



Impact of feed macronutrient composition on the nutritional quality of duck meat in intensive farming systems, Central Java, Indonesia

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ABSTRACT

The quality of duck meat is closely related to the nutritional composition of the feed. Therefore, this study aimed to analyze the relationship between the nutritional content of feed and duck meat from intensive farms in Central Java. This research was an exploratory study to measure proximate levels of macronutrients including carbohydrates, protein and crude fat in feed and duck meat. The study was conducted at five duck farms (A, B, C, D and E), and females ducks aged ± 1.5 years were selected. The proximate level in percentage was then analyzed statistically to determine the real difference and correlation. The results showed that the feed quality in the five farms was dominated by carbohydrates which reached more than 32%, and the highest levels were obtained from Farm E which reached $51.87 \pm 2.65\%$ (p value = 0.017). Meanwhile, a negative correlation was shown between the carbohydrate content of feed and meat, which means that an increase in carbohydrate content was associated with a decrease in protein content. It may be concluded that the proximate composition of duck feed in five farms has met the nutritional needs and was dominated by carbohydrates, followed by protein and crude fat content.

Keywords: Carbohydrate, Nutrition, Meat quality, Overfeeding, Proximate analysis

The main issue in terms of poultry production is the increasing demand for animal protein. The demand for animal protein is increasing along with the increasing economic status globally. The increase in animal protein consumption has its own consequences, because the sustainability of poultry production is influenced by many aspects, including feed supply, environmental impact, disease, use of natural resources, and animal welfare. Waterfowl production, especially ducks, plays a positive role in the provision of animal protein. Duck farming has been very dynamic in recent years. According to the Indonesian Central Statistics Agency, the number of ducks in Indonesia has fluctuated, recorded at 56.6 million in 2021, 56.7 million in 2022, then decreased to 33.4 million in 2023 and 43.5 million in 2024 (Badan Pusat Statistik [BPS], 2025a). Mostly, the duck population in Indonesia is raised on the island of Java, where the province of Central Java ranks third with a total population of 6.2 million heads with meat production reaching more than 9,114 tons by 2024 (BPS, 2025b).

Domestic duck breeding has gradually changed

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from traditional to modern methods. Modern duck production is directed at achieving good duck performance, meat quality, and high feed conversion ratio (FCR). Global environmental issues have also accelerated the change in domestic duck farming methods. The majority of modern duck farming is carried out using an intensive model in closed cages to ensure the composition and consumption of feed but it can face problems such as overfeeding and the use of high-carbohydrates feeds. This is because the need for carbohydrates as an energy source has a major impact on the reproduction and quality of duck meat (Fouad *et al.* 2018). Therefore, need for carbohydrates must be considered in providing duck feed (Fouad *et al.* 2018; Rodenburg *et al.* 2005). Furthermore, the intensive system causes a decrease in metabolic rate due to the limited activity of ducks, so that sugar is converted into fat and undergoes deposition.

In the growth phase, ducks require energy consumption of up to 3000 kcal, although excess sugar has a negative impact on the quality of duck fat deposits (Xia *et al.* 2019). Overfeeding causes fattening of the meat and accelerates the oxidation process to reduce the quality of duck meat. Accumulation of fat can cause prolapse and/ or oviducal inflammation to a decrease in duck productivity (Assersohn *et al.* 2021). Ducks fed complete feed based on corn and soybean meal in the right amounts can produce eggs with better antioxidant activity, egg volume and egg weight (Susanti *et al.* 2025).

The modern duck industry is relatively small in most

parts of the world, including Indonesia. Duck farming not only aims at economic fulfillment, but also at developing rural areas. Each duck farming center in different regions in Indonesia, including in Central Java province, has developed a unique duck maintenance system according to the potential of its natural and human resources. It is very important to analyze the nutritional content of feed on the quality of duck meat as a reference for breeders in compiling the optimal composition of feed. Therefore, this study aimed to analyze the nutritional content of feed and meat in intensive duck farms in Central Java.

MATERIALS AND METHODS

Research design: This research was a observational exploratory evaluation of duck feed quality across intensive-duck farm in Central Java. The sample was selected using a purposive sampling method with the following criteria: 1) Peking duck farms with an intensive system in Central Java, and 2) the number of ducks in the cage was 200-500, whth the selected ducks being females aged ± 1.5 years. Based on these criteria, five research loci were selected, namely duck Farm A, B, C, D and E (Table 1). Sampling of ducks was carried out by taking 5 ducks at random, as well as conducting direct interviews with livestock owners about the feeding pattern and maintenance of ducks.

Sample preparation: Feed samples were collected based on the actual mixture provided by farmers from each sampling location. Then up to 1 kg of mixture duck feed sample were collected for proximate analysis. Following slaughter meat samples were collected from the thickest

portion of the thigh and breast muscle (meat) for further sampling. Each thigh and breast meat were cut into blocks of 2x2x3 cm size and weighed. Then 100 g of meat samples were used for proximate analysis. Furthermore, feed and duck meat samples were taken and stored at -20 °C in the Biochemistry Laboratory, Biology Department, Universitas Negeri Semarang.

Proximate analysis: Feed and meat proximate composition (water, ash, protein, fat, carbohydrate) was determined according to Association of Official Analytical Chemists (AOAC) standard procedure (AOAC, 2022). The proximate approach was selected because macronutrients such as protein, fat, and carbohydrate are the primary determinants of duck meat quality, influencing muscle growth, fat deposition, and overall nutritive value. Proximate analysis provides a direct and practical comparison with the National Research Council (NRC, 1994) nutrient requirements for ducks and Indonesian feed standards to evaluate the feed compositions used by farmers align with recommended levels (Table 2). Furthermore, the non-standardized feed was evaluated to identify deficiencies or excesses in specific macronutrients and to assess how such imbalances may affect meat quality and reproductive performance.

Data analysis: All proximate data were tabulated as mean ± SD. One-way ANOVA was used to test differences across farms, followed by Least Significant Difference (LSD) post-hoc test at 95% confidence level (Nasrizal *et al.* 2021). Spearman correlation was applied to assess the relationship between feed macronutrients and duck meat

Table 1. Intensive duck farms location in Central Java

| Code | Regions/ Cities | Coordinates | Characteristics of Geography |
|------|--------------------|---------------------------|--|
| A | Semarang City | 6°56'46.1"S 110°26'20.0"E | North Java Sea Coast, fishing settlement and directly adjacent to the sea. |
| B | Pati | 6°39'29.7"S 111°05'21.4"E | 2 km from the North Java Sea Coastline, bordered by rice fields, and far from settlements |
| C | Temanggung | 7°19'04.8"S 110°09'01.9"E | Located in highland middle of Central Java Highland (986 m.a.s.l), located in a rice field area, the availability of running water is abundant |
| D | Magelang | 7°38'02.7"S 110°16'26.0"E | Located middle of Central Java Lowland (12 m.a.s.l), located in a rice field area, the availability of running water is abundant. |
| E | Salatiga City | 7°17'30.7"S 110°23'45.8"E | Highland (585 m.a.s.l), located in a rice field area, far from settlements |

Table 2. Minimum proximate composition thresholds of duck feed based on NRC and SNI for grower and laying phases

| Nutrient Composition (Proximate) | NRC (1994) – Peking Ducks | SNI 8508:2018 (Broiler Ducks, Grower Phase) | SNI 2006 (Peking Ducks, 14–56 days) |
|-------------------------------------|---------------------------|--|--|
| Metabolizable Energy (kcal/kg) | ~2,900 | ≥ 2,600 | ≥ 2,600 |
| Crude Protein (%) | ~22 (starter) | ≥ 18 | ≥ 14 |
| Crude Fat (%) | 2.5 – 3 | ≥ 3 | ≤ 7 |
| Crude Fiber (%) | ≤ 5 – 6 | ≤ 5 | ≤ 8 |
| Ash (%) | ≤ 8 | ≤ 8 | – |
| Moisture (%) | – | ≤ 14 | – |

composition. In addition, deviations from NRC (1994) recommendations were quantified, and their potential impact on duck meat quality (protein, fat deposition) and breeding ability were discussed. Statistical analysis was conducted using SPSS ver. 22.0.

RESULTS AND DISCUSSION

Duck feed is the primary determinant of nutrient intake and directly affects growth, reproduction, and the stability in egg production in Peking ducks. The feed composition identified across the five farms (A–E) revealed varied raw materials, though most were dominated by rice bran and dried leftover rice (Table 3). Additional types of feed are generally found in almost all farms such as kangkong and trash fish/molluscs as a source of protein. This shows that there is a uniform pattern of knowledge in feeding. In addition, the type of feed used is also dominated by carbohydrates sourced from leftover dried rice and bran. The use of rice bran and leftover-dried rice as a substitute for

concentrate feed is based on production economics because the price is cheap and easy to obtain. The proximate profile of duck meat is influenced by various factors, including nutrients intake, rearing system (Umagiliya *et al.* 2022; Tanganyika & Webb, 2019), age, species, sex, and genetics (Huang *et al.* 2023; Tanganyika & Webb, 2019).

Proximate analysis demonstrated significant differences in macronutrient composition across farms (Table 4; $p < 0.05$). Despite these differences, most feed samples fulfilled the minimum requirements for duck feed according to Indonesian National Standards (SNI 8508:2018) and National Research Council (NRC, 1994) (Figure 1). This suggests that, although farmers utilize locally available raw materials, nutritional adequacy is generally maintained.

Carbohydrates were consistently the dominant macronutrient, exceeding 30% in all samples, with the highest levels recorded in Farm B ($50.37 \pm 2.37\%$) and Farm E ($51.87 \pm 2.65\%$). The high carbohydrate concentration was likely driven by extensive use of rice bran and rice residues as substitutes for commercial concentrate. This aligns with reports that smallholder farmers often prioritize carbohydrate-rich feed for cost efficiency (Getahun *et al.* 2025; Hadiatry and Oosting, 2019; Ismoyowati, *et al.* 2020). However, over-reliance on carbohydrates can lead to excess triglyceride synthesis in the liver, contributing to fat accumulation in adipose tissue (Hérault *et al.* 2019; Pioche *et al.* 2019). Although this effect was evident in some farms, the fat levels in duck meat remained within low to moderate ranges (3.38–5.17%), consistent with findings by Zhang *et al.* (2022) and Kokoszyński *et al.* (2019), suggesting that compensatory factors such as feed diversity and farm management may have mitigated the

Table 3. Types of feed used by farms at sampling locations

| Duck farms | Feed Composition |
|------------|---|
| A | Grated coconut dregs, leftover dried rice, trash fish and shrimp heads. water spinach |
| B | Concentrate, winkle |
| C | Rice bran, concentrate, leftover dried rice, water spinach |
| D | Leftover dried rice, rice bran and concentrate, trash fish |
| E | Bran, Concentrate |

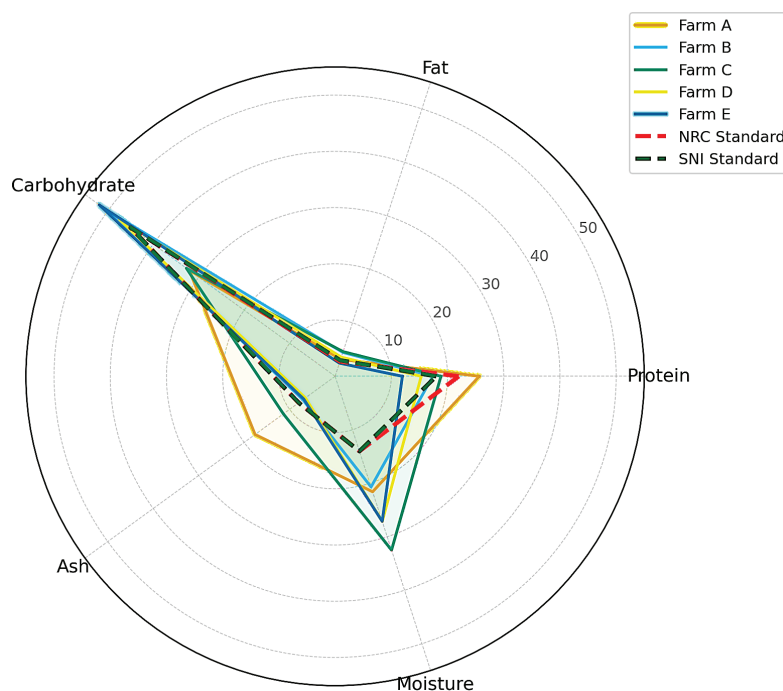


Fig. 1 Comparison of proximate composition of duck feed from intensive farms in Central Java with NRC and SNI standards.

Table 4. Macronutrient concentration in feed from intensive-duck farms center in Central Java

| Macro nutrition (%) | Feed | | | | | p-value |
|---------------------|----------------------------|---------------------------|---------------------------|---------------------------|----------------------------|---------|
| | A | B | C | D | E | |
| Carbohydrate | 32.07 ± 3.82 ^a | 50.37 ± 2.37 ^b | 32.71 ± 4.77 ^a | 47.43 ± 1.70 ^a | 51.87 ± 2.65 ^{ab} | 0.017 |
| Protein | 25.65 ± 5.25 ^a | 17.38 ± 3.36 ^a | 18.83 ± 5.61 ^a | 15.32 ± 5.15 ^a | 11.97 ± 5.39 ^b | 0.044 |
| Fat | 3.18 ± 0.09 ^a | 4.46 ± 0.07 ^b | 4.60 ± 0.07 ^b | 3.57 ± 0.04 ^c | 2.46 ± 0.13 ^d | 0.000 |
| Ash | 17.60 ± 7.37 ^{ab} | 7.10 ± 3.48 ^b | 11.37 ± 0.62 ^a | 6.53 ± 0.35 ^a | 6.89 ± 0.80 ^a | 0.046 |
| Moisture | 21.59 ± 1.94 ^a | 20.69 ± 0.41 ^a | 32.49 ± 0.65 ^b | 27.15 ± 2.51 ^c | 27.11 ± 2.35 ^c | 0.031 |

Note: Superscript alphabet (a-d) shows a significant difference between groups of one-way ANOVA test results with a significant level = 0.05 and a confidence level = 95%. Feed feasibility criteria: moisture content ≤14%; crude protein ≥18%, crude fat ≥ 3%, ash ≤8%, and crude fiber ≤5% (Indonesian National Standards Agency; SNI 8508:2018).

adverse effects.

Feed protein levels varied significantly ($p = 0.044$), with Farm A recording the highest concentration ($25.65 \pm 5.25\%$). This was associated with supplemental feeding using shrimp shells and trash fish. However, the protein content of meat did not directly mirror the protein content of feed. In fact, ducks from Farm C, which had only moderate protein feed ($18.83 \pm 5.61\%$), produced the highest meat protein (17.85%) (Table 5). This suggests that feeding frequency, absorption efficiency, and housing systems contribute to protein deposition in muscle (Bai *et al.* 2022; Huo *et al.* 2023). By contrast, Farm A meat had the lowest protein (6.67%), perhaps as the supplemental protein was provided irregularly (twice per week), reducing its impact on muscle growth. This is in line with Carney *et al.* (2022), who emphasized that protein supply must be consistent to support muscle accretion in poultry. Previous study shows that protein content of Peking duck meat reaches 15% lower than that of Muscovy and Mulard ducks, but the fat content of Peking duck meat is higher than that of Muscovy and Mulard ducks (Slobodyanik *et al.* 2021). Feeding fish and shrimp as additional feed for ducks in Farm A may not have a significant effect on the protein content of meat. This is probably due to the addition of protein which was done only twice per week. Meanwhile, the high protein content of meat in the other three sample locations was probably due to the main protein source from the feed used every day. This has an impact on the adequacy of daily protein needs for ducks. In addition, the pattern of maintenance out of the drum may also contribute to an increase in muscle mass so that it has an impact on the high content of muscle

protein.

Fat levels also varied significantly ($p < 0.001$) ranged from 3.38 to 5.17% (Table 5), with higher concentration found in Farm B and Farm C, consistent with NRC standards (4–7%) (Figure 1). Elevated fat levels in these farms may be attributed to inclusion of oil-rich feedstuffs (Assersohn *et al.* 2021). The results of the study by Slobodyanik *et al.* (2021) showed that the fat content of Peking duck meat was 35%. The crude fat content of duck meat is reported to be higher in semi-intensive systems compared to extensive systems (Umagiliya *et al.* 2022). The crude fat content of meat in groups of ducks kept in cages (intensive) is greater than that of ducks kept semi-intensively (Bai *et al.* 2021). Crossbred cherry valley and Chinese crested ducks have higher intramuscular fat content, lower saturated fatty acids and higher monounsaturated fatty acids than Cherry Valley ducks (Huang *et al.* 2023). Interestingly, correlation analysis showed that higher carbohydrate intake was positively correlated with increased fat deposition in Farm D and E (Tables 6), while negatively correlated with meat protein content. This observation supports the theory that excess dietary carbohydrates are converted into lipids via hepatic de novo lipogenesis, which in turn reduces nitrogen allocation to muscle protein synthesis (Tumanggor *et al.* 2017; Wang *et al.* 2018).

Ash and water contents also displayed significant variation ($p < 0.05$). Ash content was highest in Farm A ($17.60 \pm 7.37\%$), possibly reflecting mineral-rich feed supplements, while water content peaked in Farm C ($32.49 \pm 0.65\%$). Correlation analysis demonstrated a consistent negative relationship between water and macronutrient

Table 5. Macronutrient compounds concentration in duck meat from intensive-duck farming center in Central Java

| Macro nutrition (%) | Meat | | | | | p-value |
|---------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------|
| | A | B | C | D | E | |
| Carbohydrate | 25.21 ± 2.26 | 22.16 ± 0.82 | 24.44 ± 1.22 | 24.01 ± 1.31 | 23.12 ± 0.70 | 0.873 |
| Protein | 6.67 ± 2.51 ^a | 11.21 ± 1.98 ^b | 17.85 ± 5.57 ^c | 15.32 ± 3.99 ^c | 13.51 ± 2.75 ^c | 0.018 |
| Fat | 3.38 ± 0.19 | 3.39 ± 0.58 | 5.17 ± 0.77 | 3.57 ± 0.03 | 3.94 ± 0.24 | 0.047 |
| Ash | 51.24 ± 2.03 ^a | 50.60 ± 2.47 ^a | 44.81 ± 1.07 ^a | 6.53 ± 0.27 ^b | 52.55 ± 2.30 ^a | 0.003 |
| Water | 8.53 ± 1.41 ^a | 7.49 ± 1.31 ^a | 5.77 ± 0.62 ^b | 27.15 ± 1.95 ^c | 8.20 ± 1.27 ^a | 0.002 |

Note: Superscript alphabet (a-d) shows a significant difference between groups of one-way ANOVA test results with a significant level = 0.050 and a confidence level = 95%.

Table 6. Correlation of macronutrients in feed and duck meat from A intensive-duck farming center

| Site | Prox. | Feed | | | | | Meat | | | | | |
|-------------|-------|---------|---------|-------|-------|-------|-------|---------|--------|--------|--------|--------|
| | | Carb. | Protein | Fat | Ash | Water | Carb. | Protein | Fat | Ash | Water | |
| Duck Fram A | Feed | Carb. | 1 | -0.39 | -0.99 | 0.24 | -0.83 | -0.2 | 0.82 | 0.12 | 0.86 | 0.72 |
| | | Protein | | 1 | 0.23 | -0.99 | 0.84 | 0.98 | -0.85 | -0.96 | -0.8 | -0.92 |
| | | Fat | | | 1 | -0.07 | 0.73 | 0.03 | -0.71 | 0.06 | -0.76 | -0.59 |
| | | Ash | | | | 1 | -0.74 | -0.99* | 0.75 | 0.99 | 0.7 | 0.85 |
| | | Water | | | | | 1 | 0.71 | -1.00* | -0.65 | -0.99* | -0.99 |
| | Meat | Carb. | | | | | | 1 | -0.21 | -0.85 | -0.23 | -0.26 |
| | | Protein | | | | | | | 1 | 0.64 | 0.99* | 0.97* |
| | | Fat | | | | | | | | 1 | 0.65 | 0.69 |
| | | Ash | | | | | | | | | 1 | 0.99* |
| | | Water | | | | | | | | | | 1 |
| Duck Fram B | Feed | Carb. | 1 | -0.85 | 0.32 | -0.04 | -0.66 | 0.65 | 0.5 | 0.68 | 0.35 | -0.34 |
| | | Protein | | 1 | 0.23 | -0.49 | 0.16 | -0.15 | -0.88 | -0.19 | -0.79 | -0.21 |
| | | Fat | | | 1 | -0.96 | -0.93 | 0.93 | -0.66 | 0.91 | -0.77 | -1.00* |
| | | Ash | | | | 1 | 0.78 | -0.79 | 0.85 | -0.76 | 0.92 | 0.95 |
| | | Water | | | | | 1 | -1.00* | 0.33 | -1.00* | 0.47 | 0.93 |
| | Meat | Carb. | | | | | | 1 | -0.14 | 0.65 | -0.32 | -0.84 |
| | | Protein | | | | | | | 1 | -0.69 | 0.24 | -0.06 |
| | | Fat | | | | | | | | 1 | -0.34 | -0.5 |
| | | Ash | | | | | | | | | 1 | 0.71 |
| | | Water | | | | | | | | | | 1 |
| Duck Fram C | Feed | Carb. | 1 | -0.85 | 0.32 | -0.04 | -0.66 | 0.65 | 0.5 | 0.68 | 0.35 | -0.34 |
| | | Protein | | 1 | 0.23 | -0.49 | 0.16 | -0.15 | -0.88 | -0.19 | -0.79 | -0.21 |
| | | Fat | | | 1 | -0.96 | -0.93 | 0.93 | -0.66 | 0.91 | -0.77 | -1.00* |
| | | Ash | | | | 1 | 0.78 | -0.79 | 0.85 | -0.76 | 0.92 | 0.95 |
| | | Water | | | | | 1 | -1.00* | 0.33 | -1.00* | 0.47 | 0.93 |
| | Meat | Carb. | | | | | | 1 | -0.14 | 0.65 | -0.32 | -0.84 |
| | | Protein | | | | | | | 1 | -0.69 | 0.24 | -0.06 |
| | | Fat | | | | | | | | 1 | -0.34 | -0.5 |
| | | Ash | | | | | | | | | 1 | 0.71 |
| | | Water | | | | | | | | | | 1 |
| Duck Fram D | Feed | Carb. | 1 | 0.33 | 0.38 | 0.95 | 0.55 | 0.74 | -1.00* | 1.00* | 0.81 | 0.87 |
| | | Protein | | 1 | 0.99* | 0 | 0.97 | -0.39 | 0.34 | -0.34 | -0.29 | -0.18 |
| | | Fat | | | 1 | 0.06 | 0.98 | -0.34 | 0.39 | -0.39 | -0.23 | -0.12 |
| | | Ash | | | | 1 | 0.25 | 0.92 | 0.94 | -0.94 | 0.96 | 0.98 |
| | | Water | | | | | 1 | -0.15 | 0.56 | -0.56 | -0.04 | 0.07 |
| | Meat | Carb. | | | | | | 1 | 0.77 | -0.53 | 0.98* | 0.93* |
| | | Protein | | | | | | | 1 | -0.7 | 0.8 | 0.81 |
| | | Fat | | | | | | | | 1 | -0.65 | -0.8 |
| | | Ash | | | | | | | | | 1 | 0.97* |
| | | Water | | | | | | | | | | 1 |

contd...

Concluded

| Site | Prox. | Feed | | | | | Meat | | | | | |
|-------------------|-------|---------|---------|------|------|-------|-------|---------|--------|-------|-------|-------|
| | | Carb. | Protein | Fat | Ash | Water | Carb. | Protein | Fat | Ash | Water | |
| Duck Fram E | Feed | Carb. | 1 | 0.25 | 0.97 | 0.09 | -0.47 | 0.9 | -0.98 | 1.00* | 0.88 | 0.87 |
| | | Protein | | 1 | 0.48 | -0.94 | 0.74 | -0.2 | -0.46 | 0.25 | -0.25 | -0.27 |
| | | Fat | | | 1 | -0.16 | -0.24 | 0.76 | -1.00* | 0.97 | 0.73 | 0.72 |
| | | Ash | | | | 1 | -0.92 | 0.52 | 0.13 | 0.09 | 0.56 | 0.58 |
| | | Water | | | | | 1 | -0.81 | 0.27 | -0.47 | -0.84 | -0.85 |
| | Meat | Carb. | | | | | | 1 | -0.66 | 0.16 | 0.85 | 0.92* |
| | | Protein | | | | | | | 1 | 0.4 | -0.35 | -0.36 |
| | | Fat | | | | | | | | 1 | 0.52 | 0.51 |
| | | Ash | | | | | | | | | 1 | 0.96* |
| | | Water | | | | | | | | | | 1 |

Note: The asterisk (*) superscript indicates a significant correlation between variables at a significant level = 0.050 and a confidence level = 95%. A negative value indicates the direction of correlation between variables is antagonistic, while a positive value indicates a unidirectional relationship between variables.

concentrations across samples (Table 6). This finding support previous study that higher moisture dilutes proximate nutrient densities (Zhang *et al.* 2023). This finding is crucial for feed storage and quality assessment, as high water levels increase susceptibility to microbial spoilage and reduce nutrient stability.

The relationship between feed proximate composition and meat proximate content was generally weak, as indicated by nonsignificant correlations in most farms (Table 6). However, two notable exceptions were observed, including in Farm D, carbohydrate intake was negatively correlated with meat protein and positively correlated with fat deposition ($p < 0.05$). Then, in Farm E, carbohydrate levels in feed were positively correlated with both fat and ash content in meat. These findings suggest that overfeeding contains excess carbohydrate has a direct effect on lipogenesis and potentially reduces protein deposition, consistent with the concept of nutrient partitioning in poultry (Luo *et al.* 2023). Overfeeding also has an impact on increasing body weight and liver weight, as an implication of the accumulation of fat stored in the subcutaneous and abdominal areas (Bonfont *et al.* 2019; Wei *et al.* 2020).

Interestingly, despite high carbohydrate intake, meat fat levels remained lower than reported in other intensive systems. For instance, Slobodyanik *et al.* (2021) reported 35% fat in Peking duck meat under semi-intensive rearing, while the current study showed only 3.38–5.17%. This could be explained by feed diversification with fibrous materials such as water spinach and coconut pulp observed in the surveyed farms. Dietary fiber may have improved lipid metabolism and limited fat deposition (Bai *et al.* 2021). Additionally, supplemental shellfish and mollusks are likely to have contributed to protein quality improvement by providing balanced amino acid profiles, despite inconsistent feeding.

Furthermore, in intensive farming, ducks have low

physical activity, so the carbohydrates consumed are converted into blood sugar quickly and sent to the liver to be converted into triglycerides (Tumanggor *et al.* 2017; Wang *et al.* 2018). When triglyceride synthesis in the liver exceeds apolipoprotein secretion and the rate of fatty acid oxidation, fat begins to accumulate in the liver and in peripheral adipose tissue (Eitan & Soller, 2009; Assersohn *et al.* 2021). However, the accumulation of triglyceride may not have much effect on the quality of the meat, as indicated by the fat content of duck meat in five farms is still at low levels (Kokoszynski *et al.* 2020; Baéza *et al.* 2022; Baéza and Huang, 2022).

Based on the observation, the farmers in the five farms also diversified additional feed by mixing fiber sources such as kale and coconut pulp to maintain nutritional balance. This is likely to keep the fat content of duck meat at a low level. Additional feeding such as kale and shellfish can improve the nutritional quality of feed (Tumanggor *et al.* 2017). Shellfish contains protein so that it can be used to increase the protein content in feed. In addition, duck feed concentrate remains the main feed because of its complete nutritional content and easy application. The use of concentrate as feed for ducks is considered more effective and profitable because the concentrate consists of various mixed ingredients needed for the growth of ducks, for example: yellow corn, soybean meal, fine bran, fish meal, meat meal, bone meal, leaf meal, pollard, rock flour, salt, mineral premix, vitamin premix, antioxidants, probiotics, essential amino acids, enzymes, and others.

The proximate composition showed that the feed composition of ducks on five farms met the nutritional needs. The feed was dominated by carbohydrates, followed by protein and crude fat content but were within the standard range. Meanwhile, the quality of duck feed on the farms of A-E, showed significant differences, especially in carbohydrate content. This is also seen in meat where the highest content is carbohydrates, probably in the form

of muscle glycogen. Furthermore, there was a significant negative correlation between water content and protein and fat in both feed and meat. A negative correlation was also evident between the carbohydrate content of feed and meat, which means that an increase in carbohydrate content was associated with a decrease in protein content.

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