Influence of duck species and cross-breeding on sensory and quality characteristics of Alabio and Cihateup duck meat

La influencia de las especies de patos y cruces en las características sensoriales y de calidad de la carne de pato Alabio y Cihateup

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The current study was designed to assess the effect of strain on lipid content, fatty acid profile, and sensory attributes of duck meat derived from two duck strains, Alabio and Cihateup strain, and their crossbreeds (sex ratio 1:1). The groups evaluated were as follow: AA (Alabio ♂ × Alabio ♀), CC (Cihateup ♂ × Cihateup ♀) and the crossbreeding of AC (Alabio ♂ × Cihateup ♀) and CA (Cihateup ♂ × Alabio ♀).

Analysis of the chemical composition and sensory properties of meat was assessed on thigh muscles. The crossbreeds were characterized by the lowest fatness (P < 0.05). The crossbreeds had greater (P < 0.05) percentage total saturated fatty acids, whereas CA crossbreed had the highest total saturated fatty acid level (P < 0.05). Based on the hedonic test, no differences (P > 0.05) existed among the treatments with regard to meat taste, while meat from AC was preferred (P < 0.05) by panelists over the other groups with respect to aroma and overall acceptability. The principal component analysis (PCA) revealed that AC meat had lower off-odor intensity, and on average panelists positively differentiated (P < 0.05) AC meat. Overall, our data suggest that AC duck meat resulted in more desirable quality attributes.

Keywords: duck; fat; meat; quality; sensory analysis

El presente estudio fue diseñado para evaluar el efecto de la cepa en el contenido lipídico, el perfil de ácidos grasos y los atributos sensoriales de la carne de pato derivada de dos cepas de pato, el Alabio y el Cihateup, además de sus cruces (proporción de sexos 1:1). Los grupos evaluados fueron los siguientes: AA (Alabio ♂ × Alabio ♀), CC (Cihateup ♂ × Cihateup ♀) y el cruce de AC (Alabio ♂ × Cihateup ♀) y CA (Cihateup ♂ × Alabio ♀). Se evaluó el análisis de la composición química y las propiedades sensoriales de la carne en los músculos de los muslos. Los cruces fueron caracterizados por tener menor grasa (P < 0.05). Los cruces tuvieron un mayor (P < 0.05) porcentaje total de ácidos grasos saturados, mientras que los cruces CA tuvieron el mayor nivel total de ácidos grasos saturados (P < 0.05). Según el análisis hedónico no existieron diferencias (P > 0.05) entre los tratamientos en relación al sabor de la carne, mientras que la carne de AC fue preferida (P < 0.05) por parte de los panelistas por encima del resto de grupos respecto al aroma y al total de aceptación. El análisis de los componentes principales (PCA) reveló que la carne de AC tuvo menor intensidad de rancidez, además el promedio de panelistas diferenciaron de manera positiva (P < 0.05) la carne AC. En total, nuestros datos sugieren que la carne de pato AC resultó tener unos atributos de calidad más deseables.

Palabras clave: pato; grasa; carne; calidad; análisis sensorial

Introduction

Duck meat is the third most widely produced poultry meat in the world after chicken and turkey, and duck meat production in Indonesia comprises 20% of domestic products (Purwantini, Yuwanta, & Hartatik, 2013). Many native ducks in Indonesia are named according to the location with particular morphological traits. Native ducks in the West Java Island are known as Cihateup ducks, while in the Borneo Island especially in the South Kalimantan province they are known as Alabio ducks (Is moyowati & Purwanti, 2011).

During the last few decades, with the increase in meat consumption, consumer's demand for quality meat has also increased; and several factors such as the genotype, sex, diet, and post-mortem technological treatments of the carcasses can affect meat quality (Kopuzlu, Onenc, Bilgin, & Esenbuga, 2011; Laudadio et al., 2012). Consumer satisfaction is very crucial for repeat purchase of any product; therefore, studying the consumer acceptance of a product plays a very important role in the food industry. Many studies have analyzed the effects of poultry strain on meat quality, mainly focusing on sensory characteristics and consumer acceptability of cooked meat and on lipid oxidation during meat storage. Because lipid levels in poultry meat are low (about 1–2% in breast meat of chicken and turkey, Laudadio, Tufarelli, Dario, D’Emilio, & Vicenti, 2009; Sirri, Tallarico, Meluzzi, & Franchini, 2003), the relationship between lipid levels and sensory characteristics has received little attention. Conversely, the lipid level is higher in duck meat than in chicken and turkey (Baéza, Dessay, Wacrenier, Marché, & Listrat, 2002). Charrin, et al. (2006) reported that the development of duck meat flavor is affected by the intramuscular fat level.

Different genotypes of ducks are used to produce meat, including common ducks such as Pekin ducks (Anas platyrhynchos), Muscovy ducks (Cairina moschata), and crossbred ducks such as mule ducks. To the best of our knowledge, there have been few reports to date on strain and...
crossbreeding effects on meat quality and sensory parameters in poultry, especially in ducks. LeBihan-Duval et al. (2003) reported heritability and genetic correlations for meat quality parameters in chicken and turkey meat, and they obtained moderate to high heritability values for meat traits, demonstrating the applicability of a genetic approach to improve meat quality in poultry. Larzul, Imbert, Bernadet, Guy, and Remignon (2002) upon comparing Pekin and Muscory ducks found significant additive effects on breast meat quality, as well as significant heterosis effects on color parameters. The consumption of duck meat in Indonesia is predominantly caused by the odor of duck meat making sensational perception as off-odor. Therefore, the aim of this study was to determine the effect of two duck strains (Alabio and Cihateup) and their crossbreeding in thigh muscles on meat lipid and fatty acid composition as well as sensory attributes of the meat, and also the principal component analysis (PCA) was applied to the sensory variables to describe meat quality.

Materials and methods

Animals and rearing conditions

All experimental procedures with birds were in accordance with the Indonesian National Guidelines for the care and use of animals for research purposes. Male ducks from two different breeds were used: Alabio (South Kalimantan, Indonesia) and Cihateup (West Java, Indonesia) ducks and their crossbred ducks. The ducks (40 per breed and crossbred, respectively) were provided by the same producers. The ducks were divided into 4 equal experimental groups (4 replicates each of 10 birds/group) as follow: AA (Alabio ♂ × Alabio ♂), CC (Cihateup ♂ × Cihateup ♂) and the crossbreeding of AC (Alabio ♂ × Cihateup ♂) and CA (Cihateup ♂ × Alabio ♂). Ducks were raised under controlled conditions in a poultry facility until the fourth week of age and next on range of limited and sheltered area with straw bedding. Birds were fed ad libitum on the same commercial standard diet (National Research Council [NRC], 1994). The diet from hatching to 4 weeks of age contained 21.5% crude protein and 2.920 kcal/kg metabolizable energy (ME) and from 4 to 8 weeks of age 19.5% crude protein and 3.020 kcal/kg ME of diet. Slaughter of birds and excising of thigh muscles were made in a local slaughterhouse. The thigh muscle was excised and weighed immediately after plucking and two samples were removed. One sample was frozen and stored at −20°C before chemical analysis.

Chemical analysis

Meat samples from thigh were analyzed for total lipids that were extracted according to the method of Folch, Lees, and Sloane-Stanley (1957) and values were expressed as percentages on a fresh matter basis. In preparation, for fatty acid (FA) composition analysis, samples of meat (5 g each) were freeze-dried. Briefly, methyl heptadecanoate (no. 51633, Fluka, St. Louis, MO) was dissolved into n-hexane (1 mg/mL) as an internal standard. Methyl esters of the FA were prepared (Sukhija & Palmquist, 1988); samples (300 mg each) and 5 mL of internal standard were incubated (2 h at 80°C) with methanolic acetic acid in a Shimadzu (model 2GC17A, Shimadzu, Kyoto, Japan) gas chromatograph with a Hewlett-Packard HP 6890 gas system (Palo Alto, CA) and using flame ionization detection. Helium was used as the carrier gas at a constant flow rate of 1.7 mL/min. The oven temperature was programmed as follows: 175°C, held for 4 min; 175–250°C at 3°C/min; and then maintained for 20 min. The injector port and detector temperature was 250°C. Samples (1 μL) were injected using an auto-sampler. Output signals were identified and quantified from the retention times and peak areas of known calibration standards. The composition was expressed as percentage of the total FA.

Sensory analysis

The meat samples were cooked in pans covered with aluminum foil at an internal temperature of 76°C according to the method described by Sams (1990). Cooked thigh meats were used for sensory and instrumental analysis. The four treatments were evaluated by an 87-member consumer panel. The sensory testing facility consisted of individual testing booths with controlled lighting and positive airflow. The panelists were presented with one treatment at a time that consisted of three 1 to 1.25cm cubes of thigh meat identified by a random 3-digit code (Meilgaard, Civille, & Carr, 1999). Room-temperature water was also served. A total of four treatments were served, and the treatment order was completely randomized for each panelist. Once the consumers received the sample, they were asked to enter the code into the computer and evaluate the product for overall impression, flavor, and texture on a 7-point hedonic scale with 1 = dislike extremely and 7 = very like.

Sensory testing sessions were conducted in a panel booth area. For the purpose of replication, a second testing session was conducted the next day. All meat samples were cooked at the same time. All samples were served simultaneously to each panelist after reaching room temperature. Each trained panelist was provided with two cuts of every meat type, hence a glass of mineral water for a palate cleanser, and a quantitative descriptive analysis (QDA) evaluation sheet. After tasting each sample, panelists placed a vertical mark on a linear scale with two opposing anchor words for their perceived intensity of each attribute. The line spectrum was numerically converted into values ranging from 0 to 10, read left to right.

Statistical analysis

The total lipid content and fatty acid profile data were analyzed by one-way analysis of variance as a randomized complete block design using the general linear model procedure of the statistical analysis software (SAS) program (SAS Institute [SAS], 2000) as a completely randomized design. When significant differences by the group were detected, Duncan’s multiple-range test was used for mean comparisons (Steel & Torrie, 1993). All statements of significance were based on probability of P < 0.05. Sensory data from the QDA were then analyzed using principal component analysis (PCA), which was carried out using XLSTAT-2011 (Addinsoft Inc., New York, NY).

Results and discussion

Meat lipid content and fatty acid profile

The total lipid content of thigh muscles in ducks is reported in Table 1. Meat from thigh of crossbreed ducks exhibited a
significant lower fat content \((P < 0.05)\), especially in CA ducks, confirming the optimal nutritional value of meat produced when birds were crossbred compared to the pure breeds. The total lipid content of meat contributes to both the flavor and, most importantly, the nutrient composition of poultry meat. The decrease in total lipid content of thigh muscles in crossbreed ducks could be related to the diet, which played an important role in altering the content of the total lipid (Laudadio & Tufarelli, 2011).

The influence of the duck type on the fatty acid composition of thigh muscles is presented in Table 1. Thigh meat from both crossbreed ducks had higher amounts of saturated fatty acids \((P < 0.05)\), whereas the higher unsaturated fatty acid concentration \((P < 0.05)\) was reported in meat from CA ducks than those muscles from pure breeds and AC ducks.

The production of meat containing high concentrations of UFA is of considerable interest because they are considered as functional ingredients capable of reducing the incidence of coronary heart disease and other chronic diseases (Peiretti, Mussa, Prola, & Meineri, 2007). Our findings are in agreement with Kwon et al. (2014) reporting that meat from Korean native ducks had more total \(n = 6\) fatty acids and total polyunsaturated fatty acids than commercial meat-type pure breed ducks. The dietary fat profile is reflected in the fatty acid composition of meat in poultry species (An, Banno, Xia, Tanaka, & Ohtani, 1997). In our study, both pure breeds and crossbreeds were provided with the same diets, and thus some important differences observed in the fatty acid profiles were due to the genotype.

Poultry meat is a popular and versatile proteinaceous food consumed in large amounts relative to other meats. Moreover, poultry meat can therefore serve as a vehicle for supplying nutrients such as the \(n - 3\) fatty acids whose human consumption is below recommendations (Laudadio, Nahashon, & Tufarelli, 2012). While the dietary supply of the UFA has declined over the years, poultry meat has been and continues to serve as a significant source of these fatty acids (Rymer, Gibbs, & Givens, 2010). Thus, in this study, we attempted to influence the content of poultry meat fatty acids known to be detrimental to human health. Meat from CA ducks had also higher amounts \((P < 0.05)\) of oleic, linoleic, and linolenic acids than the muscles from the other duck groups. The saturated fatty acid/unsaturated fatty acid \((\text{SFA}/\text{UFA})\) ratio (unsaturation index) was similar \((P > 0.05)\) among muscles of ducks in all groups. The SFA and UFA are positively correlated with meat quality, since they can improve the characteristics in terms of meat tenderness, juiciness, and flavor (Bačza et al., 2002). However, high levels of UFA in meat are undesirable, especially in poultry, because they adversely affect consistency, storage stability, and texture of the processed products. Thus, the fatty acid composition could have a positive or negative impact on poultry meat quality (Laudadio & Tufarelli, 2011). Moreover, the high UFA levels tended to form volatile components as the result of fatty degradation causing off-flavor toward the duck meat (Márquez-Ruiz, García-Martínez, & Holgado, 2008).

### Table 1. Total fat content (mean ± SD) and fatty acid composition (% on total FA) of thigh duck meat.

| Item                  | Duck type1            | %     |
|-----------------------|-----------------------|-------|
|                       | AA (Alabio × Alabio)  |       |
|                       | CC (Cihateup × Cihateup) |       |
|                       | AC (Alabio × Cihateup) |       |
|                       | CA (Cihateup × Alabio) |       |
| Total fat (%)         | 7.08±0.031            | 7.35±0.012 | 6.98±0.042 | 6.46±0.033 |
| Fatty acids           |                       |       |
| Saturated fatty acids (SFA) |               |       |
| C10:0 (capric acid)   | 0.05                  | 0.07  | 0.04  | 0.03  |
| C12:0 (lauric acid)   | 0.64                  | 0.82  | 0.54  | 0.53  |
| C14:0 (myristic acid) | 0.69                  | 0.85  | 0.65  | 0.63  |
| C16:0 (palmitic acid) | 18.30                 | 19.89 | 18.39 | 18.22 |
| C18:0 (stearic acid)  | 4.44                  | 4.98  | 4.09  | 3.89  |
| C20:0 (arachidic acid)| 0.10                  | 0.12  | 0.11  | 0.09  |
| C22:0 (behenic acid)  | −                     | −     | 0.02  | 0.02  |
| Total SFA             | 24.22±0.033b          | 26.71±0.037c | 23.83±0.043d | 23.42±0.043e |
| Unsaturated fatty acids (UFA) |              |       |
| C14:1 (myristoleic acid) | 0.03                 | 0.03  | 0.04  | 0.04  |
| C16:1 (palmitoleic acid) | 1.86                 | 1.83  | 1.94  | 2.20  |
| C18:1 (oleic acid)    | 34.32±0.033a          | 35.02±0.032d | 32.40±0.034c | 37.97±0.035d |
| C18:2 (linoleic acid) | 14.07±0.035b          | 14.91±0.036b | 13.71±0.034c | 15.21±0.037c |
| C18:3 (linolenic acid) | 0.56±0.031b           | 0.50±0.034b | 0.47±0.031a | 0.53±0.031b |
| C20:1 (gondoic acid)  | 0.21                  | 0.22  | 0.21  | 0.23  |
| C20:4 (arachidonic acid) | 0.22                | 0.33  | 0.42  | 0.42  |
| Total UFA             | 51.25±0.033b          | 52.85±0.039c | 49.20±0.037d | 56.61±0.037e |
| SFA/UFA               | 2.12                  | 1.98  | 2.06  | 2.42  |

Notes: 1 AA [Alabio × Alabio], CC [Cihateup × Cihateup], and the crossbreeding of AC [Alabio × Cihateup], CA [Cihateup × Alabio].

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** Notes: Means within the row with the same letter are not significantly different \((P < 0.05)\).

FA: fatty acids; SFA/UFA, saturated fatty acid to unsaturated fatty acid ratio.

SD, standard deviation.

- AA [Alabio × Alabio], CC [Cihateup × Cihateup], and the crossbreeding of AC [Alabio × Cihateup], CA [Cihateup × Alabio].

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** Notes: Means within the row with the same letter are not significantly different \((P < 0.05)\).

FA: fatty acids; SFA/UFA, saturated fatty acid to unsaturated fatty acid ratio.

SD, desviación estándar.

### Sensory characteristics of meat

With respect to consumer acceptability of duck meat, there were differences between treatments (Table 2). On average, consumers did have a slight preference \((P < 0.05)\) for thigh meat derived from ducks AC when compared with the meat from ducks in the other groups with respect to aroma. However, the numerical
differences were minimal and were in an acceptable range (4.5–5.0) on the hedonic scale. Furthermore, no difference existed (P > 0.05) between treatments with respect to acceptability in regard to meat taste. These values are close to those reported in other studies on duck meat (Muhlisin et al., 2013). Therefore, the sensory quality of cooked thigh meat of crossbreed ducks was better than that of pure breed ducks.

Descriptive analysis tests using cooked duck meat have revealed some sensory differences (Figure 1). Results related to the off-odor attribute showed that the pure duck ancestor CC has a dominant off-odor component, especially fishy flavor, whereas AA duck meat resulted in more fatty flavor. Thus, pure breed ducks exhibited higher off-odor intensity compared with the AC and CA crossbreed ducks. Overall, the average of off-odor intensity displays that it is lower in the AC duck meat, and this result could be related to the meat fatty acid composition of AC duck. Moreover, this result is supported by the hedonic test toward the AC duck aroma attribute, which was more liked by panelists when compared to CA, AA, and CC ducks. Furthermore, the increased “fishy” notes in the duck meat could have been the result of increased availability of volatile flavor compounds due to serving the samples heated. Despite conflicting results, differences in feed antioxidant levels and cooking methods as well as presentation methods to panelists could have all influenced the sensory outcomes (Goldberg, Ryland, Gibson, Aliani, & House, 2013; Rohall, Ballintine, Vowels, Wexler, & Goto, 2009).

Principal component analysis (PCA), on significant discriminating attributes, found that significant (P < 0.05) principal components, explaining 98% (PC1 90% and PC2 8%), respectively, of the experimental variance, described the differences in sensory character between samples (Figure 2). The

Table 2. Hedonic scale for duck thigh meat evaluated by the consumer sensory panel (mean ± SD).

| Duck type¹ | Aroma | Taste |
|------------|-------|-------|
| AA         | 4.5⁴ ± 0.02 | 4.9 ± 0.10 |
| CC         | 4.7⁶ ± 0.35 | 5.0 ± 0.15 |
| AC         | 5.0⁰ ± 0.04 | 5.0 ± 0.08 |
| CA         | 4.7⁴ ± 0.07 | 4.9 ± 1.14 |

Notes: ¹ AA [Alabio ♂ × Alabio ♀], CC[Cihateup ♂ × Cihateup ♀], and the crossbreeding of AC [Alabio ♂ × Cihateup ♀], CA [Cihateup ♂ × Alabio ♀].
² Hedonic scale: 1 = dislike extremely and 9 = very like.
²² Means within the column with the same letter are not significantly different (P < 0.05).
SD, standard deviation.

Table 2. Escala hedónica para muslo de carne de pato evaluado por el panel sensorial del consumidor (promedio ± SD).

| Aroma | Taste |
|-------|-------|
| 4.5⁴ ± 0.02 | 4.9 ± 0.10 |
| 4.7⁶ ± 0.35 | 5.0 ± 0.15 |
| 5.0⁰ ± 0.04 | 5.0 ± 0.08 |
| 4.7⁴ ± 0.07 | 4.9 ± 1.14 |

Notes: ¹ AA [Alabio ♂ × Alabio ♀], CC[Cihateup ♂ × Cihateup ♀] y el cruce AC [Alabio ♂ × Cihateup ♀], CA [Cihateup ♂ × Alabio ♀].
² Escala hedónica: 1 = no gustó nada y 9 = gusto mucho.
²² Los promedios en la misma columna con la misma letra no son significativamente distintos (P < 0.05).
SD, desviación estándar.

Figure 1. Sensory profiles of duck thigh meat based on quantitative descriptive analysis (QDA).
Notes: AA [Alabio ♂ × Alabio ♀], and the crossbreeding of AC [Alabio ♂ × Cihateup ♀], CA [Cihateup ♂ × Alabio ♀].

Figura 1. Perfiles sensoriales del muslo de carne de pato basados en el análisis cuantitativo descriptivo (QDA).

Figura 2. La conexión de los atributos cualitativos de ranciedad de la carne basada en el análisis de los componentes principales (PCA) de diagrama de dispersión biespacial.

Notes: AA [Alabio ♂ × Alabio ♀], CC[Cihateup ♂ × Cihateup ♀] y el cruce de AC [Alabio ♂ × Cihateup ♀], CA [Cihateup ♂ × Alabio ♀].

Figura 2. La conexión de los atributos cualitativos de ranciedad de la carne basada en el análisis de los componentes principales (PCA) de diagrama de dispersión biespacial.

Notes: AA [Alabio ♂ × Alabio ♀], CC[Cihateup ♂ × Cihateup ♀] y el cruce de AC [Alabio ♂ × Cihateup ♀], CA [Cihateup ♂ × Alabio ♀].
result of the test using PCA showed that the meat putrid off-odor attribute was higher in the duck pure breed CC (positive area PC1), whereas the fatty attribute was reported at the AA duck column (positive area PC2). The AC and CA crossbreed ducks are represented on the graphic negative area. Based on the biplot graphic, it can be explained that the off-odor attributes such as putrid, moldy, and earthy are dominant in the CC purebreed duck meat, while fatty and rancid off-odor attributes were detected in the AA duck ancestor. The off-odor attribute of the AC and CA duck crossbreeds, thus, the crossbreed ducks resulted in a low intensity level of off-odor, especially in AC duck meat when compared to their ancestors. This result related to the off-odor intensity of AC ducks could be due to the meat fatty acid composition because of unsaturated fatty acid resulted lower compared to the other groups. Moreover, the level of likeness toward the meat aroma attribute was also very high for the panelist. So, the PCA results provided useful information about the similarities and differences for purebreed and crossbreed duck meat, as well as the significance of variables and the relationship among variables themselves.

In conclusion, crossbreeding Alabio and Cihateup ducks resulted in a meat fat level and fatty acid composition modifications. The crossbreed AC duck has lower fat content and enhanced lipid profiles, since unsaturated fatty acids such as oleic, linoleic, and linolenic acids were lower than pure breed ducks and crossbreed CA ducks. Moreover, the meat from AC ducks resulted in improved sensorial quality with lower off-odor intensity and meat was preferred by panelists.

Disclosure statement
No potential conflict of interest was reported by the authors.

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