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Off-flavor Production of Cihateup Duck Meat at Different Slaughter Ages

Maria Kristina Sinabang^{1*}, Rukmiasih², Tuti Suryati², and Jonathan Anugrah Lase³

¹Postgraduate in Animal Production Science and Technology, Faculty of Animal Science, IPB University, Bogor, 16116, Indonesia

²Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor, 16116, Indonesia

³Assessment Institute for Agricultural Technology (BPTP) Maluku Utara, Tidore Kepulauan, 97813, Indonesia

ABSTRACT

This study aims to evaluate the age of off-odor detection to ensure more efficient and economical provision of antioxidants in the production of Cihateup ducks. This study used a Completely Randomized Design (CRD) with 3 different treatments of slaughter age, i.e. 4, 8 and 12 week. Each treatment consisted of 6 replications and each replication consisted of 13 ducks. The results showed that the percentage of fat content at the age of 12 weeks was higher than the age of 4 and 8 week. High fat-containing meat tends to undergo fat oxidation. High levels of Fe at 12 week of slaughter age cause high levels of myoglobin in duck meat. Fe²⁺ is a catalyst in the process of fat oxidation. the brightness value (L) is inversely proportional to the value a of Cihateup duck meat. The darker brightness of the meat causes the flesh to be redder due to myoglobin level in duck meat. The percentage of polyunsaturated fatty acids (ALTJG) is 4- and 12-week slaughter age lower than 8 week of age. The high levels of MDA at 12 week of slaughter age are due to fat oxidation which causes off-odor. Based on the result, the conclusion is that the high fat content, Fe content, color of Cihateup duck meat at 12 weeks of slaughter age caused the percentage of polyunsaturated fatty acids (ALTJG) to be low due to fat oxidation. Fat oxidation caused high levels of MDA in duck meat (12 weeks of slaughter age) resulting in Off-odors in Cihateup duck meat.

Keywords: Fat oxidation, Local duck, Malonaldehyde, Off-flavor, Slaughter age

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*Corresponding author:

Telp. +62 85211178503

E-mail:

mariakristina160192@gmail.com

Introduction

Cihateup duck is egg-laying type duck, which also has potency to produce meat. Cihateup duck has large overall bodyweight, thus producing large carcass percentage, namely thigh and breast. Randa *et al.* (2007) reported that the thigh and breast carcass percentage of Cihateup ducks are greater than Alabio duck's. The thigh and breast percentage of Cihateup duck are 28.15% and 31.42%, respectively. Meanwhile, the percentage on the alabio duck are only 21.33% and 25.67% on the same respective. However, the Cihateup duck meat has stronger rancid odor (off-odor) which is less favorable among consumers.

From previous studies, it is known that the off-odor comes from the process of fatty acids oxidation. Meat containing greater fat content tends to produce stronger off-odor, signed with such rancid odor. Kim *et al.* (2006) reported that duck meat has greater fat content than chicken meat, namely 8.2% vs 4.8%. Fat deposition on poultry dominantly takes place on thigh and breast parts. Damayanti (2003) reported that 8-week-old

local duck produces meat containing fat as much as 3.84% and 8.47% on the breast and thigh respectively. High percentage of fat content is one of causal factors affecting the rancid odor produced from its oxidation. Matitaputty *et al.* (2010) reported that meat containing greater fat tends to produce more off flavour, such as rancid odor.

Duck meat has darker red color than chicken meat, which is caused by high level of myoglobin content which binds Fe in the process of heme formation. Heme-bound Fe can be released from heme structure to become non-heme Fe (Fe²⁺) if the myoglobin undergoes denaturation. Non-heme Fe (Fe²⁺) can catalyze the process of oxidation. Heme molecule (Fe²⁺) inside the hemoglobin and myoglobin is a strong prooxidant. Non-heme Fe (Fe²⁺) can react with hydroperoxide to form radical peroxide (Apriyantono and Lingganingrum, 2001). Those radical molecules have roles in the off-odor formation on duck meat.

Duck meat contains large amount of unsaturated fatty acid which easily can be oxidized. The greater number of double bonds on the unsaturated fatty acid chains leads to the

lenience of oxidation can occur. Lipid oxidation is one of causes of the strong rancid odor production on duck meat. The degree of oxidation on meat can be indicated by assessing the fat content, meat color, Fe level, fatty acid compositions, and malondialdehyde (MDA) level. MDA is a product of lipid production, which is a reactive aldehyde molecule and also is a product of polyunsaturated fatty acid (PUFA) peroxidation.

One of feasible means to promote duck meat to be able to be on par of chicken or other type meat is antioxidant supplementation, that hopefully will overcome the shortcomings of duck meat appearance and flavor. However, the time manner of antioxidant supplementation to reduce the off-odor on Cihateup duck meat is not yet available.

Materials and Methods

Location and time

This study was conducted on two stages, namely: 1. Duck rearing at field laboratory of IPB, 2. Duck meat sample analysis which were handled at three separate laboratories (Integrated Laboratory of Animal Production and Technology Department IPB, Integrated Chemistry Laboratory of IPB Barangsiang, and *Laboratorium Pusat Antar Universitas* – Laboratory of Food Analysis and Laboratory of Processing). The study was conducted from December 2017 to March 2018.

Materials

Materials used on this study were day old duck (DOD) of Cihateup duck, commercial meat-type feed (starter and finisher phase), water, H₂SO₄, HgO, K₂SO₄, H₃BO₃, Brom Cresol Green-Methyl Red indicator, NaS₂O₃, distilled water, NaOH, BF₃, NaSO₄ anhydride, HCl, hexane, propyl gallate, ethylenediaminetetraacetic acid (EDTA) 292.24 g/mol (merk-SIGMA ALDRICH-USA), antifoaming agent, thiobarbituric acid (TBA) 144.15 g/mol(merk-SIGMA ALDRICH-USA), tetraethoxypropane (TEP) 220.31 g/mol (merk-SIGMA ALDRICH-USA), HNO₃, H₂O₂, FeSO₄, boiling stone.

Equipment and apparatus

Battery cages, feeder and drinker, mass scale (Mettler Toledo AB204), electric furnace (Vulcan TN 3550 NDI0, gas chromatography (GC-Shimidizu Series GC 2010 pIUS), spectrophotometer (Agilent), atomic absorption spectrophotometer (Agilent Technologies 200 Series AA), Chromameter (Minolta Cr-310), Hot Plate (Karl Kolb D 6172, West Germany), Oven (WTB Binder, Germany), Kjeldahl apparatus (Pyrex IWAKI), Soxhlet apparatus (Duran Schott).

Methods

This study consisted of two stages. On the first stage ducks were reared until sampling day. 234 male Cihateup ducks (13 ducks/box) were reared since DOD. The ducks were fed with commercial meat-type chicken complete feed for

starter phase CP BR 11 – given since DOD to week -12. The nutrient value of feed used in this study are as follow: water content 13.0%, protein 21.0-23.0%, fat 5.0%, fiber 5.0%, ash 7.0%, calcium 0.9%, phosphor 0.6%, metabolizable energy 2.820-2.920 kkal/kg. Ducks were given the feed twice a day (morning and afternoon) and ad libitum of water access. The amount of feed given to the ducks was referring to Prasetyo *et al.* (2010) – the daily nutrient requirement for 3-4 week old is 93 g/duck/day, 7-8 old is 120 g/duck/day, 11-12 week old is 145 g/duck/day. Decapitation was performed according to three different treatments based on age of the duck, namely 4, 8, and 12 weeks.

The second stage was involving meat (including the skin) sampling, chemical analysis, and sensory analysis. Before sampling, meat was cooled with ice cube until 4°C to lower the meat temperature, inhibit chemical reaction on the meat. The meat were then parted and deboned, stored in vacuum condition in -20°C. Frozen meat and its skin were then chopped using a knife as a mean of sample homogenization before analysis.

Water content

Water content analysis was conducted by using oven method. Crucibles were dried in 105°C oven and then cooled down inside desiccator for 30 minutes before being weighed. The process was repeated until a constant weight is obtained. As much as 2 gram of sample was placed on dried and weighed crucible, then dried in 105°C for 8 hours. Samples were then cooled inside dessicator and weighed. The process was repeated until constant weight is obtained. The water content percentage was calculated according to this following formula (AOAC, 2005).

$$\% \text{Water content} = \frac{\text{Sample fresh weight} - \text{sample dried weight}}{\text{sample fresh weight}} \times 100\%$$

Ash content

Crucibles were dried in 105°C oven. After being cooled inside dessicator for 30 minutes, all crucibels were weighed. The process was repeated until the crucibles reached constant weight. 1 gram of sample were placed on the crucibles that have been dried and weighed. Samples were then burned on Bunsen or electric stove until it did not produce any fog. Samples were then placed in 600°C for 6 hours. Samples were placed in dessicator for 30 minutes to cool them down. Samples were then weighed and percentage of ash content was calculated according to this following formula (AOAC, 2005).

$$\% \text{Ash content} = \frac{\text{Ash weight}}{\text{sample weight}} \times 100\%$$

Protein content

Protein determination is conducted according to Kjeldahl method. The principal of the method include destruction, distillation, and titration steps. As many as 0.25 gram of sample was put in the 100 ml of Kjeldahl tube and added with 0.25 gram selenium and 3 ml of H₂SO₄.

Sample were then subjected to destruction process (heating) for 1 hour until the solution reached clear color. 50 ml of distilled water and 20 ml of NaOH 40% were added to sample. The distillate were then transferred into Erlenmeyer that has been added with 10 ml of H₃BO₃ 2% and 2 drops of pink-colored Brom Cresol Green-Methyl Red indicator. After the distillate volume reached 40 ml and had green color, the distillation process were stopped. The distillate were then subjected to determination by titration with HCl 0.1 N until pink color formed. The formula to determine the protein content is (AOAC, 2005):

$$= \frac{\text{Volume titran sample} - \text{volume titran blank}}{\text{sample dried weight} \times 1000 \times 2.5} \times \text{NHCL} \times 14$$

(% protein = % N content x correction factor (6.25))

Lipid content

Water free samples (dried) were weighed as much as 7-10 gram, then placed on cotton-covered paper mini bag, which then covered with lipid free paper. Samples were then placed on Soxhlet apparatus which has been connected to dried and weighed boiling stone. Extraction was using hexane solvent or other lipid solvent for at least 6 hours until the solvent flowing to fat glass is observed clear. Hexane was then distilled and extracted lipid were then dried in 105°C oven. Fat was cooled and weighed. The fat drying process was performed until constant weight was obtained. The percentage of lipid content was calculated according to this following formula (AOAC, 2005).

$$\% \text{Lipid content} = \frac{W2 \text{ (g)} - W1 \text{ (g)}}{W \text{ (g)}} \times 100\%$$

Notes: W = sample weight (gram)
W1 = pre-extraction weight (gram)
W2 = post-extraction weight (gram).

Fatty acid composition

Fat or oil sample were weighed as much as 20-30 mg in the teflon-covered tube. 1 ml NaOH 0.5 N was added in methanol. NaOH 0.5 N was pushed by nitrogen, heated in the water heater for 20 minutes. 2 ml of BF₃ 20 % was added to the tube and then heated for 20 minutes. Samples were cooled down. 2 ml of saturated NaCl and 1 ml of isooctane or hexane were added to the ample and homogenized. Hexane layer were then transferred to 0.1 gram of NaSO₄anhydride-filled tube by using pipette. Samples were then rested for 15 minutes. Liquid phase were separated from organic phase. The organic phase or fatty acid methyl ester (FAME) were injected to gas chromatography (GC), and the FAME components were identified by comparing the retention time with standard on the same procedure (AOAC, 2012a). Sample analyzed on this study were thigh meat (including the skin).

MDA content

MDA content can be used as indicator that illustrate autooxidation process on meat. 10 gram of meat sample were weighed and added with

97.5 ml of distilled water which contains 0.1% propyl gallate and 0.1% EDTA. 2.5 ml of HCL 4N and 5 drops of antifoaming agent were added to sample. The homogenate were then distilled until obtaining 50 ml of distillate. 5 ml of distillate were added with 5 m of TBA reagent. Samples were then incubated for 40 minutes at 100°C and read on spectrophotometer at 532 nm of wavelength (Sorensen and Jorgensen, 1996).

Fe Analysis

2.5 gram of thigh meat (including the skin) of Cihateup duck were weighed and placed on Erlenmeyer. 25 ml of HNO₃ were added to the Erlenmeyer. Samples were then heated on hot plate at 100-120°C for 30-45 minutes to remove oxidation prone molecules, then cooled down. The cool liquid samples were added with 10 ml of HClO₄ 70%, and then heated on hot plate at 100°C until the samples had clear color. Samples were then cooled. 50 ml of distilled water were added and then reheated until all NO₂ flew out. Samples were then cooled and subjected to filtration into 100 ml measurement glass. Sample were then diluted until 100 ml. Samples were homogenized and read on atomic absorbance spectrophotometer at 248.3 nm wavelength (AOAC, 2012b).

$$\text{Fe content } (\mu\text{g/g}) = \frac{\left(\frac{\mu\text{g}}{\text{mL}} \text{ of Fe content from calibration curve} \right) \times v}{m}$$

Notes: v = dilution volume (mL)
m = sample weight (g)

Meat color

The meat color was analyzed according to modified method of Hutching (1999) using Chromameter Minolta CR-310. Meat color was assessed on L, a, and b scale. L indicates the brightness, which denoted from 0 (black) to 1000 (white). a value indicates chromatic color of red-green, with positive value (+a) for red, and negative value (-a) from 0 to -80 for green color. b value indicates the chromatic color of blue-yellow, with positive value (+b) from 0-70 for yellow, and negative value (-b) from 0 to -70 for blue color. The color measurement was initiated with instrument calibration process. Samples were put on petri dish until covering all base area of the petri dish. The optic head was placed vertically above the sample and then the measurement was initiated by pressing START button. The data were displayed on the data processor of Chromameter (Hutching, 1999).

Hedonic quality test

Hedonic quality analysis was used to determine the consumers' acceptability for off-odor of the duck meat (including the skin) that have received treatments. Hedonic quality test was performed by 30 semi-trained panelists. Scale used on the test ranges from 1 to 4. Sample tested on this test were thigh meat. Sample were cut into 2x3 cm cubes, which then boiled in a bottle for 5 to 10 minutes. Samples were then

placed and covered on 5x3 cm. plates (@1 cube of meat). All panelists were requested to identify, differentiate, and describe off-odor of the meat according to variables and scoring criteria presented on Table 1.

Table 1. Score of hedonic quality organoleptic rating

Variables	Score	Criteria	
		Raw meat	Cooked meat
Rancid smell	1	No rancid smell	No rancid smell
	2	Moderately	Moderately rancid
	3	rancid smell	smell
	4	Rancid smell	Rancid smell
		Very rancid	Very rancid smell
Fishy smell	1	No fishy smell	No fishy smell
	2	Moderately fishy	Moderately fishy
	3	smell	smell
	4	fishy smell	fishy smell
		Very fishy smell	Very fishy smell

Data analysis

This study was performed on 3 treatments with 6 replications (@13 ducks). Treatments were different slaughter age, namely: P1 = 4-week-old of slaughter age, P2 = 8-week-old of slaughter age, P3 = 12-week-old of slaughter age.

Experiment design on this study was completely randomized design with linear model (Steel and Torrie, 1995):

$$Y_{ij} = \mu + \alpha_i + \epsilon_{ijk}$$

Notes:

Y_{ij} = observed value

μ = mean

α_i = effect of treatment (P1, P2, dan P3)

ϵ_{ijk} = effect of treatment's gallate factor from slaughter age -i (1, 2, and 3).

Feed consumption, bodyweight, feed conversion, carcass weight percentage, meat:bone:skin percentage of both breast and thigh meat, water content, lipid content, protein content, ash content, Fe content, MDA level, fatty acid composition, and meat color were all subjected to ANOVA analysis (Matjijk and Sumertajaya, 2013) and Duncan Multiple Range Test (DMRT) on statistical software of SAS version 9.3(32). Data from hedonic quality test were analyzed descriptively.

Results and Discussion

Effects of different slaughter age on chemical composition of male Cihateup duck meat

Slaughter age has significant effects on water content (Table 2). Water content of duck meat slaughtered at 12-week-old was less than P1 and P2 groups. Moreover, the water content of P2 group was significantly smaller than P1 group. The increasing fat content causes water content reduction. Khasrad (2006) reported that meat fat content has negative correlation with meat water content, thus higher fat content on the meat reduces the water content on the meat. Moreover, Untoro *et al.* (2012) stated that the water content

of meat is inversely proportional to meat fat content.

Water content can regulate freshness and shelf life of meat. High water content can compromise the shelf life of meat as it enables bacteria contamination to occur. On fresh meat, high water content is high considering its high importance in supporting life, i.e. delivering nutrition, temperature homeostatic, toxin detoxification, and cell regeneration. On this study, the range of water content of meat is 68.55 to 72.95%, which considered still within normal value. Soeparno (2009) stated that water content of meat is affected by many factors such as age, type of animal, and slaughtering process that can influence water-binding capacity.

Slaughter age affected meat fat content significantly. Table 2 shows that fat content of P3 group was significantly higher than P1 group, but not different than P2 group. Fat content of P1 was not significantly different than P2 group. This finding is in line with Damayanti (2003) and Hustiany (2001) who reported that fat content of duck meat slaughtered at 8 week old is 8.47% and the meat fat content of unproductive female duck is 12.21%. On this study, meat fat content ranges from 7.57 to 16.52%.

On this study, meat fat content was analyzed by including the skin as high fat is deposited on the duck skin. Fat content of local duck thigh meat without skin slaughtered at 8 week old is 8.47%. Meanwhile, the fat content increases to 52.67% if its skin is included (Damayanti, 2003). Water poultry commonly has subcutaneous high fat deposition as it is indicated by thicker skin than chicken. This study also used thigh meat for fat analysis. Fat content varies and affected by species, age, muscle type, and feed (Nugroho, 2008). Fat content of thigh meat is higher than breast meat. Damayanti (2003) reported that fat content of breast and thigh meat of local duck slaughtered at 8weekold are 3.84% and 8.47% respectively.

Genetically, duck meat has twice fat deposition of chicken meat. Baeza (2006) and Rukmiasih *et al.* (2010) reported that the increasing fat content is along with the age of the poultry, feed, and genetic. High fat content potentially becomes the source of rancid odor on Cihateup duck meat. Matitaputty *et al.* (2010) stated that meat with high fat content tends to produce greater off-flavor, such as rancid odor. Rancid odor is caused by greater oxidizable unsaturated fatty acid content. Kim *et al.* (2006) reported that fat content of duck meat is 8.2%, which on chicken meat is 4.8%.

Slaughter age did affect protein content significantly. Protein content of P3 groups is significantly smaller than P2 and P1 group. Moreover, the protein content of P2 groups is significantly smaller than P1 group. Small protein content reduces the water content on meat. (Lawrie, 2003) stated that meat protein plays role in water binding on meat. Different water content can lead to different protein content of duck meat.

Tabel 2. Proximate analysis of Cihateup duck meat with skin

Variables	Treatments					
	P1	P2	P3	P1	P2	P3
	----- % -----			----- % 100 g BK -----		
*water content	72.95±1.16a	70.75±0.63b	68.55±0.32c	-	-	-
**fat content	7.57±0.19b	11.30±1.17ab	16.52±4.74a	27.64±0.70b	38.63±4.00ab	52.52±15.07a
*protein content	18.20±0.32a	16.80±0.29b	13.87±0.21c	67.26±1.19a	57.44±1.00b	44.10±0.68c
*ash content	1.28±0.05a	1.15±0.15ab	1.06±0.20b	4.74±0.19a	3.91±0.53b	3.37±0.64b

*Results of IPB Center for Inter-university (PAU) laboratory analysis; ** Results of IPB integrated chemical laboratory analysis; P1: 4-week-old of slaughter age; P2: 8-week-old of slaughter age; P3: 12-week-old of slaughter. Different letters on the same row indicates statistical difference (P<0.05) among treatments

Small meat protein content compromises the water binding capacity of meat, thus the free water increases. Protein content has negative correlation with fat content. Soeparno (2009) stated that meat with higher fat content will have smaller water content. The average of meat protein content on this study ranges from 13.87 to 18.20%, which is lower than Kim *et al* (2006) who reported that duck meat has 18.6 to 20.1% of protein.

This study shows that slaughter age affected ash content significantly. Ash content of P3 group was significantly smaller than P1 group, but not than P2 group. Moreover, the ash content of P1 and P2 were not significantly different (Table 2). Ash is minerals from the body. Calcium and phosphor are major mineral in the body. Nurwantoro and Mulyani (2003), stated that ash is anorganic compounds resulting from burning. Range of ash content on this study is 1.06 to 1.28%. Hustiany (2001) reported that ash content of duck thigh meat (skin included) is 1.03%, thus values obtained on this study is withing normal range.

Fe level and meat color of male Cihateup duck meat

Slaughter age had significant effect on Fe level. The Fe level of P3 group was higher than P2. Moreover, the P2 group also had higher Fe level than P1 group (Table 3).

The average of Fe level on duck meat ranges from 1.82 to 5.09 mg/100 gram. High Fe content causes the darker red color on meat. Red color on meat comes from high hemoprotein which consist of myosin, globin, and heme structure that widely known as myoglobin and hemoglobin (peroxidant compound) (Amrullah, 2000). On red meat, fat oxidation is cused by non-heme Fe catalysis which accelerates the rancid and off-flavor formation during storage (Lawrie, 1991; Min *et al.*, 2010; Yoon *et al.*, 2010). Other

catalysator may come from ferritin. Ferritin can release Fe²⁺ with the reducing agent availability, such as superoxide O₂⁻. Fe²⁺ breaks O-O bond to form very reactive alkoxy radical. Reaction between Fe²⁺ and oxygen can produce radical compounds which are able to hog hydrogen from PUFA to start oxidation.

Slaughter age affected brightness (L) and a value of Cihateup duck meat significantly (table 3). Brightness (L) and a value of duck meat slaughtered at 12 week old is significantly lesser than those slaughtered at 8 and 4 week old. Moreover, the value on P2 group is also significantly lesser than P1 group. Reduced brightness value (L) on meat increases a value that indicates the high myoglobin content. High myoglobin content on Cihateup duck meat causes red color on the meat. The result is aligned with Aberle *et al.* (2001) and Lukman (1999) who stated that meat color is determined by myoglobin content, ages, and activity of the animal. Meat color differences are followed by differences on myoglobin level, hemoglobin level, and other minor compounds such as protein, fat, B12 vitamin, and flavin (Lawrie, 1991). B value of duck meat was not significantly altered by slaughter age. B value ranges from 4.34 to 5.39. Yellow color on the meat comes from fat content on the skin and meat. Ketaren (2008) reported that the appearance of yellow color on fat is caused by carotene pigment content.

Fatty acid composition of male Cihateup duck meat

Slaughter age affected the composition of polyunsaturated fatty acid (PUFA) significantly. Table 4 demonstrates the PUFA percentage of P3 is lower than P2 group. Meanwhile, PUFA of P3 groups is not significantly different than P1 group.

Different slaughter age influences the percentage of poly unsaturated fatty acid on duck meat. This study demonstrated that slaughter age

Table 3. Fe Content and Duck meat color Look at different slaughter ages

Variables	Treatments		
	P1	P2	P3
**Fe level	1.82± 0.08c	3.76±0.25b	5.09±0.39a
*L	49.29±4.96a	42.27±3.00b	34.11±3.01c
*a	10.27±0.44c	13.16±2.33b	15.65±0.99a
*b	5.39±1.53a	5.04±1.42a	4.34±0.32a

*Results of the IPB Inter-University Center (PAU) laboratory analysis;** Results of IPB integrated chemical laboratory analysis; P1: 4-week-old of slaughter age; P2: 8-week-old of slaughter age; P3: 12-week-old of slaughter. Different letters on the same row indicates statistical difference (P<0.05) among treatments

Table 4. The composition of fatty acids from duck meat at different slaughter age

Fatty acid	treatments		
	P1	P2 (%)	P3
SFA			
C10:0	0	0.02±0.00a	0.03±0.01a
C12:0	0.04±0.00a	0.05±0.02a	0.04±0.00a
C14:0	0.38±0.02a	0.40±0.04a	0.40±0.04a
C15:0	0.05±0.00b	0.06±0.00a	0.06±0.01a
C16:0	19.01±0.50a	17.94±0.96b	19.51±1.06a
C18:0	5.22±0.27a	4.93±0.87a	4.93±0.69a
C20:0	0.09±0.01b	0.13±0.04a	0.13±0.02a
C22:0	0.03±0.01a	0.04±0.01a	0.04±0.01a
C24:0	0	0	0.02±0.01
TOTAL	24.82±0.82ab	23.57±1.95b	25.16±1.85a
ALTJT			
C14:1	0.02±0.01a	0.02±0.00a	0.03±0.01a
C16:1	1.16±0.08ab	1.00±0.19b	1.25±0.24a
C17:1	0.06±0.01a	0.07±0.01a	0.06±0.01a
C18:1n9c	31.34±1.06a	29.60±2.58a	30.04±2.27a
TOTAL	32.57±1.16a	30.69±2.77a	31.37±2.52a
ALTJG			
C18:2n6c	17.00±0.58b	18.45±0.88a	16.38±0.89b
C18:3n3	1.23±0.05a	1.11±0.13ab	1.08±0.15b
C18:3n6	0.07±0.01a	0.07±0.01a	0.05±0.02b
C20:2	0.14±0.02ab	0.17±0.01a	0.12±0.03b
C20:3n6	0.10±0.01a	0.10±0.01a	0.06±0.02b
C20:4n6	0.52±0.11a	0.76±0.21a	0.52±0.25a
C20:5n3	0	0.03±0.00	0
C22:6n3	0.07±0.04a	0.08±0.06a	0.05±0.03a
TOTAL	19.13±0.83b	20.75±1.31a	18.67±1.84b
ALTJ			
C14:1	0.02±0.01a	0.02±0.00a	0.03±0.01a
C16:1	1.16±0.08ab	1.00±0.19b	1.25±0.24a
C17:1	0.06±0.01a	0.07±0.01a	0.06±0.01a
C18:1n9c	31.34±1.06a	29.60±2.58a	30.04±2.27a
C18:2n6c	17.00±0.58b	18.45±0.88a	16.38±0.89b
C18:3n3	1.23±0.05a	1.11±0.13ab	1.08±0.15b
C18:3n6	0.07±0.01a	0.07±0.01a	0.05±0.02b
C20:2	0.14±0.02ab	0.17±0.01a	0.12±0.03b
C20:3n6	0.10±0.01a	0.10±0.10a	0.06±0.02b
C20:4n6	0.52±0.11a	0.76±0.21a	0.52±0.25a
C20:5n3	0	0.03±0.00	0
C22:6n3	0.07±0.04a	0.08±0.06a	0.05±0.03a
TOTAL	51.70±1.99a	51.44±4.08a	50.04±4.36a

The results of IPB integrated chemical laboratory analysis; P1: 4-week-old of slaughter age; P2: 8-week-old of slaughter age; P3: 12-week-old of slaughter. Different letters on the same row indicates statistical difference ($P < 0.05$) among treatments

at 12 week old decreases the percentage of polyunsaturated fatty acid, such as linoleic acid (C18:2n6c), linolenic acid (C18:3n3), γ -linolenic acid (C18:3n6), cis-11,14-asameicosadienoic acid (C20:2), cis-8,11,14-eikosatrienoic acid (C20:3n6). The alteration indicates that PUFA is not protected from oxidation. This can be confirmed that the highest level of MDA is observed on P3 group, producing aldehyde compound from fat oxidation that causes rancid odor on duck meat.

On small intestine, membrane cell containing high unsaturated fatty acid that easily abstracted on their hydrogen atom by free radical. Superoxide (O_2^*) formed due to substrate oxidation is one of free radical that starts oxidation process. During that process, unsaturated fatty acid will be attacked and lose their hydrogen atom, thus forming radical fat. Radical fat will react with oxygen and form free peroxy radical that can be disordered into volatile compounds, including aldehyde.

This study demonstrates that total unsaturated fatty acid of Cihateup duck meat is higher than total saturated fatty acid. Unsaturated fatty acid is a matter that easily undergoes auto-oxidation. High fat content, mainly unsaturated

fatty acid on duck meat tends to produce off-odor. Unsaturated fatty acid containing greater number of double bonds produce more off-odor. This is aligned with Cortinas *et al.* (2005) and Barciela *et al.* (2008) who reported that fat oxidation rate on meat is influenced by many factors, e.g. species, number of saturated fatty acid contents (mainly PUFA), prooxidant such as heme and non-heme Fe, and antioxidant. Fat oxidation is a source of rancid odor on meat. Bou *et al.* (2004) stated that lipid oxidation is a main cause on poultry product damage, primarily producing unfavorable odor as well as shorten the shelf life.

Malondialdehyde (MDA) level on male Cihateup duck meat

Different slaughter age influence MDA level significantly. MDA level of P3 group is higher ($1.1 \pm 0.13a$) than P1 ($0.41 \pm 0.07b$) and P2 group ($0.40 \pm 0.06b$). However, the MDA level of P2 group was not significantly different than P1 group (Table 5).

The average of MDA level of duck meat in this study ranges from 0.40 to 1.11 mg/kg. one of final product from oxidation is MDA. Higher fat content on P3 group causes higher MDA level on

Tabel 5. MDA level of male Cihateup duck meat

variable	Treatments		
	P1	P2	P3
MDA level (mg/kg)	0.40±0.06b	0.41±0.07b	1.11±0.13a

The results of the IPB laboratory of science production and animal husbandry technology; P1: Slaughtered at 4 weeks of age; P2: Slaughtered at 8 weeks of age; P3: Slaughtered at 12 weeks of age; numbers that are accompanied by different letters on the same line show significantly different ($P<0.05$).

Table 6. Hedonic quality test on raw and cooked duck meat (skin included)

Variables	Score	Panelists stating rancid odor			Panelist stating fishy odor		
		4	8	12	4	8	12
		----- % -----			----- % -----		
Raw meat	1	66.67	56.67	50.00	53.33	43.33	30.00
	2	16.67	26.67	40.00	30.00	50.00	50.00
	3	16.67	13.33	6.67	16.67	6.67	16.67
	4	0.00	3.33	3.33	0.00	0.00	3.33
Cooked meat	1	53.33	46.67	50.00	60.00	60.00	53.33
	2	20.00	23.33	23.33	33.33	30.00	26.67
	3	16.67	26.67	20.00	3.33	10.00	16.67
	4	10.00	3.33	6.67	3.33	0.00	3.33

P1: 4-week-old of slaughter age; P2: 8-week-old of slaughter age; P3: 12-week-old of slaughter. Different letters on the same row indicates statistical difference ($P<0.05$) among treatments on Kruskal-Wallis test

Hedonic Quality: Rancid smell: 1. No rancid smell 2. moderately rancid smell 3; Rancid smell 4. Very rancid smell; Fishy smell: 1. No fishy smell 2. Moderately fishy smell 3. Fishy smell 4. Very fishy smell

the group. The percentage of polyunsaturated fatty acid on P3 group is low as the result of fat oxidation. This finding is supported by Rukmiasih (2011) who stated that meat containing fat content has high MDA level due to their high risk to oxidation. MDA is aldehyde compound that can serve as indicator of secondary oxidation reaction on polyunsaturated fatty acid (Pignoli *et al.*, 2009).

Hedonic quality test of male Cihateup duck meat

This study demonstrates that percentage value 1 as part of panelist evaluation is observed smaller on P3 group than on P1 and P2 groups. Furthermore, it is also lower on P2 group than P1 group.

The percentage of panelist giving score 2 on raw cooked meat slaughtered at week 12 week old is higher than meat slaughtered at 4 and 8 week old. Moreover, the percentage is also observed on P2 group than P1 group. The percentage of panelist evaluating the fishy odor of raw meat with score 2 is observed higher on P3 group than P1 group. Meanwhile, P3 and P2 group has same percentage for the same criteria. Some panelists also evaluated that there were meat with rancid or fishy odor already (score 3) and very rancid and fish (score 4).

The percentage of panelists evaluating rancid odor on score 1 on raw cooked meat is observed lower on P3 group than P1 group, and higher than P2 group. For fishy criteria of cooked meat, the percentage of panelists giving score 1 is lower on P3 group than P1 and P2 group, while P1 and P2 group has same percentage. The percentage of panelist giving score 2 for rancid criteria on cooked meat is observed higher on P2 and P3 groups than P1 group, meanwhile the P2 and P3 groups have same percentage. For fishy criteria on cooked duck meat, the percentage of panelists giving score 2 is lower in P3 group than P1 and P2 groups. The percentage on P2 group is lower than P1 group. The percentage of panelists

giving score 3 for rancid or fishy criteria starts to be high on P3 group.

The percentage of panelists stating that cooked meat is more rancid than raw meat (Table 6). This might be a result that during cooking process, meat fat underwent physical and chemical changes. Those changes may be caused by fat oxidation. Meat that exposed to heat and radical oxygen will undertake fat oxidation (Kochhar, 1996). Fat oxidation is initiated with interaction between carbon radical and oxygen molecule. This interaction causes hydrogen transfer that can produce free radical. The reaction can form hydroperoxide and other free radical, thus, aromatic volatile compound primarily aldehyde is formed. Aldehyde as main component of fat degradation that form distinct odor on duck meat.

Conclusions

High fat content, Fe content, and red color on meat, as well as the low polyunsaturated fatty acid composition indicate fat oxidation that produce MDA, thus, forming strong off-odor on Cihateup duck at 12 week old.

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