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Carcass Production and Meat Tenderness Characteristics of Culled Quail Fed with *Azolla microphylla* Flour Supplemented Basal Feed

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ABSTRACT

The aim of this research was to understand the effect of *Azolla microphylla* flour supplementation in the basal feed on carcass production and meat tenderness characteristics of culled quail. The materials used in this research were 100 culled quails at 48-week-old age and commercial quail feed. The research was conducted as an experimental research and used Completely Randomized Design. Four treatments were done in this research, which was basal feed without *Azolla microphylla* flour supplementation; basal feed supplemented with 1% *Azolla microphylla* flour; basal feed supplemented with 2% *Azolla microphylla* flour, and basal feed supplemented with 3% *Azolla microphylla* flour. Each treatment was done 4 times with each fed into 5 quails. The observed variables include carcass production (carcass percentage, breast meat percentage, thigh meat percentage, back meat percentage, and wing meat percentage) and meat tenderness characteristics (meat fat content, collagen content, pH and meat tenderness). The obtained data were then analyzed by analysis of variance and if the result showed a significant effect, further analysis will be done by honestly significant difference test. The analysis of variance showed that *Azolla microphylla* flour supplementation showed significant effect ($P<0.05$) on the carcass percentage, breast meat percentage, meat fat content, collagen content, and meat tenderness but showed no significant effect ($P>0.05$) on the thigh meat percentage, back meat percentage, wings meat percentage and meat pH. The research concluded that *Azolla microphylla* flour supplementation in the basal feed will increase carcass production and meat tenderness of culled quail meat at maximum 2% of supplementation level.

Keywords: Carcass, Collagen, Meat fat, Culled quail, *Azolla microphylla flour*

Introduction

The egg-laying Quail (*Coturnix coturnix japonica*) can also be utilized as meat producers through the culling process after its egg production declined (Suprijatna *et al*., 2012). The quail meat has a high protein content, which reached 21.1%, with 7.70% fat, low cholesterols, rich of vitamins and micronutrients such as folate, vitamin B complex, vitamin E, vitamin K, iron, calcium, and phosphorus (Dahlia, 2014; Wahyuri *et al*., 2014). Furthermore, quail meat also rich in unsaturated fatty acid (Genchev *et al*., 2008). The egg-laying quail should be culled after its egg production declined and inefficient. However, when its meat will be utilized for consumption, the culled quail usually has low carcass percentage with relatively unfavorable meat characteristics, such as hard to chew/tough.

An effort to increase the culled quail's carcass percentage and meat qualities can be done through feed improvement. Alkan *et al.* (2009) stated that culled quail has a rather stable and flat growth rate, however, when it is fed with a better quality feed, it will yield more fats in the meat, resulting into more juicy and tender meat. The fat content in poultry meat is divided into three types based on its location, including subcutaneous fats located under the skin, abdominal fats located in the lower part of the abdomen, and intramuscular fats located between the muscle (Muchtadi *et al.,* 2010).

The commercial quail feed does not always give high quail's productivity, especially for the quails raised in the tropical area and for the old quails. On the contrary, quails required high-quality feed to support its production, thus an effort has to be done to improve the commercial feed quality. One effort can be done by giving feed additive on the basal feed which aimed to increase the carcass production and improve the meat quality. Furthermore, the feed additive should contain bioactive compounds which could increase the quail vitality, high protein content, and sustainable availability. One of the feed additives which meet the condition is *Azolla microphylla.*

Azolla microphylla is an aquatic fern which has fast growth, capable to replicate in around 2-10 days with daily growth phase reached 35%, thus showed its potentials to be utilized as feed ingredient (Hasan *et al*., 2009). *Azolla microphylla* flour showed several advantages when utilized for feed ingredients, as it has 23.78% protein, 19.83% ash, 14.07% water, 0.77% fats, and also several beneficial bioactive compounds such as flavonoid (0.42%), sitosterol (1.43%), stigmasterol (3.60%), β-carotene (1.09%), chlorophyll, cytosine, essential amino acids, alkaloid, steroid, saponin, tannin and phenol. Flavonoid is a potential secondary metabolite for antioxidant, protecting cell structure, increase the vitamin effectiveness, anti-inflammation, anti-fungi, anti-virus, anti-cancer and natural antibiotics (Geissman, 1962; Sukadana, 2010; Redha, 2010). Phytosterol is a plant-based sterol useful for a diuretic, hypoglycemic, and suppress the cholesterols absorption in the digestive tract, while also prevent and treat hyperlipidemia (Andayani, 2003; Bender, 2012; Wu *et al*., 2009). Furthermore, β-carotene is one form of the carotenoids, which are synthesized by plants. It is a strong antioxidant, which not only binds the singlet oxygen but also suppresses lipid peroxidation. The compound could also be converted into vitamin A, which both compounds could act as an antioxidant against free radicals in the body (Nishino *et al*., 2017).

Based on various beneficial contents in *Azolla microphylla*, the addition of the *Azolla microphylla* flour as feed additives is expected to increase the culled quail's performance, carcass production, and meat qualities. The aim of this research is to observe the effect of *Azolla microphylla* flour addition on the carcass production and meat qualities of the culled quails.

Materials and Methods

The materials used in this research were 100 culled quails at 48-week-old age and commercial quail feed. The culled quails are the quails which its egg production already declined to around 46-48% and economically unfavorable. The used commercial quail feeds were SP-22 produced by PT. Sinta Prima Feedmill. The *Azolla microphylla* was obtained by self-raising in the pond and harvested every two days. The nutritional content of SP-22 and *Azolla microphylla* flour can be seen in Table 1, and the nutritional content of the feed treatment can be seen in Table 2.

Battery cage with the dimensional value of 60 cm long, 16 cm width, and 25 cm, was used for quails raising. Each cage plots containing feed and water container were filled with five quails on a random placement. Other materials used in this research include a knife, scissors, a digital scale, analytical scale, plastic tray, and materials used for culled quail meat physical quality test.

This research used the experimental method with Completely Randomized Design. Four treatments were done in this research, which were basal feed without *Azolla microphylla* flour supplementation, basal feed supplemented with 1% *Azolla microphylla* flour, basal feed supplemented with 2% *Azolla microphylla* flour, and basal feed supplemented with 3% *Azolla microphylla* flour. Each treatment was done 4 times with each fed into 5 quails. The obtained data were then analyzed by analysis of variance and if the result showed a significant effect, further analysis will be done by Honestly Significant Difference test.

The quails raising was done in the research farm in Keniten Village, Kedungbanteng Sub-district, Banyumas District, for eight weeks, starting from February to April 2018. Preliminary treatment was done for 7 days before raising the quails to eliminate the feed effect factors before research was started. The feed treatment was given for 7 weeks, two times a day at 06.30 in the morning and 15.00 in the afternoon. Water was given ad libitum by placing it in the quail-specified drinking container. The quails were slaughtered at the age of 56 weeks and then cut to get the carcass and other parts followed by direct weight measurements. The breast meat then measured for its tenderness, collagen and fat content. The tenderness was measured with Warner-Bratzler shear force test (Soeparno, 2005). The collagen and fat content was measured with NIRS (Near

Table 1. The nutritional content of quail commercial feed and *Azolla microphylla* flour

Feed ingredients	Water content (%)	Protein content (%)	Lipid content (%)	Crude fiber content (%)	Ash content (%)
A. *microphylla* flour	14.07	23.78	0.77	23.97	19.83
Quail commercial feed SP-22	7.17	20.25	4.07	4.18	14.05

Proximate analysis was done in the Laboratory of Nutrition and Animal Feed, Faculty of Animal Husbandry, UNSOED.

Table 2. The nutritional content of feed treatment

	Basal feed	Basal feed + 1% A. *microphylla* flour	Basal feed + 2% A. *microphylla* flour	Basal feed + 3% A. *microphylla* flour
SP-22	100	100	100	100
A. *microphylla* flour	0	1	2	3
Water content (%)	7.17	7.31	7.45	7.60
Protein content (%)	20.25	20.49	20.73	20.96
Fat content (%)	4.07	4.08	4.09	4.10
Crude fiber content *(%)*	4.18	4.42	4.66	4.90
Ash content *(%)*	14.05	14.25	14.45	14.65

Infra-Red Spectroscopy). The carcass and other parts measurement were done in the Laboratory of Poultry Production, while physical quality was measured in the Laboratory of Meat Science and Technology, Faculty of Animal Science, Universitas Gadjah Mada.

Result and Discussion

Carcass production

The effect of *Azolla microphylla* flour supplementation in the basal feed on the culled quails' carcass production can be seen in Table 3. The culled quails' carcass production in this research showed a better result compared to Suprayogi (2012), which yielded 48.38±1.56-48.84±0.34% carcass production with cage density treatment. The analysis of variance showed *Azolla microphylla* flour supplementation in the basal feed gave a significant effect (P<0.05) to the carcass percentage of culled quails.

The increased carcass percentage is due to the high protein content in Azolla *microphylla* flour (23.78%). Furthermore, the protein in *Azolla microphylla* consisted of 45% non-essential amino acids and 55% essential amino acids, especially leucine, lysine, arginine, phenylalanine, and tyrosine as the substances are the dominant essential amino acids (Sanginga dan Van Hove, 1989). According to Sreenath dan Kannapan (2015), *Azolla microphylla* contained 40.53%%±1.14% essential amino acids, consisted of threonine as much as 7.61±0.12 g/100g protein, valine as much as 7.60±0.30 g/100g protein, leucine as much as 10.60±0.32g/100g protein, isoleucine as much as 5.75±0.19 g/100g protein, phenylalanine as much as 5.10±0.12 g/100g protein, lysine as much as 2.34±0.06 g/100g protein, methionine as much as 0.46±0.12 g/100g protein, tyrosine as much as 0.92±0.03 g/100g protein, aspartic acid as much as 11.58±0.53 g/100g protein, glutamic acid as much as 14.2±0.25g/100g protein, serine as much as 9.36±0.26g/100g protein, proline as much as 1.62±0.03 g/100g protein, glycine as much as 8.59±0.39g/100g protein, alanine as much as 7.86±0.39 g/100g protein, histidine as much as 3.30±0.09g/100g protein, arginine as much as 2.04±0.05 g/100g protein and tryptophan as much as 1.00±0.02 g/100g protein. The rich essential amino acids content in the *Azolla microphylla* will fulfill protein turnover in the body, resulting in higher carcass production in the culled quails fed with *Azolla microphylla* flour supplementation compared to sole basal feed. In addition, *Azolla microphylla* flour also contained 0.42% flavonoid and 1.09% β-carotene; those substances are known as growth promoters, capable to increase the production and reproduction performances and animal's immunity, while also acting as an antioxidant (Kurniawan *et al*., 2010; Surai, 2014; Tugiyanti *et al*., 2016). Mushawwir and Latipudin (2013) added that feeding flavonoid could increase humoral immunity and chicken productivity.

The average breast meat percentage in this research was around 21.374±0.508 to 27.425±4.556% (Table 3); lower than the research done by Nugraeni (2012) which yielded 44.67±1.00-45.40±0.69% culled quail breast meat with cage density treatment. The analysis of variance showed that *Azolla microphylla* flour supplementation in basal feed gave a significant effect (P<0.05) to the breast meat percentage of culled quails. The honestly significant difference test showed that culled quails fed with 1% and 2% *Azolla microphylla* flour supplemented basal feed yield different breast meat percentage compared to sole basal feed and 3% supplementation, indicates that the protein content in *Azolla microphylla* flour was deposited in the breast area. The result is in accordance with Mentari *et al*. (2014), which stated that consumed protein in poultry will be deposited in the breast area. However, *Azolla microphylla* flour contained high crude fibers, which is around 23.97%, restricting its potential as feed ingredients noting that higher crude fibers consumption resulted in faster peristalsis and digestive rates in the intestine, while also lower the nutrient absorption (Amrullah, 2004). This explains the lower breast meat percentage in culled quails fed with 3% *Azolla microphylla* flour supplemented basal feed compared to the 1% and 2% supplementation level.

The average thigh, back, and wing meat percentages of culled quails were around 11.162±2.206 - 12.941±1.766%, 10.619±0.818 - 12.640±0.769% and 9.783±0.423 - 10.307±0.461% respectively (Tabel 3). The result of this research is lower compared to research done by Suprayogi (2012), which were around 30.18±0.55-30.98±0.47%, 26.40±2.07-27.56±0.57 and 14.09±0.16-14.98±0.20% with cage density treatment. The differences are caused by the changes in carcass composition as the quails mature, especially on the thigh and breast area (Sarjana *et al*., 2010). Analysis of variance

Table 3. The effect of *Azolla microphylla* flour supplementation in the basal feed on the culled quail carcass production

Treatment	Carcass percentage	Breast meat percentage	Thigh meat percentage	Back meat percentage	Wing meat percentage
Basal feed	55.014±0.640[a]	21.374±0.508[a]	11.162±2.206[ns]	12.520±3.365[ns]	9.949±1.222[ns]
Basal feed + 1% *A. microphylla* flour	59.297±4.772[b]	24.780±4.526[b]	12.941±1.766[ns]	10.670±0.680[ns]	10.219±0.408[ns]
Basal feed + 2% *A. microphylla* flour	59.452±1.015[b]	27.425±4.556[b]	12.450±0.420[ns]	10.619±0.818[ns]	10.307±0.461[ns]
Basal feed + 3% *A. microphylla* flour	59.176±0.769[b]	22.983±2.306[a]	11.439±0.769[ns]	12.640±0.769[ns]	9.783±0.423[ns]

Different superscripts in the same column showed a significantly different effect (P <0.05). The same superscript in the same column showed a significantly different effect (P>0.05).

showed that *Azolla microphylla* flour supplementation in basal feed did not give significant effect (P>0.05) to the thigh, back, and wing meat percentage of culled quail meat. The result is caused by the condition that those respective areas are used for the quails' daily activity such as standing and maintaining body balance. Furthermore, the culled quails were more active compared to quails which still have high egg productivity, regarding that culled quails will have more time to move than staying idle for egg production. In addition, the result showed that the nutritional and bioactive content in *Azolla microphylla* flour supplemented in the basal feed is not enough to fulfill the requirement for those three carcass parts.

Meat tenderness

The meat tenderness is one of the factors which determine meat quality. Furthermore, meat tenderness is affected by several factors, including fat content, collagen content, and pH (Soeparno, 2005; Tambunan, 2009; Tugiyanti *et al*., 2013). The average meat fat content in this research was around 3.598±0.021-4.584±0.064% (Table 4), significantly lower compared to the research done by Febriana (2015), which reported that the fat content on quails meat fed with noni leaves flower was 17.71%.

The low meat fat content in the culled quails' meat is caused by the antioxidant compounds occurred in the *Azolla microphylla* flour, such as flavonoid, saponin, and tannin. Those compounds will elevate the lipoprotein lipase enzymatic activity (Khakim, 2000), resulting in higher fat degradation or lipolysis in the fatty tissue. Rodrigues *et al*. (2005), also added that flavonoid, saponin, and tannin suppress the fatty acid synthesis, while Kuppusamy and Das (1994) stated that cell adipogenesis and adipocytes also suppressed by the compounds. Furthermore, the availability of polyphenol and flavonoid in feed significantly suppress the occurrence of hyperlipidemia (Xia *et al*., 2010). Hsu and Yen (2007) added that flavonoid and polyphenol also suppress the Gliserol 3-phosphate dehydrogenase (GPDH) enzymatic activity in adipocytes, while saponin is known to suppress lipid absorption in the intestine, thus excreted in feces (Dong *et al*., 2007).

The analysis of variance showed that *Azolla microphylla* flour supplementation in the basal feed significantly affect (P<0.05) the fat content in the culled quails meat. The honestly significant difference test showed different meat fat content between culled quails fed with solely basal feed and fed with basal feed with *Azolla microphylla* flour supplementation. It is caused by the antioxidant compounds in the *Azolla microphylla* flour which improve the quails' vitality. The culled quails' fed with *Azolla microphylla* flour supplemented basal feed had a higher consumption rate compared to the control groups (fed with sole basal feed). The culled quails which fed without *Azolla microphylla* flour supplementation consumed around 23.89±3.24 g feed daily, while culled quails which fed with 1% *Azolla microphylla* flour supplemented basal feed consumed 26.10±2.46 g feed daily. Furthermore, the culled quails which fed with 2% *Azolla microphylla* flour supplemented basal feed consumed 27.45±4.02g feed daily, and culled quails which fed with 3% *Azolla microphylla* flour supplemented basal feed consumed 27.59±3.94g feed daily. The higher consumption rate resulted in the higher fat content, thus culled quails which fed with *Azolla microphylla* flour supplemented basal feed will have higher meat fat content.

The average collagen content in the culled quails meat in this research was around 1.700±0.163-2.280±0.014%, relatively similar with the research done by Maiorano *et al*. (2011) which is 1.938±0.079-2.484±0.0162% on quails with different genetic groups, but higher than research done by Tavaniello *et al*. (2014), which is 1.322±0.042–1.414±0.061% in Japanese quails. The analysis of variance showed that *Azolla microphylla* flour supplementation in basal feed gave a significant effect (P<0.05) to the collagen content in the culled quails meat (Table 4). The result of honestly significant difference showed different collagen content between quails fed with and without *Azolla microphylla* flour supplementation. The collagen content in culled quails' meat fed with *Azolla microphylla* flour supplementation had lower collagen content, which resulted in more tender meat. This is regarding that the active compounds in *Azolla microphylla* flour, such as flavonoid, triterpenoid, saponin, tannin and essential oil had antioxidant properties. Those compounds are capable to stimulate faster collagen biosynthesis, up to the remodeling phase. The simultaneous collagen synthesis and degradation are occurred during the remodeling phase, resulting in lower collagen synthesis compared to the proliferation phase which also yields imperfect collagen synthesis (Han *et al*., 2017), thus improve the production

Table 4. The effect of *Azolla microphylla* flour supplementation in the feed on the culled quail meat characteristics

Treatment	Meat fat content (%)	Collagen content (%)	pH	Meat tenderness (kg/cm^2)
Basal feed	3.598±0.021^a	1.856±0.078^a	6.246±0.021^{ns}	1.560±0.177^b
Basal feed + 1% *A. microphylla* flour	4.584±0.064^b	1.700±0.163^a	6.190±0.064^{ns}	1.170±0.071^a
Basal feed + 2% *A. microphylla* flour	4.260±0.556^b	1.774±0.233^a	6.120±0.042^{ns}	1.550±0.955^b
Basal feed + 3% *A. microphylla* flour	4.410±0.141^b	2.280±0.014^b	6.104±0.014^{ns}	1.560±0.354^b

Different superscripts in the same column showed a significantly different effect (P <0.05). The same superscript in the same column showed a significantly different effect (P>0.05).

performance and meat quality which are tender and has low cholesterol (Gopi *et al*., 2015).

The average pH value in culled quails' meat fed with *Azolla mycrophylla* flour supplemented basal feed was around 6.104±00014-6.246±0.021, relatively similar with the result of Genchev *et al*. (2008), which was around 6.2-6.3 for Japanese quails' meat. The analysis of variance showed that *Azolla mycrophylla* flour supplementation in basal feed gave a non-significant difference (P>0.05) to the meat pH of culled quails' meat. This indicates that the antioxidant properties of the active compounds and protein in the *Azolla mycrophylla* flour could maintain the hydrogen ions balance in the culled quails' meat. Shebis *et al*. (2013), stated that the antioxidant compounds work by donating hydrogen atom in the metabolism process, in which preventing the pH change caused by glycolysis process and lactic acids production.

The average meat tenderness of culled quails' meat fed with *Azolla mycrophylla* flour supplemented basal feed was around 1.170±0.071-1.560±0.177 kg/cm^2, relatively similar to the research done by Wahyuninghasti *et al*. (2017), which showed that the culled quails' meat tenderness in the m*usculus pectoralis* area was around 0.79-1.26 kg/cm^2 after supplemented by several vitamins in the drink. However, the analysis of variance showed that the *Azolla microphylla* flour supplementation in basal feed showed a significant difference (P<0.05) to the meat tenderness of culled quails meat. The result indicates that the flavonoid, β-carotene, chlorophyll, and other active compounds which have antioxidant properties in the *Azolla microphylla* flour could act as a natural antioxidant which reduces the oxidation rate by donating its hydrogen (Afrila dan Jaya, 2012). On the other hand, the phenolic compound in *Azolla microphylla* flour is able to reduce, absorb, while also neutralize free radicals and peroxide decompositions (Javanmardi *et al.,* 2003). The availability of natural antioxidants in *Azolla microphylla* flour also helps the protein decomposition in meat, resulting in an easier to digest meat (Dono, 2010). Furthermore, the natural antioxidants also maintain the physical properties in meat which determine its quality (Soeparno, 2005).

Conclusions

Azolla microphylla flour supplementation in feed could improve the carcass percentage and culled quail breast meat, while also increase the fat content, reduce the collagen content and increase meat tenderness. However, at 3% *Azolla microphylla* flour supplementation level, the increased collagen would suppress the meat tenderness. The carcass production and meat tenderness of culled quail can be improved by *Azolla microphylla* flour supplementation in basal feed at a maximum of 2% supplementation level.

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