Elly Tugiyanti et al./Animal Production. 17(2):114-122, May 2015
Accredited by DGHE No. 81/DIKTI/Kep./2011. ISSN 1411-2027

# Supplementation of vitamin E and C in Feed on Color, Cooking Loss and Tenderness of Muscovy duck Meat Stored in Room Temperature, Refrigerator and Freezer

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**Abtract.** Research has been conducted to determine the effectiveness of antioxidant supplementation of vitamin E and C in feed on color, cooking loss and tenderness of the Muscovy duck meat stored at room temperature, refrigerator and freezer. Eighty-four male Muscovy duck aged 9 weeks were maintained for 5 weeks and allocated into 7 treatments with 4 replications each with 3 ducks. Completely Randomized Design was applied, in the which treatments were vitamin E and vitamin C supplementation to basal feed containing 21% protein and 3100 kcal/kg, metabolic energy into seven groups namely E0C0: basal feed without Vit E and Vit C, E400: basal feed plus 400 IU of vitamin E, E600: basal feed plus 600 IU vitamin E, C400: basal feed plus 400 mg/kg feed vitamin C, C600: basal feed plus 600 mg/kg feed vitamin C, E200C200: basal feed plus 200 IU vitamin E and 200 mg/kg feed vitamin C, and E300C300: basal feed plus 300 IU of vitamin E and 300 mg/kg feed of vitamin C. The parameters measured were the color of meat that consisted of L* (lightness), a* (Redness) and b* (yellowness), cooking loss and tenderness of Muscovy duck meat that stored at room temperature, refrigerator and freezer. The data obtained and the analysis of variance followed honestly significant difference test. Muscovy duck meat that stored at room temperature for 3 days resulted levels of brightness (L*) did not differ with meat stored in a freezer for 3 days, but different highly significant effect on meat stored at room temperature for 3 hours, 6 hours and stored in the refrigerator 3 day. Supplementation of vitamin E and C and their combination had highly significant effect on redness (a*) meat value which stored in different storage condition. b* value of Muscovy duck meat untreated (E0C0) progressively decreases. Analysis of variance showed that the Effect of vitamin E, C supplementation and their combination in feed significantly affected the cooking loss Muscovy duckmeat stored at room temperature (0, 3 and 6 hours) but not significantly affected the cooking loss Muscovy duck meat stored 3 days at room temperature, refrigerator and freezer. Supplementation of vitamin E, C and the combination had significant effect on tenderness of meat Muscovy duck stored at room temperature for 3 hours and in the freezer for 3 days, but not significantly different from that stored at room temperature for 6 hours and and in refrigerator for 3 days. Increasing storage time would decrease the value of brightness and tenderness but increased redness value and cooking loss. Muscovy duck meat fed with supplemented vitamin E, C or the combination combination of vitamins E and C if stored at room temperature or refrigerator up to 3 days still had high value of L* and a* but low b*. The highest redness value was in Muscovy duck meat supplemented with 400 mg/kg vitamin C, and the highest tenderness was in Muscovy duck meat supplemented with vitamin E 400 IU.

**Key words**: antioxidants, meat color, vitamin E, ascorbic acid, muscovy duck

**Abstrak.** Penelitian dilakukan untuk menentukan efektivitas suplementasi antioksidan vitamin E dan C dan kombinasinya dalam pakan terhadap kualitas daging entok yang disimpan pada suhu kamar, kulkas dan freezer. Delapan puluh empat ekor entok jantan berumur 9 minggu dipelihara selama 5 minggu. Terdapat 7 perlakuan dengan 4 ulangan dan setiap ulangan terdiri dari 3 ekor entok. Rancangan yang digunakan adalah Rancangan Acak Lengkap, dengan perlakuan suplementasi vitamin E dan vitamin C ke dalam pakan basal yang mengandung protein 21% dan energl metabolik 3100 kcal/kg yang terdiri 7 yaitu E0C0: pakan basal tanpa diberi vit E and vit C, E400: pakan basal + 400 IU vitamin E, E600: pakan basal +600 IU vitamin E,C400: pakan basal + 400 mg/kg feed vitamin C, C600: pakan basal + 600 mg/kg feed vitamin C sebanyak, E200C200: pakan basal + 200 IU vitamin E and 200 mg/kg feed vitamin C, and E300C300: pakan basal + 300 IU vitamin E and 300 mg/kg feed vitamin C. Parameter yang diukur adalah warna daging yang mencakup nilai L* (kecerahan), a* (kemerahan) dan b* (kekuningan), susut masak dan keempukan daging entok yang disimpan pada suhu kamar, kulkas dan freezer. Data yang diperoleh dianalisis variansi dan dilanjutkan dengan uji beda nyata jujur. Analisis varians menunjukkan bahwa daging entok yang disimpan pada suhu kamar selama 3 hari menghasilkan nilai L* tidak berbeda dengan daging yang disimpan dalam freezer selama 3 hari, tetapi berbeda sangat nyata dengan

daging yang disimpan pada suhu kamar selama 3 jam, 6 jam dan disimpan dalam lemari es 3 hari. Suplementasi vitamin E, C dan kombinasinya memiliki pengaruh yang sangat signifikan pada nilai a* daging yang disimpan dengan cara yang berbeda. Nilai b* daging entok E0C0 semakin menurun. Pengaruh suplementasi vitamin E, C dan kombinasinya dalam pakan berpengaruh sangat nyata terhadap susut masak daging entok yang disimpan pada suhu kamar tetapi berpengaruh tidak nyata terhadap susut masak daging entok yang disimpan 3 hari pada suhu kamar, kulkas dan freezer, keempukan daging bebek Muscovy disimpan pada suhu kamar selama 3 jam dan disimpan dalam freezer selama 3 hari. Akan tetapi tidak berbeda nyata terhadap daging entok yang disimpan pada suhu kamar selama 6 jam, 3 hari, dan pada kulkas selama 3 hari. Semakin lama daging disimpan nilai L* dan nilai a* semakin menurun namun meningkatkan susut masak. Daging entok yang pakannya disuplementasi dengan vitamin E, C serta kombinasinya jika disimpan pada suhu kamar atau lemari es selama 3 hari mempunyai nilai L* dan a* yang masih tinggi, tetapi nilai b* yang rendah. Nilai a* tertinggi dicapai oleh daging entok yang disuplementasi vitamin C 400 mg/kg, dan keempukan daging tertinggi dicapai oleh daging entok yang disuplementasi dengan vitamin E 400 IU dalam pakannya.

**Kata kunci**: antioksidan, warna daging, vitamin E, asam askorbat, entok

## Introduction

To date, the dominant source of poultry meat is broiler meat. Efforts to support the requirement of the national meat need to be developed others meat sources including Muscovy duck. Muscovy duck meat has standar quality including physical quality, color, texture and flavor.

Color and consistency are important consumer's concern in choosing poultry products, therefore the factors that can negatively affect the quality attributes are important to note (Qiao et al., 2002). Efforts to maintain the quality of wild duck meat require appropriate post-harvest handling, so as to extend the duration of storage of the meat. The duration of storage of meat is influenced by several factors, among others, the handling before and after slaughter. In general, people buying meat not procesed immediately so that in advance needs to be stored. The process of degradation can be seen from the discoloration of meat, whereas consumers do not want the meat color that deviates from the color of fresh meat. Consumers found the duck meat color is one of the attributes that can be used as an indicator whether or not the meat is fresh (Adiyoga et al., 2012). Meat color can be influenced by environmental condition, such as feed, housing conditions and storage time (Du and Ahn, 2002). Lightness (L*) of breast muscle could be used in the technological evaluation of meat with the standardized threshold value L*, to detect pre-slaughter or processing effects, with a good reliability with different genetic strains (Abeni and Bergoglio, 2001). Ali et al. (2007) stated that the color of duck meat has very high value redness, but very low lightness or brightness. Color has psychological response, economical value and consumer preferability toward food product. Meat color is determined by the level and status of myoglobin pigment (Mancini and Hunt, 2005). Lightness (L*) chest muscle meat can be used in the evaluation of the standard threshold value L* shortly after slaughter and after stored at different storage temperatures (Abeni and Bergoglio, 2001). According to Baggio and Bragagnolo (2006), for the storage of meat can undergo oxidation which triggered the presence of heat, light, metal and oxygen produce ROS are toxic and are responsible for tissue damage due to lipid peroxidation.

Cooling at refrigerator temperature (refrigerator) is the most simple and commonly used way to preserve and extend the shelf life of chicken meat (Pestariati et al., 2003). Treatment of storage time showed changes into a reddish white color, aroma becomes tend to rot and have a mushy texture, but the meat is stored in a refrigerator has a fresh bright yellow

color, with a distinctive aroma and a chewy texture (Love et al., 2012). To inhibit such damage, the necessary substances that can prevent or slow the oxidation is an antioxidant. At the beginning of the reaction, vitamin E will capture and neutralize free radicals, but by the reaction of vitamin E and then turned into a vitamin E radical that needs to be neutralized. Vitamin C binds the vitamin E radical, turning it into a vitamin E-free that can function again as an antioxidant. With a different mechanism is, if both of these vitamins are used in conjunction expected to be more effective in inhibiting the activity of free radicals (Sulityowati, 2006).

## Materials and Method

The materials used were 84 nine-week-old male Muscovy ducks weighing 850-1100 g, kept in 28 litter cage compartments each containing three ducks. Muscovy ducks were reared for five weeks and given basal feed containing 21% protein, 3100 kcal/kg feed metabolic energy (30% corn, soy bean meal 7%, 38.20% of poultry meat meal, 6:10% oil, L-lysine 0:10% HCl, 0:30% DL-methionin, topmix 0:20%, 0:10% NaCl and 1% CaCO3), powdered vitamin E (d-α-tokoferolasetat) and vitamin C (L-ascorbic acid). Ducks were New Castle Disesase (NCD) vaccinated in the first week. Drinking water was supplied ad libitum and feed was administered twice a day in the morning and afternoon. At 14 weeks old, two ducks were taken from each compartment and slaughtered to take the meat colour. Futhermore, Muscovy duck meat was observed meat color, cooking loss and tenderness stored at room temperature, in refrigerator and freezer for 3 days.

The treatments were vitamin E and vitamin C supplementation to basal feed containing 21% protein and 3100 kcal/kg and metabolic energy into seven groups namely E0C0: basal feed without Vit E and Vit C, E400: basal feed plus 400 IU of vitamin E, E600: basal feed plus 600 IU of vitamin E, C400: basal feed plus 400 mg/kg feed vitamin C, C600: basal feed plus 600 mg/kg feed vitamin C, E200C200: basal feed plus 200 IU vitamin E and 200 mg/kg feed vitamin C, and E300C300: basal feed plus 300 IU of vitamin E and 300 mg/kg feed vitamin C. Each treatment was replicated four times.

The parameters measured were the color value of L*, a*, b*; cooking loss and tenderness of Muscovy duck meat stored for 3 hours, 6 hours, 3 days in room temperature, 3days in refrigerator or and 3 days in freezer. Data were subject to Completely Randomized Design, followed by Honestly Significant Difference Test. Quantitative testing of the brightness or color of the meat was done by chromatographic analysis. The color parameters (L*, a*, b*) were measured using MINOLTA Chroma Meter CR-300, following the CIELAB color system. The CIELAB color system was used considering the L* (lightness), a* (Redness) and b* (yellowness) colorimetric coordinates as follows: (1) L* (value 100 corresponded to absolute white, value - absolute black); (2) a* (a+ corresponded to the red spectrum, a-corresponded to the green spectrum); (3) b* (b+ corresponded to the yellow spectrum, b- corresponded to the blue spectrum). Flesh color analysis done by the sample in the beaker glass to put on the whole basis of the glass beaker covered by material.

Analysis of cooking loss used method by Soeparno (2005) that the meat was cut the same size and cutting samples was conducted in such a way towards the muscle becomes parallel to the long axis and weighed. Samples weighing 20 grams incorporated into polyethylene plastic bags that have been labeled. Then meat sample was cooked at 80°C for 30 minutes, removed then thoroughly soaked in a container filled with 10°C cold water for 15 minutes. Meat sample was then removed from the pocket and dried with a paper towel without suppression and re-weighing ensued.

The percentage of cooking loss was = $\frac{\text{weight before cooking - weight after cooking}}{\text{weight before cooking}} \times 100\%$

Tenderness analysis followed Warner-Bratzler (Bouton and Harris, 1972 in Soeparno, 2005) where meat sample was cut 0.67 cm thick and 1.5 cm wide perpendicular to muscle fibers. The meat was cooked first at 80°C for 30 minutes then cooled to room temperature and then cooled at a 0°C. Then the measured value of power broke Warner-Bratzler. The unit is kg/cm2.

## Results and Discussion

**Meat Colour**

Muscovy duck meat without vitamin E and C (E0C0) supplement in feed had a high brightness level up to 6 hours after cut. Meat that was not processed immediately should be stored in the refrigerator up to 3 days. Meat stored at room temperature for more than 6 h dark meat will return as well if stored in a freezer for 3 days. This was demonstrated by meat stored at room temperature for 3 days had levels of brightness (L*) not different (P> 0.05) from that stored in a freezer for 3 days, but significantly different (P<0.01) from meat stored at room temperature for 3 hours, 6 hours and in the refrigerator 3 days (Table 1). It suggested that Muscovy duck meat 0 hours during rigormotis still have dark flesh, then if stored at room temperature for up to 6 hours the myoglobin will react with oxygen to turn the flesh becomes oxymioglobin and brighter. After 6 hour storage, the brightness began to decline. Meat started to break down and oxidized, dry and black, because the status of myoglobin turned into metmyoglobin. The brightness of meat stored in a freezer for 3 days was low because of decreasing water holding capacity. Water holding capacity of muscle tissue affected meat contraction during storage. Lower water holding capacity of meat caused the amount of fluid lost, so the dark meat. This was in accordance with t Petracci and Fletcher (2002), Honikel (1998) and Ismed et al. (2013) that duck meat color is darker than chicken and turkey meat. During storage, meat color changes due to the processe of oxygenation and oxidation of myoglobin and its intensity depends on the physicochemical and mineral content of meat. Asmara et al. (2006) and Love et al. (2012) stated that the value of meat brightness changes in a longer storage, in which the intensity of meat color turned darker. Meat brightness level of Muscovy duck fed with supplemented vitamin E did not differ (P>0.05) from non-supplemented, while that of Muscovy duck given vitamin C or combined vitamin E and C in feed had high level of brightness up to 3 days stored at either room temperature or refrigerator. It suggested that vitamin C or the combined vitamin E and C prevented or stopped the process of fat oxidation in meat. Muscovy duck meat without vitamin E and C supplement in feed (E0C0) stored at room temperature for 3 hours had the lowest value of L* compared to supplemented vitamin E and C treatment. It suggested that vitamin E and C function as antioxidant that can prevent the oxidation processes for meat to experience rigormortis. Skrabka-Błotnicka et al. (2002) reported Muscovy ducks breasts meat had low valued of L* (42.27) because the myoglobin content of 8 and 14 week old Muscovy duck was at 3,26 mg / g (Alexieva et al., 1998) and 9 , 07 ± 0.57 mg/g (Tugiyanti et al., 2014), respectively.

Table 2 showed that supplementation of vitamin E and C and their combination had highly significant effect (P<0.01) on redness (a*) meat value stored in different storage condition. Muscovy duck meat fed with vitamin E and C supplement and stored in various storage had more intense reddish color than that without supplement. Muscovy duck meat

Table 1. L* value (lightning) of Muscovy duck meat that stored on room temperature, refrigerator, and freezer

| Treatment | Room Temperature | | | Refrigerator | Freezer |
|---|---|---|---|---|---|
| | 3 hours | 6 hours | 3 days | 3 days | 3 days |
| EoCo | 34.69±2.00$^{b}$ | 36.68±2.19$^{b}$ | 19.64±2.52$^{a}$ | 27.23±1.96$^{b}$ | 25.29±0.52$^{a}$ |
| E 400 | 42.64±10.32$^{c}$ | 45.58±5.65$^{c}$ | 24.65±4.47$^{a}$ | 27.88±1.06$^{ab}$ | 34.69±0.33b$^{c}$ |
| E 600 | 43.78±3.88$^{b}$ | 47.56±3.14$^{b}$ | 28.68±2.92$^{a}$ | 34.01±1.49$^{a}$ | 33.30±0.65$^{a}$ |
| C400 | 46.27±3.59$^{b}$ | 49.87±5.86$^{b}$ | 31.19±3.32$^{a}$ | 30.05±2.64$^{a}$ | 29.81±0.42$^{a}$ |
| C600 | 48.46±7.46$^{b}$ | 48.93±7.84$^{b}$ | 30.79±2.72$^{a}$ | 35.56±1.93$^{a}$ | 30.68±1.32$^{a}$ |
| E200C200 | 47.35±4.68$^{c}$ | 46.21±3.45$^{c}$ | 31.22±2.62$^{a}$ | 37.28±0.12$^{b}$ | 29.53±0.09$^{a}$ |
| E300C300 | 50.68±0.89$^{b}$ | 49.37±2.45$^{b}$ | 30.11±3.54$^{a}$ | 29.97±2.46$^{a}$ | 26.87±0.38$^{a}$ |

Values bearing different superscript within rows indicate significantly different at P<0,01

Table 2. a* value (reddish) of Muscovy duck meat that stored on room temperature, refrigerator, and freezer

| Treatment | Room Temperature | | | Refrigerator | Freezer |
|---|---|---|---|---|---|
| | 3 hours | 6 hours | 3 days | 3 days | 3 days |
| EoCo | 6.49± 0.17 | 6.49±0.17 | 6.18±0.21 | 5.47±0.29 | 7.20±0.68 |
| E 400 | 7.84±1.92$^{b}$ | 7.84±1.92$^{b}$ | 6.93±0.23$^{b}$ | 6.03±0.19$^{a}$ | 9.68±0.83$^{b}$ |
| E 600 | 8.03±1.32$^{a}$ | 8.69±1.09$^{a}$ | 7.14±0.24$^{a}$ | 5.82±0.41$^{a}$ | 9.62±1.07$^{b}$ |
| C400 | 7.48±0.99$^{a}$ | 8.37±0.55$^{b}$ | 7.10±0.42$^{a}$ | 12.55±0.44$^{b}$ | 10.30±0.69$^{b}$ |
| C600 | 7.81±1.51$^{a}$ | 8.33±0.66$^{a}$ | 7.06±0.27$^{a}$ | 7.20±0.17$^{a}$ | 10.26±0.38$^{b}$ |
| E200C200 | 7.63±1.22$^{a}$ | 8.66±0.71$^{ab}$ | 7.10±0.22$^{a}$ | 10.25±0.21$^{b}$ | 7.61±0.25$^{a}$ |
| E300C300 | 10.46±1.49$^{c}$ | 11.50±0.45$^{c}$ | 7.00±0.23$^{a}$ | 7.27±0.08$^{a}$ | 7.20±0.36$^{a}$ |

Values bearing different superscript within rows indicate significantly different at P<0,01

not supplemented with vitamin E and C in feed had low redness (a*) and did not differ (P>0.05) from that stored in room temperature, refrigerator and freezer. Increasing shelf life of Muscovy duck meat with E0C0 treatment had low meat redness (a*) value. Muscovy duck meat supplemented with 400 IU and 600 IU vitamin E and stored in the freezer for 3 days had higher redness (a*) value than that stored in refrigerator. Muscovy duck meat supplemented with 400 mg/kg vitamin C in feed and stored in refrigerator or freezer for 3 days had higher redness (a*) value than that in room temperature for 3 days. Muscovy duck meat supplemented with 600 mg/kg vitamin C in feed had high redness (a*) value if stored in the freezer up to 3 days. Duck has higher red muscle fiber in breast compared to chicken (Smith et al., 1993) and is considered red meat. The quality of duck meat after slaughter would degrade as seen from the color and texture. High levels of fat and unsaturated fatty acids would cause oxidation of duck meat that would affect the reddish to greenish discoloration. According to Baggio and Bragagnolo (2006), meat storage could experience oxidation which triggered the presence of heat, light, metal and oxygen. To inhibit damage process, Muscovy duck meat needs substances that could prevent the oxidation process, namely antioxidant. Muscovy duck meat supplemented with vitamins E and C in feed could maintain meat red value in accordance with Matitaputy and Suryana (2010), while Goddess and Astuti (2014) stated that the age of meat and meat shelf life would be longer. Based on the results of redness (a*) value of Muscovy duck meat not supplemented with vitamin E and C (E0C0) in feed and supplemented by combination of 300 IU vitamin E and 300 mg/kg vitamin C (E300C300) and stored in the refrigerator was not different (P>0.05) with C 600 mg/kg, but the redness (a*) value of Muscovy duck meat fed with supplemented vitamin C 400 mg/kg (C400) then stored in a refrigerator had the highest redness (a*) value and different (P<0.01) from other treatment. Although L-ascorbic acid (vitamin C) can not destroy lipophilic radicals directly, it is very soluble in water and nonionic shaped so it can penetrate

and accumulate in the flesh (Lin et al., 2003). About 80-90% ascorbic acid carnitine and the catecholamines was absorbed in the gastrointestinal tract (Iqbal et al., 2004). Besides the color component a* is associated with the amount and chemical state of myoglobin, the main pigment of muscle tissue (Lawrie, 2005; Lopes et al., 2013). Increasing the values of a* were due to the oxidation of myoglobin during the storage, the resulted in browned meat (Lopes et al., 2013).

b* value of Muscovy duck meat without supplement (E0C0) progressively decreased, it indicated that blue color increased. However, meat stored in refrigerator for 3 days had different flesh color from that at room temperature (Table 3). b* value of Muscovy duck meat supplemented with vitamin C in feed was different from that with a combination of vitamins E and C. The results showed that the antioxidant of vitamin C or a combination of vitamins E and C could prevent meat from turning dark. b* value of Muscovy duck meat supplemented with vitamin C or the combined vitamin E and C then stored in refrigerator or freezer for 3 days was not different (P>0.05). b* value of Muscovy duck meat stored at room temperature for 3 hours was significantly different (P<0.05) from that stored for 0 hour at room temperature. Baeza and Chartrin (2007) stated that the declined meat yellow color due to the fat content of meat. Fernandez et al. (2003) added that the paleness of meat, high or low b* and a* value was also caused by high-fat overfeeding. Oxidation of fatty meat was closely related to the oxidation of myoglobin, further oxidation of myoglobin would reduce the ratio a*/b* so the meat would be dark bluish. Oteku et al. (2006) stated that duck meat had higher level of unsaturated fatty acids approximately 60% of total fatty acids, causing oxidation of meat that affected meat color changes. A lower yellowness (b*) of Muscovy duck meat containing greater amount of PUFA and the presence of oxygen and storage time will cause a decrease in the value of b* (Nam et al., 2002). According to Lopes et al. (2013) b* value could relate to the action of the antioxidant to block the propagation of free radicals, preserve the pigments and give a yellower color to meat fat. Increased concentration of vitamin E (a natural antioxidant) in the diet has reduced the fat rancidity. Fernandez et al. (2003) stated that vitamin E reduced lipid oxidation in breast muscles as well as the lightness and yellowness of the meat, although the effect of overfeeding could not be fully eradicated by vitamin E supplementation.

**Cooking Loss**

Analysis of variance showed that the supplementation of vitamin E, C and their combination in feed significantly affected (P <0.01) cooking loss of Muscovy duck meat stored at room temperature (0, 3 and 6 hours) but not significantly affected (P>0.05) meat stored 3 days at room temperature, refrigerator and freezer (Table 4).

Muscovy ducks fed without vitamin E and C supplement (E0C0) and those with vitamin E 400 IU and 600 IU supplement showed relatively similar cooking loss, and the highest cooking loss was at room temperature storage (3, 6 and 3 days), refrigerator and freezer. Muscovy duck meat supplemented with vitamin C 400 mg, vitamin C 600 and supplemented combination of 200 IU of vitamin E and C 200 mg and supplemented combination of 300 IU of vitamin E and C to 300 mg had low cooking loss of meat that was stored in the same way. It indicated that Muscovy duck meat fed without vitamin E, C and the combination supplement if stored at room temperature would be more easily damaged than that supplemented with vitamin E, C and combinations as shown by the high cooking loss value.

Table 3. b*value ( yellownish) of Muscovy duck meat that stored on room temperature, refrigerator, and freezer

| Treatment | Room Temperature | | | Refreegerator | Freezer |
|---|---|---|---|---|---|
| | 3 hours | 6 hours | 3 days | 3 days | 3 days |
| EoCo | 6.12±0.88[a] | 6.64±0.62[a] | 5.47±0.29[a] | 7.07±0.17[b] | 6.30±0.26[a] |
| E 400 | 8.06±3.52 | 6.62±0.86 | 6.03±0.19 | 7.80±0.30 | 9.62±0.57 |
| E 600 | 10.62±1.94 | 8.08±0.84 | 6.38±0.41 | 8.61±0.14 | 9.49±1.32 |
| C400 | 10.81±1.52[b] | 9.57±1.08[b] | 6.35±0.41[a] | 9.22±0.15[a] | 8.40±0.32[a] |
| C600 | 11.35±1.48[a] | 9.00±1.83[a] | 6.34±0.31[a] | 9.78±0.09[b] | 9.34±0.08[b] |
| E200C200 | 9.92±2.13[ac] | 9.71±1.02[c] | 6.39±0.09[b] | 9.19±1.31[b] | 8.01±1.52[ab] |
| E300C300 | 10.03±1.74 | 8.56±1.68 | 6.25±0.28 | 8.13±0.02 | 6.50±0.18 |

Values bearing different superscript within rows indicate significantly different at P<0,01

Table 4. Cooking loss of Muscovy duck meat that stored at room temperature, refrigerator and freezer

| Treatment | Room Temperature | | | Refreegerator | Freezer |
|---|---|---|---|---|---|
| | 3 hours | 6 hours | 3 days | 3 days | 3 days |
| EoCo | 35.47±1,32[b] | 34.10±1.14[b] | 34.31±0.28 | 30.32±0.32 | 29.70±0.64[b] |
| E 400 | 35.56±0.97[b] | 33.68±0.34[b] | 34.42±0.63 | 30.45±1.82 | 28.68±0.37[a] |
| E 600 | 33.44±0.40[a] | 32.96±0.59[a] | 34.23±1.26 | 29.96±0.32 | 28.96±0.51[a] |
| C400 | 32.45±1.23[a] | 30.38±0.35[a] | 34.36±0.64 | 29.23±0.52 | 29.13±0.21[a] |
| C600 | 32.33±1.01[a] | 31.90±0.35[a] | 34.23±0.70 | 29.00±0.90 | 28.90±0.99[a] |
| E200C200 | 33.41±1.22[a] | 31.91±0.75[a] | 34.15±1.04 | 30.14±0.24 | 29.91±0.24[b] |
| E300C300 | 30.15±1.95[a] | 31.88±1.38[a] | 34.20±0.88 | 30.47±0.22 | 29.38±0.51[a] |

Values bearing different superscript within rows indicate significantly different at P<0,01

Meat stored at room temperature for 3 days, although the supplement effect of vitamin E, C and the combination showed no significant effect (P>0.05) on cooking loss, but high value of cooking loss indicated the meat was damaged and started physically not juice.

Muscovy duck meat is easily damaged because the content of PUFA and MUFA is easily oxidized, as reported by Jensen et al. (1997) and Bou et al. (2009) the lipid stability during animal products storage depended on its pro-oxidant and antioxidant content, fat content, FA profiles of fat, and the degree of processing and the storage conditions of products. Meat composition was affected by feed nutrient content particularly vitamin E and C. Increasing supplement of vitamin E, C and the combination in feed would increase antioxidant, therefore reducing meat juice lost when cooking and it was closely related to pH and water holding capacity. Prawirokusumo (1990) stated that vitamin E is fat-soluble, effectively prevents fat oxidation that damages tissues; therefore, cooking loss when boiling meat can be reduced. Linder (1992) supported that at molecular level, vitamin C becomes reductive like vitamin E and active form. This characteristic is assumed to be able to defend cell stability against damage so meat juice loss can be limited.

**Tenderness**

Supplementation effect of vitamin E, C and the combinations had significant effect (P<0.05) on tenderness of meat Muscovy duck stored at room temperature for 3 hours and in the freezer for 3 days, but not significantly different (P>0.05) from that at room temperature for 6 hours and 3 days, and on refrigerator for 3

Table 5. Tenderness of Muscovy duck meat that stored on room temperature, refrigerator and freezer

| Treatment | Room Temperature | | | Refreegerator | Freezer |
|---|---|---|---|---|---|
| | 3 hours | 6 hours | 3 days | 3 days | 3 days |
| EoCo | 5.45±0.31[a] | 5.26±0.19 | 4.90±0.42 | 5.76±0.38 | 6.10±0.25 |
| E 400 | 4.49±0.26[b] | 5.22±0.09 | 5.11±0.22 | 4.72±0.15 | 5.06±0.13 |
| E 600 | 5.13±0.10[a] | 5.59±0.55 | 5.09±0.31 | 5.34±0.16 | 5.68±0.22 |
| C400 | 5.04±0.32[a] | 5.60±0.28 | 4.96±0.10 | 5.86±0.51 | 6.44±0.36 |
| C600 | 5.10±0.42[a] | 5.31±0.19 | 4.75±0.34 | 5.81±0.06 | 6.15±0.22 |
| E200C200 | 5.03±0.35[a] | 5.34±0.44 | 4.92±0.33 | 5.59±1.07 | 6.43±0.15 |
| E300C300 | 5.05±0.34[a] | 5.15±0.49 | 4.68±0.11 | 5.92±0.22 | 6.24±0.09 |

days. Muscovy duck meat supplemented with 400 IU vitamin E and stored at room temperature, refrigerator and freezer had the best tenderness because vitamin E is lipophilic so that it can seep into meat tissue and intramuscular fat resulting in the most tender meat. According to Tugiyanti et al. (2014), 400 IU vitamin E should be supplemented to produce high tenderness. Additional α -tocopherol source in feed is beneficial to increase the oxidative stability of meat (Jensen, 1995). Numerous articles discuss the effect of feeding animals with supplementary vitamin E levels on the deposition of α -tocopherol in the muscle and its effect on meat quality. Alpha-tocopherol may protect the integrity of cell membranes and protect them from freeze injury. Alpha-tocopherol has also been shown to protect the membranes from the action of phospholipase enzyme. Phospholipase hydrolyses a fatty acid chain from the phospholipids reducing their fluidity, which may increase the drip loss. The deposition of -tocopherol in the muscle has several beneficial effects on meat quality, reducing drip loss and increasing the oxidative stability of meat. (Kemin, 2009).

## Conclusions

Increasing meat shelf life would decrease brightness and tenderness value but increase redness value and cooking loss. Muscovy duck meat without vitamin E, C and the combined supplement in feed and stored at room temperature had high brightness value up to 6 hours but in refrigerator up to 3 days. Muscovy duck meat supplemented with 400 IU and 600 IU vitamin E, 400 and 600 mg/kg vitamin C and stored in refrigerator or freezer for 3 days had high redness value.

The highest redness value was obtained by Muscovy duck meat supplemented with 400 mg/kg vitamin C, and the highest tenderness was in Muscovy duck meat supplemented with 400 IU vitamin E.

## Acknowledgement

The author would like to thank to Directorate General of Higher Education, Ministry of Education and Culture for the Doctorate scholarship in Post Graduate Animal Science Study Program, Gadjah Mada University Yogyakarta.

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