}\pm0.20$	$4.10^{a}\pm0.10$	$3.45^{a}\pm0.20$	$2.84^{a}\pm0.19$
CV	26	40	27	38	32
p-value	0.079	0.52	<0.0001	0.01	0.4

Means within the same column with different superscripts differ significantly (p<0.05)

Relative Weights of Organs at Day 14 and Day 42 of Broiler Birds

The relative weights of spleen, bursa and caeca of broilers at 14 d were increased by the dietary treatments of EconomasE® and VE (p<0.05) at 14 d (Table 6). The relative weights of proventriculus, gizzard, pancrease, liver, heart were not affected by the EconomasE® and VE treatments (p>0.05) at 14 d of broiler birds.

Table 6. Effect of EconomasE® and Vitamin E in diet on organ weights of broiler birds at day 14 (Mean ± SE)

Treatment	Proven-triculus (g/kg BW)	Gizzard (g/kg BW)	Pancreas (g/kg BW)	Liver (g/kg BW)	Heart (g/kg BW)	Spleen (g/kg BW)	Bursa (g/kg BW)	Caeca (g/kg BW)
T0	$1.2^{a}\pm0.5$	$22.4^{a}\pm1.3$	$4.5^{ab}\pm0.2$	$26.7^{a}\pm0.8$	$6.14^{a}\pm0.2$	$0.77^{c}\pm0.07$	$2.1^{c}\pm0.3$	$7.8^{b}\pm0.8$
T1	$0.6^{abc}\pm0.1$	$25^{a}\pm0.8$	$4.1^{b}\pm0.1$	$25.5^{a}\pm0.8$	$6.3^{a}\pm0.1$	$0.93^{b}\pm0.06$	$2.2^{c}\pm0.2$	$8.4^{a}\pm0.5$
T2	$0.61^{abc}\pm0.1$	$24.5^{a}\pm1$	$3.8^{a}\pm0.2$	$24.8^{a}\pm1$	$6.4^{a}\pm0.2$	$0.83^{b}\pm0.04$	$2.3^{c}\pm0.1$	$9.1^{a}\pm0.6$
T3	$0.6^{abc}\pm0.1$	$23.1^{a}\pm0.7$	$3.8^{b}\pm0.2$	$26.7^{a}\pm1.5$	$5.5^{b}\pm0.2$	$1.51^{a}\pm0.6$	$2.8^{ab}\pm0.2$	$8.3^{a}\pm0.4$
T4	$0.54^{c}\pm0.1$	$24.9^{a}\pm0.1$	$4^{ab}\pm0.2$	$26.3^{a}\pm1$	$5.9^{ab}\pm0.2$	$1.15^{a}\pm0.1$	$2.6^{b}\pm0.1$	$8.1^{a}\pm0.7$
T5	$0.6^{abc}\pm0.2$	$24.7^{a}\pm0.1$	$4.1^{a}\pm0.2$	$26.8^{a}\pm0.9$	$6.1^{a}\pm0.2$	$1.19^{a}\pm0.1$	$3.1^{a}\pm0.2$	$8.2^{a}\pm0.5$

Means within the same column with different superscripts differ significantly (p<0.05)

Gizzard, spleen and bursa relative weights were improved at 42 d of birds which treated with EconomasE® diet and the proventriculus, pancreas, liver, heart and caeca were not affected by the dietary treatments (p< 0.05) (Table 7). Hetland and Svihus, (2001) and Hetland *et al.* (2003) reported that a heavier and more muscular gizzard could be related to closely with better utilization of nutrients. Nevertheless, well developed gut is essential for poultry to perform better (Ao and Choct, 2006). Hence, increased relative weight of gizzard in EconomasE® treated birds may attribute to increased nutrient digestion and utilization at the highest level of EconomasE® treated over the birds fed on basal diet.

Increased relative weight of bursa and spleen from EconomasE® treated birds may be due to the enhanced lymphocyte concentration in bursa and spleen with the increased selenium yeast incorporated EconomasE® (Swain, 1996).

Table 7. Effect of EconomasE® and Vitamin E in diet on organ weights of broiler birds at day 42 (Mean ± SE)

Treatment	Proven-triculus (g/kg BW)	Gizzard (g/kg BW)	Pancrease (g/kg BW)	Liver (g/kg BW)	Heart (g/kg BW)	Spleen (g/kg BW)	Bursa (g/kg BW)	Caeca (g/kg BW)
T0	$4.0^{a}\pm0.02$	$1.33^{c}\pm0.04$	$1.95^{a}\pm0.01$	$16.8^{ab}\pm0.04$	$4.0^{b}\pm0.02$	$1.1^{c}\pm0.01$	$2.5^{b}\pm0.01$	$4.3^{b}\pm0.02$
T1	$3.7^{a}\pm0.02$	$1.40^{bc}\pm0.05$	$2.1^{a}\pm0.01$	$16.7^{a\pm}0.04$	$4.3^{ab}\pm0.02$	$1.1^{bc}\pm0.01$	$2.5^{b}\pm0.01$	$5.4^{a}\pm0.03$
T2	$3.8^{a}\pm0.01$	$1.45^{ab}\pm0.05$	$1.9^{a}\pm0.01$	$15.6^{c}\pm0.03$	$3.8^{b}\pm0.01$	$1.0^{ab}\pm0.005$	$2.7^{a}\pm0.01$	$5.3^{a}\pm0.06$
T3	$4.0^{a}\pm0.02$	$1.43^{ab}\pm0.04$	$1.9^{a}\pm0.01$	$16.1^{abc}\pm0.03$	$4.1^{a}\pm0.01$	$1.2^{a}\pm0.01$	$2.8^{a}\pm0.01$	$4.4^{b}\pm0.02$
T4	$3.8^{a}\pm0.01$	$1.51^{a}\pm0.06$	$2.1^{a}\pm0.01$	$16.6^{abc}\pm0.03$	$4.2^{a}\pm0.01$	$1.1^{ab}\pm0.01$	$2.7^{a}\pm0.01$	$4.8^{a}\pm0.03$
T5	$4.0^{a}\pm0.02$	$1.52^{a}\pm0.03$	$2.0^{a}\pm0.01$	$16.4^{abc}\pm0.04$	$4.1^{a}\pm0.01$	$1.0^{ab}\pm0.01$	$2.7^{a}\pm0.01$	$4.2^{b}\pm0.02$

Means within the same column with different superscripts differ significantly ($p<0.05$)

The relative weights of duodenum and jejunum were increased at the EconomasE® treated birds over the control ($p<0.05$) at 14 d, and the relative lengths of all three regions were not affected by the dietary treatments (Table 8). The relative weights of duodenum, jejunum and ileum and ileum relative lengths of birds treated with EconomasE® and VE were increased ($p<0.05$) at 42 d (Table 9). According to the results, EconomasE® treated birds may have enhanced the digestibility and absorptive capacity by increasing the available mucosal tissues such as number of villi at the duodenum jejunum and ileum, and thereby improving the weight gain and FCR of birds compared to the birds fed only with basal diet.

Table 8. Effect of EconomasE® and Vitamin E in diet on segments of small intestinal weight and length of broiler birds at day 14 (Mean ± SE)

Treatment	Duodenum wt (g/kg BW)	Duodenum length (cm/kg BW)	Jejunum wt (g/kg BW)	Jejunum length (cm/kg BW)	Ileum wt (g/kg BW)	Ileum length (cm/kg BW)
T0	$8.17^{c}\pm0.3$	$48.17^{b}\pm1.2$	$12.31^{c}\pm0.6$	$121.6^{b}\pm3.5$	$8.6^{a}\pm0.5$	$74.6^{a}\pm3.2$
T1	$8.22^{b}\pm0.5$	$52.06^{a}\pm1$	$12.94^{c}\pm0.5$	$124.7^{a}\pm3.3$	$7.6^{b}\pm0.3$	$77.7^{a}\pm1.5$
T2	$8.67^{b}\pm0.5$	$45.68^{b}\pm1$	$14.77^{a}\pm0.5$	$111.2^{c}\pm2.8$	$8.9^{a}\pm0.3$	$63.2^{c}\pm6.5$
T3	$8.22^{b}\pm0.4$	$48.30^{b}\pm0.8$	$14.82^{a}\pm0.4$	$125.5^{a}\pm5.1$	$8.4^{ab}\pm0.3$	$71.4^{b}\pm3.3$
T4	$8.67^{b}\pm0.2$	$44.33^{c}\pm1$	$14.40^{b}\pm0.8$	$120.8^{ab}\pm5.5$	$10.3^{a}\pm0.8$	$68.2^{bc}\pm3.8$
T5	$10.17^{a}\pm0.4$	$46.08^{b}\pm1.2$	$15.60^{a}\pm0.4$	$111.0^{c}\pm2.8$	$9.0^{a}\pm0.4$	$61.6^{c}\pm3.8$

Means within the same column with different superscripts differ significantly ($p<0.05$)

Table 9. Effect of EconomasE® and Vitamin E in diet on segments of small intestinal weight and length of broiler birds at day 42 (Mean ± SE)

Treatment	Duodenum wt (g/kg BW)	Duodenum length (cm/kg BW)	Jejunum wt (g/kg BW)	Jejunum length (cm /kg BW)	Ileum wt (g/kg BW)	Ileum length (cm /kg BW)
T0	$4.2^{c}\pm0.02$	$16.6^{c}\pm0.06$	$10.1^{b}\pm0.05$	$38.2^{c}\pm0.01$	$5.8^{b}\pm0.03$	$38.1^{c}\pm0.07$
T1	$4.6^{bc}\pm0.02$	$17.3^{a}\pm0.06$	$10.8^{ab}\pm0.03$	$39.2^{b}\pm0.01$	$5.7^{b}\pm0.03$	$39^{ab}\pm0.05$
T2	$4.7^{ab}\pm0.03$	$15.6^{ab}c\pm0.03$	$10.7^{a}\pm0.04$	$35.4^{bc}\pm0.01$	$6.0^{a}\pm0.03$	$36.7^{b}\pm0.05$
T3	$5.1^{a}\pm0.02$	$16.4^{ab}\pm0.03$	$11.1^{a}\pm0.05$	$40.6^{a}\pm0.01$	$6.2^{a}\pm0.03$	$37.8^{ab}\pm0.05$
T4	$5.1^{a}\pm0.02$	$16.6^{bc}\pm0.04$	$11.4^{a}\pm0.04$	$35.3^{bc}\pm0.01$	$6.4^{a}\pm0.03$	$39.7^{a}\pm0.06$
T5	$4.7^{ab}\pm0.01$	$15.8^{c}\pm0.06$	$11^{ab}\pm0.08$	$34.8^{c}\pm0.02$	$6.6^{a}\pm0.02$	$38.6^{ab}\pm0.04$

Means within the same column with different superscripts differ significantly ($p<0.05$)

Sklan and Noy (2003) elucidated that development of gastrointestinal tract and nutrient utilization are intricately related as well as hydrolysis of macromolecules in the small intestine is achieved, to a large extent by pancreatic enzyme activities, which are correlated with body weight and intestinal weight. With respect to the nutritional alterations some of morphological changes that may be happened in the mucosa such as modification of villus height, villus width, crypt depth and thickness of muscularis mucosae at the small intestine.

Smith *et al*., (1990) agreed to Choct (2009) in elaborating the proper and rapid weight gain of chickens and food utilization are directly related to the nutrition and the morpho functional integrity of the digestive system, especially in the small intestine where part of the digestive process and absorption of nutrients occur in enterocytes. In the present study the relative weights of the duodenum, jejunum and ileum of broiler birds at 42 d treated with EconomasE® were increased over the control group. This may be due to the increased cellular hyperplasia, hypertrophy or a combination of the two processes (Morisset, 1993) with the presence of EconomasE®. This is accomplished mainly by an increase in cell size such as increment of villus height and width, as indicated by the protein: DNA ratio (Iji *et al*., 2001).

CONCLUSIONS

The dietary supplementation of EconomasE® had the similar or better effects on performance, meat quality and organ weights of broilers compared to the dietary supplementation of 100 IU VE /kg. The maximum weight gain, the lowest FCR, the lowest cook loss and higher water holding capacity of breast meat were recorded at 200 g/ton of EconomasE®. Increased level of EconomasE® can be added to the broiler diet to enhance the overall performance and meat quality of local broilers. As vitamin E replacer EconomasE® augmented the gut associated immune organ weights such as bursa and spleen and weights of small intestine segments.

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