Research Article

Effects of Electrolyte Concentrations in Diets on Feed Utilization and Performance of Intensively Reared Cihateup Ducks

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Abstract | Ducks are reared from day-old ducks (DOD) until they are 8 weeks old in cages; ducks only have access to water for drinking. The treatment gave rations with various electrolyte balances (100, 150, 200, 250, and 300 mEq/kg ration). Ducks fed rations with electrolyte Balance 150 and 200 mEq/kg had digestibility of dry matter (DDM), organic matter (DOM), and crude protein (DCP) highest with values of DDM between 59.74 % - 61.01 % ($P<0.05$), Value DOM between 61.88 to 62.36 % and the value of DCP 70.79 -71.90 %. Ducks fed rations with electrolyte balances 150 and 250 mEq gave the highest ME, MEn, and nitrogen retention, with ME values between 2664-2676 kcal/kg, the value of MEn between 2589- 2605 kcal/kg, and nitrogen retention between 71.21 % - 74.85 % ($P<0.05$). Ducks that have performance lower than ducks fed rations with an electrolyte balance of 250 mEq/kg. At age 8 weeks, ducks were fed rations with an electrolyte balance of 100 mEq/kg, lower ($P<0.05$) than 300 and 350 mWq/kg. Ducks fed rations with electrolyte balances 250, 300, and 350 mEq/kg have a high feed intake for up to 5 weeks and a high body weight until 7 weeks. Until 8 weeks, the lowest feed conversion is achieved by ducks fed rations with an electrolyte balance of 250 mEq/kg and a feed conversion rate of 4.33, followed by the highest weight (1213 g), although not significantly different from the others ($P>0.05$). The level of electrolyte balance does not affect drinking water consumption. This indicates that such levels of electrolytes can be tolerated in relation to the water transportability and osmotic pressure of the extracellular fluid.

Keywords | Ducks, Electrolyte, Intensive, Performance, Metabolism

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INTRODUCTION

Ducks are also called waterfowl because some parts of their lives are spent in watery environments. This is indicated by physical structures such as finger membranes and long and wide beaks. In addition to the physical form, it can also be seen that its existence on this earth, where ducks are primarily located in low-lying areas, often found in swamps, rice fields, and river estuaries (Rodenburg *et al*., 2015). Ducks use areas like this to play and look for food. In this condition, the maintenance of ducks still relies on the traditional rearing system by being herded. Ducks generally forage on the surface of rice fields and around stems/ clumps on rice stems.

Duck-rearing practices have evolved into more intensive systems due to the increasing demand for duck meat and eggs. This new approach focuses on providing suitable housing, customized feeding strategies (Muller *et al*., 2022), and effective disease management (Muhammad *et al*., 2023). Intensive rearing (without access to water areas) has a significant impact on duck ecology. Access to the aquatic environment has become limited, and many ducks are now kept in cages. This situation can significantly affect their physiological processes. Access to wet areas is essential for ducks, as it helps regulate their body temperature (Mushawwir *et al*., 2021).

Raising ducks by depriving them of habitual access to water causes stress and difficulty in heat evaporation (Ravindran *et al*., 2018); other studies have shown changes in ADH hormone profiles (Mushawwir *et al*., 2024) as well as reduced productivity (Ahmed-Farid *et al*., 2021). Heat stress in animals can disrupt the electrolyte and acid-base balance of body fluids. During heat stress, the respiration rate increases as a mechanism to release excess body heat, known as panting (Tanuwiria *et al*., 2022a; Adriani *et al*., 2024) panting also causes electrolyte loss (Ravindran *et al*., 2018). The release of carbon dioxide (CO_2) during this rapid breathing can lead to alkalosis in body fluids (Ahmed-Farid *et al*., 2021; Mushawwir *et al*., 2024). In addition, heat stress promotes increased excreta, accompanied by electrolyte expenditure (Rodenburg et al., 2015; Mushawwir *et al*., 2024).

Electrolyte imbalance can inhibit duckling growth and disrupt eggshell formation during the egg-laying period (Saneyasu *et al*., 2017). Decreased production with impaired electrolyte balance appears to be positively correlated with CO_2 accumulation in blood plasma (Rodenburg *et al*., 2015). Several previous studies have also shown an increase in blood plasma pH in ducks deprived of water access (Lawal *et al*., 2020; Petrilla *et al*., 2022; Yalcinkaya *et al*., 2008), in addition to causing changes in the organic profile that acts as a buffer for plasma pH and metabolic imbalances (Muhammad *et al*., 2023; Li *et al*., 2022).

The balance of cations and anions in the body plays a vital role in maintaining electrolyte stability. According to Rodenburg et al. (2015), the balance of cations against anions can be expressed as follows: mEq (Na^{2+}, K^{2+}, Ca^{2+} + Mg^{2+}) - mEq (Cl^- + SO_4^{2-} + $H_2PO_4^{2}$+ HPO_4^{2+}). However, it is essential to note that only sodium (Na), potassium (K), and chloride (Cl) are mainly involved in the homeostasis process, which simplifies the preparation of rations (Li *et al*., 2022). Sodium, potassium, and chloride are essential minerals that regulate osmotic pressure (Lawal *et al*., 2020) and help maintain the acid-base balance of body fluids (Abouelezz *et al*., 2022).

Maintaining the proper electrolyte balance between sodium (Na), potassium (K), and chloride (Cl) is essential to support normal physiological function. Na can represent this balance as the ratio of K: Cl ratio, which is measured in milli-equivalents per kilogram (mEq/kg). Research into the impact of rearing ducks without access to water has widely shown reduced performance and ration efficiency (Mushawwir *et al*., 2023). However, reports on electrolyte balance for such duck-rearing systems have not been specifically reported. Therefore, ensuring proper electrolyte balance is essential for ducks reared without access to water.

MATERIALS AND METHODS

Ducks Samples

This study involved 140 ducks, with a 10% coefficient of variation in body weight. The ducks were randomly assigned to 24 cage units, each housing five ducks. Each cage, constructed from a wire mesh fence and a wooden frame, measures 80 cm in length, 80 cm in width, and 60 cm in height and accommodates five ducks.

For lighting, 24 electric lamps, each rated at 60 watts, were installed at an initial height of approximately 15 cm above the floor across 20 cage units to provide artificial lighting. Each cage is equipped with a round feeder and a round waterer. The ducks were housed from day-old (1 day of age) until they reached 8 weeks old.

Research Diets

The dietary treatment was designed to fulfill the nutrient requirements needed during the ducks' growth phase (Ketaren, 2002). It contained a Metabolic Energy level of 2900 kcal/kg and a crude protein content of 19%. The composition of the research diet is presented in Table 1.

Feed electrolyte content as a percentage converted to milli-equivalents per kg of ration (mEq/kg). The treatment consists of diets that include different electrolyte balances, such as:

1. Diets with an electrolyte concentration of 100 mEq/kg.
2. Diets with an electrolyte concentration of 150 mEq/kg.

3. Diets with an electrolyte concentration of 200 mEq/kg.
4. Diets with an electrolyte concentration of 250 mEq/kg.
5. Diets with an electrolyte concentration of 300 mEq/kg.
6. Diets with an electrolyte concentration of 350 mEq/kg.

Table 1: Feed composition and ingredients of experiment diets.

Feed	R_{100}	R_{150}	R_{200} %	R_{250}	R_{300}	R_{350}
Ingredient Yellow Corn	65,00	65,29	65,10	65,23	64,97	64,70
Soya Bean Meal	13,00	13,00	13,00	13,00	13,00	13,00
Fish Meal	14,00	14,00	14,00	14,00	14,00	14,00
Rice Bran	5,00	5,00	5,00	5,00	5,00	5,00
NH_4Cl	0,54	0,25	0,21	0,00	0,00	0,00
Na_2CO_3	0,00	0,00	0,23	0,31	0,57	0,84
$CaCO_3$	0,60	0,60	0,60	0,60	0,60	0,60
Premix	0,50	0,50	0,50	0,50	0,50	0,50
DCP	0,99	0,99	0,99	0,99	0,99	0,99
Methionine	0,12	0,12	0,12	0,12	0,12	0,12
NaCl	0,25	0,25	0,25	0,25	0,25	0,25
	100,00	100,00	100,00	100,00	100,00	100,00
Calculated Analysis						
EM (kcal/kg)	2944,00	2953,00	2947,00	2951,00	2943,00	2934,00
Crude Protein %	19,24	19,26	19,25	19,26	19,24	19,22
Lysine %	1,05	1,054	kcal	1,05	1,05	1,05
Methionine	0,50	0,50	0,50	0,50	0,50	0,50
Methionine + cysteine	0,94	0,94	0,94	0,94	0,94	0,94
Ca (%)	0,91	0,91	0,91	0,91	0,91	0,91
Non-phytate P%	0,44	0,44	0,44	0,44	0,44	0,44
Cl (%)	0,60	0,42	0,40	0,27	0,27	0,27
K (Potassium) (%)	0,63	0,63	0,63	0,63	0,63	0,63
Na (Sodium) (%)	0,25	0,25	0,35	0,38	0,49	0,61
Na+K-Cl (mEq/kg)	100,01	149,90	199,94	251,07	299,86	350,53

Feeding and Watering Protocol

Ducks were fed an ad libitum diet until the study was completed at 8 weeks of age. A round feeder is used for this purpose. During the study, the ducks received both mashed and crumbled feed. Day-old ducks are given satisfactory mashed rations until they reach 3 weeks old, after which they are transitioned to crumbled rations from 3 to 8 weeks of age. Additionally, drinking water is available in round water. The feed is administered twice daily at 07:00 am and 17:00 pm.

Parameters Observed

This research encompasses several parameters, including ration consumption, weight gain, feed conversion, drinking water consumption, protein digestion, nitrogen retention, and metabolic energy. Nitrogen retention and metabolic energy data were sampled using the internal indicator method, with lignin as the indicator. This followed the complete procedure established by Rusmana and Adriani (2020). Excreta sampling has been conducted weekly. The collected manure was treated with distilled water containing 5% boric acid (H_3BO_3) every three hours to bind the nitrogen and prevent evaporation. After this treatment, the excreta were cleaned of any remaining feed and fur. The cleaned excreta were weighed and dried using a modified oven set at 40°C until the moisture content was sufficiently low. Once dried, the excreta samples were ground, and all samples corresponding to each treatment were mixed and prepared for analysis.

The nitrogen analysis procedure was carried out in the following stages: 0.5 - 1 gram sample (recorded as sample weight) covered with slippery paper, then put into a Kjeldahl flask. A catalyst as much as 6 g of sulfuric acid is used. The Kjeldahl flask containing the sample, catalyst, and sulfuric acid is placed into a fume hood and heated in a small flame. If it is not bubbly, the destruction continues with a large flame. Destruction is considered complete when the solution is clear green in color. After that, cool down. Borax 5% was used, and two drops of the indicator were then paired at the end of the condenser tube on the distillation device. The end of the condenser must be submerged in the solution. The material solution from deconstruction was flavoured by adding 40-60 ml of 40% NaOH through a side funnel. The funnel tap is closed immediately after the solution enters the boiling Erlenmeyer. Titrate with HCl to determine normality, which is indicated by a color change from blue to pink. Then, the amount of HCl solution used was recorded. Nitrogen content was determined following the following formula:

$$Nitrogen\ (\%) = \frac{Vol.HCl \times N\ HCl \times 14 \times 0{,}001}{sample\ weight} \times 100$$

Lignin was determined by weighing 0.5 grams of the sample and adding 100 ml of $_{CTAB+H2SO4}$ mixture solution. The sample was brought to a boil, and the precipitate was transferred to another beaker. 25 ml of 72% $_{H2SO4}$ was added and then allowed to stand overnight. The mixture was heated on the stove and installed in a condenser for one hour after boiling, then filtered with a 2-G-4 glass filter, and the precipitate was washed with hot distilled water and mixed with acetone. The filter and precipitate were dried in a 100 °C oven until a fixed weight was obtained (recorded as weight after drying). The filter and precipitate were fumigated in a 600°C furnace for 6 hours (recorded as weight after fumigation). Calculation using the formula:

$$Lignin\ (\%) = \frac{(eight\ after\ drying - Weight\ after\ fumigation)}{Sample\ weight} \times 100$$

Statistical Analysis

The study was conducted using an experimental method, a completely randomized design (CRD) consisting of six ration treatments repeated four times. The data obtained was analyzed using variance (P<0.05). If the variance of the prints has an effect from the treatment, then Duncan's Multiple Distance Test was performed.

RESULTS AND DISCUSSION

Effect of Electrolyte Balance on Digestion, EM and Nitrogen Retention

The effect of electrolyte balance in the diet on nutrient digestibility, metabolic energy, and nitrogen retention can be seen in Table 2. The impact of electrolyte balance in the ratio significantly affected the digestibility of dry matter, organic matter, and protein (P>0.05). The highest dry matter digestibility (DDM) and the highest organic matter digestibility (DOM) were achieved by ducks fed rations with an electrolyte balance of 150 mEq/kg ration, significantly higher (P<0.05) than the duck fed with electrolyte balance of 100 mEq/kg ration 250 mEq/kg ration, 300 mEq/kg ration and 350 mEq/kg ration. However, DDM and DOM between ducks fed ration with electrolyte balance between 150 mEq/kg ration and 200 mEq/kg ration did not show significant differences (P <0.05). The highest protein digestibility (DCP) was observed in ducks-fed rations containing an electrolyte balance of 200 mEq/kg. This was significantly higher (P<0.05) than those receiving rations with electrolyte balances of 100 mEq/kg, 250 mEq/kg, 300 mEq/kg, and 350 mEq/kg. Additionally, there was no significant difference (P>0.05) in DCP between ducks-fed rations with electrolyte balances of 150 mEq/kg and 200 mEq/kg. Therefore, it can be concluded that the optimal electrolyte balance for achieving the best digestibility of DDM, DOM, and DCP in ducks is within the range of 150-200 mEq/kg.

The digestibility of nutrients occurs after digestive enzymes hydrolyze food substances into smaller molecules, which are then absorbed by the intestine through the semipermeable membrane of the digestive tract cells. Electrolyte balance plays a crucial role in the nutrient absorption process across these membranes. Sodium (Na) minerals are essential as they facilitate the absorption of amino acids and glucose via the Na^+, K^+-adenosine triphosphate (ATPase) active transport system, commonly referred to as the sodium pump mechanism (Zaffar *et al.*, 2020; Aritonang *et al.*, 2024; Kharazi *et al.*, 2022; Manin *et al.*, 2024). Furthermore, low concentrations of sodium can inhibit the absorption of glucose and amino acids.

Research indicates that the digestible dry matter (DDM), digestible organic matter (DOM), and digestible crude protein (DCP) in ducks are adversely impacted when their diet contains electrolyte balances below 150 mEq/kg or above 200 mEq/kg, particularly concerning sodium levels. As the electrolyte balance in the diet increases, the sodium content also rises.

Research by Petrilla *et al.* (2022) determined that the sodium requirement for starter broilers is 2.8 g/kg of feed. Similarly, a study by Purwanti *et al.* (2024) observed the impact of different electrolyte levels (150, 225, 300, and 375 mEq/kg) on broiler chickens. They found that excessively high electrolyte imbalances, particularly at 300 and 375 mEq/kg, reduced amino acid absorption due to elevated sodium levels of 3.5 and 4.4 g/kg, respectively. The study measured the sodium content at various electrolyte balances of 100, 150, 200, 250, 300, and 350 mEq/kg, yielding values of 0.24, 0.25, 0.34, 0.38, 0.49, and 0.61 g/kg, respectively.

Table 2: Effect of electrolyte balance feed on DDM, DOM, DCP, ME, MEn and nitrogen retention.

Electrolite Balance mEq/kg diet	DDM (%)	DOM (%)	DCP (%)	ME (kkal/kg)	MEn (kkal/kg)	Nitrogen Retention(%)
100	48.18 b	49.77 c	61.98 b	2406 b	2339 b	66.49 b
150	61.01 a	62.36 a	70.79 a	2676 a	2605 a	71.21 ab
200	59.74 a	61.88 a	71.90 a	2405 b	2339 b	65.99 b
250	48.39 b	52.38 b	62.83 b	2664 a	2589 a	74.85 a
300	47.65 b	50.45 bc	63.46 b	2098 c	2042 c	56.17 c
350	51.43 b	55.30 b	65.53 b	2033 c	1980 c	53.35 c

The same letter notation in the direction of the column indicates an effect that is not significantly different (P < 0.05).

The impact of electrolyte balance on nitrogen retention is illustrated in Table 2. Ducks fed rations with an electrolyte balance of 250 mEq/kg demonstrated the highest nitrogen retention, which was significantly greater (P<0.05) than those fed rations with electrolyte balances of 100, 200, 300, and 350 mEq/kg. However, this level was similar to the nitrogen retention observed in ducks given rations with an electrolyte balance of 150 mEq/kg. Conversely, ducks that consumed rations with electrolyte balances of 300 mEq/kg and 350 mEq/kg exhibited low nitrogen retention, which was significantly lower (P<0.05) than the retention seen in ducks fed with 100, 150, 200, and 250 mEq/kg. Based on these findings, it is concluded that ducks should not be provided with rations with an electrolyte balance exceeding 250 mEq/kg to achieve optimal nitrogen retention.

The effect of electrolyte balance in the ration on the EM and MEn ration values can be seen in Table 2. The highest ME and MEn rations were achieved by ducks fed rations with an electrolyte balance of 150 mEq/kg, significantly higher (P <0.05) compared to ducks who were given rations with electrolyte counts of 100, 200, 300, and 350 mEq/kg, but were not significantly different from the ducks given rations with an electrolyte balance of 250 mEq/kg. Low ME and MEn, observed in the groups of ducks fed rations with an electrolyte balance of 300 mEq/kg and 350 mEq/kg, were significantly lower (P<0.05) than those with electrolyte balances of 100, 150, 200, and 250 mEq/kg.

As with the effect of electrolyte balance on DDM, DOM, and DCP, the pattern that is almost the same is found to influence nitrogen, ME, and MEn retention that the electrolyte balance is too high when the electrolyte balance reaches 300 and 350 mEq/kg which has a low value. This is related to the concentration of Na, which is too high in the ratio. This is with the results achieved by Rahmania *et al.* (2022), namely the administration of ration with electrolyte counts of 150, 225, 300, and 375 mEq/kg in broiler chickens, the electrolyte balance is too high at 300 and 375 mEq/kg with the womb Na 3.5 and 4.4 g/kg cause a decrease in absorption of amino acids, while the ME Nitrogen and MEn retention decreases significantly when the electrolyte balance reaches 375 mEq/kg. The same research results in ducks were shown by Mushawwir *et al.* (2023), who reported the occurrence of electrolyte shocks with excessive Na and Cl feeding, more than 300 mEq/Kg, and caused excessive water consumption in an effort to achieve electrolyte balance.

The difference in the effect of the electrolyte balance ratio pattern occurred in DDM, DOM, and DCP with nitrogen retention when the electrolyte balance was 250 mEq/kg. DDM, DOM, and DCP in ducks-fed rations with 250 mEq electrolyte balances were significantly lower than in ducks-fed rations with 100, 150, and 200 mEq/kg electrolyte balances. Conversely, it was found that ducks fed rations with an electrolyte balance of 250 mEq were significantly higher than ducks fed rations with electrolyte balance of 100 and 200 mEq/kg. Digestion is a food substance absorbed by the body or the difference from what is consumed by being excreted through feces. At the same time, nitrogen retention is food absorbed by the digestive tract and accumulates in the body. Nitrogen retention is the difference between nitrogen consumed and that secreted through feces and urine (Rahmania *et al.*, 2022); nitrogen retention and DCP are indicators of the extent to which the protein is absorbed and utilized by the body (Selim *et al.*, 2021; Pazla *et al.*, 2023; Tanuwiria *et al.*, 2022b). The digested protein does not fully accumulate in the body; instead, it is metabolized, and its byproducts are excreted, including through urine (Cui *et al.*, 2022; Alian *et al.*, 2023; Mushawwir *et al.*, 2024). Additionally, nitrogen retention refers to the nitrogen derived from protein that accumulates or remains in the body. Thus, nitrogen retention indicates body protein utilization (Saneyasu *et al.*, 2017; Petrilla *et al.*, 2022).

The acid-base process of the electrolyte balance can explain the difference in the impact of the electrolyte balance on the meters. Ravindran et al. (2018) show that the addition of Na (without Cl) in the diet increases HCO_3 and plasma pH, known as alkalosis (Lawal *et al.*, 2020), while the addition of Cl (without Na) decreases HCO_3 and pH together, known as acidosis. Changes in the acidity of the plasma or extracellular fluid lead to impaired fluidity of the cell membrane (Ewart, 2020; Chrystal *et al.*, 2020), as well as decreased affinity of ligands to receptors and transport proteins on the cell membrane (Alian *et al.*, 2023). Research results Cui *et al.* (2022) show a decrease in nutrient utilization as a result of impaired fluidity and affinity of proteins at the cell membrane.

The low electrolyte balance has a higher Cl concentration, so the chance of acidosis is higher. Conversely, a high electrolyte balance has a higher Na concentration. So, the chances of alkalosis are higher. Acidosis can increase NH_4, which escapes from the kidneys, giving $NaHCO_3$ decreases or reduces the escape of NH_4 in urine (Lakhssassi *et al.*, 2021), whereas HCl gives the opposite effect (Lawal *et al.*, 2020; Chrystal *et al.*, 2020). NH_4 is a metabolite from protein metabolism (Li *et al.*, 2022; Rahmania *et al.*, 2022; Mushawwir *et al.*, 2021).

From the discussion above, the optimal impact of electrolyte balance is considered in preparing rations to produce DDM, DOM, DCP, ME, MEn, and N retention. In addition to the electrolyte balance of the components Na, K, and Cl, the optimal content of each mineral is also considered. Electrolyte balance with a range of 150 to 250 mEq is considered.

Effect of Electrolyte Balance Feed on Feed Consumption

Table 3 shows the effect of electrolyte balance in the ration on the consumption of cumulative rations from DOD to the age of 8 weeks.

The effect of the electrolyte balance ratio on cumulative feed consumption up to 1 week of age did not show a significant difference (P>0.05). The difference is first observed in the cumulative consumption of rations up to the age of 2 weeks until the cumulative consumption of 8 weeks. Ducks fed rations with an electrolyte balance of 100 to 200 mEq/kg ration tended to be lower than those with an electrolyte balance of 250 to 350 mEq/kg ration. However, ducks fed rations with electrolyte counts of 150 and 200 mEq/kg rations

Table 3: Effect of electrolyte balance feed on cumulative feed consumption.

Electrolyte Balance mEq/kg diet	Feed Consumption (g)							
	1 week old	2 weeks old	3 weeks old	4 weeks old	5 weeks old	6 weeks old	7 weeks old	8 weeks old
100	193 a	454 ab	827 bc	1338 bc	1665 c	3040 b	3958 b	4696 b
150	200 a	499 a	854 abc	1347 bc	2118 abc	3927 a	4788 ab	5217 ab
200	225 a	389 b	741 c	1262 c	1957 bc	3863 a	4673 ab	5329 ab
250	214 a	534 a	961 ab	1526 a	2176 ab	3796 a	4786 ab	5233 ab
300	228 a	502 a	966 a	1392 abc	2295 ab	4104 a	5096 a	5968 a
350	197 a	491 a	936 ab	1446 ab	2395 a	4380 a	5263 a	5760 a

The same letter notation in the direction of the column indicates an effect that is not significantly different ($P < 0.05$).

Table 4: Effect of electrolyte balance feed on body weight.

Electrolyte Balance mEq/kg diet	Body Weight (g)							
	1 week old	2 weeks old	3 weeks old	4 weeks old	5 weeks old	6 weeks old	7 weeks old	8 weeks old
100	155 ab	234 a	341 b	476 c	770 bc	892 ab	1031 b	1075 a
150	131 b	204 a	272 b	423 c	748 c	872 b	1023 b	1066 a
200	168 a	251 a	307 b	480 bc	779 bc	855 b	1049 ab	1079 a
250	168 a	266 a	404 a	580 a	896 a	986 a	1156 ab	1213 a
300	168 a	243 a	422 a	555 a	902 a	983 a	1184 a	1179 a
350	166 a	291 a	412 a	544 ab	871 ab	964 ab	1162 ab	1183 a

The same letter notation in the direction of the column indicates an effect that is not significantly different ($P>0.05$).

were able to compensate for ration consumption at 6 weeks of age so that even at the age of 8 weeks, showed a different consumption of rations ($P <0.05$) with ducks fed 250 rations - 350 mEq/kg ration. The results of this study could be due to a more savory feed taste, which is perceived through the oral nerves of the ducks, as stated by Petrilla *et al*. (2022), that higher Na and Cl taste can increase ration consumption.

The highest cumulative weekly consumption is almost every week and is dominated by ducks fed rations with a balance of 300 and 350 mEq electrolytes. This is closely related to the EM and MEn ratio values. ME and MEn values of 300 and 350 mEq/kg are shallow, ranging from 2033 to 2098 kcal/kg for ME and 1980 to 2042 kcal / kg for MEn. The low ME and MEn rations in broiler chickens due to overly high electrolyte balance were reported by Dudi *et al*. (2023), there was a decrease in MEn when the electrolyte balance was 375 mEq/kg with a Na ration content of 5.2 g / kg. The low ME and MEn in the ration will impact the consumption of rations. One that determines the amount of ration consumption in poultry is the energy content of the ration (Tanuwiria *et al*., 2022a; Aritonang *et al*., 2024).

Effect of Electrolyte Balance on Body Weight

The effect of the electrolyte balance ratio on body weight achieved every week can be seen in Table 4.

Until the age of 2 weeks, there was no significant difference ($P>0.05$) in the body weight of ducks across different treatment groups. However, by 3 weeks of age, the electrolyte balance began to have a significant effect ($P< 0.05$) on body weight. Ducks that received rations with electrolyte balances of 250, 300, and 350 mEq/kg had significantly higher body weights than those with rations of 100, 150, and 200 mEq/kg. At 4 and 5 weeks of age, ducks receiving rations with electrolyte balances of 250 and 300 mEq/kg continued to show significantly higher body weights than those receiving 150 and 200 mEq/kg. By the ages of 7 and 8 weeks, the body weights of ducks fed lower electrolyte balances (100, 150, and 200 mEq/kg) began to catch up to those fed higher balances (250, 300, and 350 mEq/kg). However, by 8 weeks, there were no significant differences ($P>0.05$) in body weight among the various treatments. Based on the results of the current research, it can be explained that the same body weight at week eight, despite being given different concentrations of electrolytes, indicates the ability of ducks to physiologically achieve homeostasis of cations and anions in plasma (Pazla *et al*., 2023), thus supporting biochemical modulation related to growth (Lakhssassi *et al*., 2021; Alian *et al*., 2023).

Figure 1 shows the data shows that at the age of the beginning, the weight of the duck body given the ration with a balance of electrolytic 250, 300, and 350 mEq/kg tends to be higher than the weight given ration with a lower electrolyte balance (100, 150 and 200 mEq/kg). In contrast, ducks are given rations with the exact composition of feed ingredients to have iso nutrients.

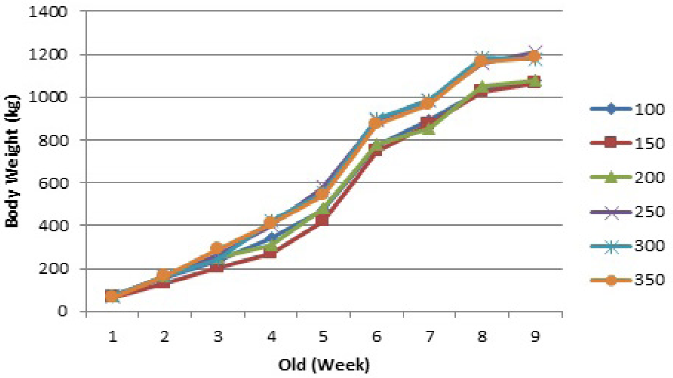

Figure 1: Body weight of ducks fed rations with various electrolyte balance.

The results indicate that electrolyte balance significantly impacts duck performance. The data on how electrolyte balance affects body weight did not align with the measurements of metabolizable energy (ME), metabolizable energy-nitrogen (MEn), and nitrogen retention. Just like ME, a high MEn is associated with increased body weight. Ducks fed rations containing 300 and 350 mEq/kg had lower values for MEn and nitrogen retention; however, their body weight was higher than ducks fed rations with lower electrolyte balances (100, 150, and 250 mEq/kg).

Ducks fed rations with balanced electrolyte levels of 300 and 350 mEq, along with low metabolizable energy (ME) and metabolizable energy of nutrients (MEn), tend to consume larger quantities of feed. One significant factor influencing feed consumption in poultry is the energy content of the feed (Yalcinkaya *et al*., 2008; Ravindran *et al*., 2018; Mushawwir *et al*., 2023). When the energy content is low, birds increase their feed consumption to meet their energy needs. As ducks eat more feed, they also take in more nutrients. Therefore, although the percentage of nitrogen retention may be lower, the increased feed consumption leads to a greater overall body weight.

Effect of Electrolyte Balance Feed on Ration Conversion

The impact of electrolyte balance ratios on ration conversion is illustrated in Table 5. The cumulative ratio conversion from 1 week to 8 weeks showed no significant differences ($P < 0.05$) nearly every week, except for ages 3 weeks, 4 weeks, and 6 weeks. At 3 and 4 weeks, ducks fed rations with an electrolyte balance of 150 mEq/kg demonstrated a significantly higher conversion ($P < 0.05$) compared to those receiving rations with electrolyte balances of 100, 200, 250, 300, and 350 mEq/kg. Furthermore, at 6 weeks, the conversion of ducks given rations with an electrolyte balance of 100 mEq/kg was significantly higher ($P < 0.05$) than that of ducks fed rations with electrolyte balances of 150, 200, 250, 300, and 350 mEq/kg.

Feed conversion is an indicator of the quality of rations consumed by ducks. Rahmania *et al.* (2022) state that the Feed conversion ratio is calculated by dividing feed intake by weight gain during maintenance. The higher the conversion value, the lower the quality of the ratio. The ration quality shows how far the nutrients are absorbed and converted for body weight growth. The high conversion rate of rations in ducks at 3 and 4 weeks of age, fed rations with an electrolyte balance of 150 mEq/kg, is attributed to their significant growth. Although the values for DDM, DOM, DCP, ME, MEn and nitrogen retention are high, the overall ration consumption is low.

At 6 weeks, ducks fed rations with an electrolyte balance of 100 mEq/kg demonstrate a high conversion rate. This is due to their impressive growth, low annual consumption, and favorable values for KCBO, ME, MEn, and nitrogen retention. As a result, the consumption of rations that are converted for growth is relatively low.

Effect of Electrolyte Balance on Feed on Drinking Water Consumption

The effect of electrolyte balance on drinking water consumption is illustrated in Table 6. The electrolyte balance ratio does not significantly influence daily drinking water consumption per kg of metabolic weight. However, ducks given rations with a low electrolyte balance tend to consume more drinking water. The highest water consumption was observed in ducks fed rations with an electrolyte balance of 100 mEq/kg, followed by ducks fed rations with an

Table 5: Effect of feed electrolyte balance on feed conversion.

Electrolyte Balance mEq/kg diet	Feed Conversion							
	1 week old	2 weeks old	3 weeks old	4 weeks old	5 weeks old	6 weeks old	7 weeks old	8 weeks old
100	2.86 a	1.97 a	2.44 b	2.83 b	2.19 a	3.44 b	3.89 a	4.43 a
150	3.12 a	2.52 a	3.14 a	3.19 a	2.85 a	4.51 a	4.69 a	493 a
200	3.14 a	1.64 a	2.44 b	2.63 b	2.53 a	4.53 a	4.46 a	4.98 a
250	3.11 a	2.07 a	2.40 b	2.64 b	2.42 a	3.86 a	4.15 a	4.33 a
300	3.27 a	2.09 a	2.29 b	2.51 b	2.55 a	4.17 a	4.30 a	5.06 a
350	2.96 a	1.69 a	2.27 b	2.66 b	2.75 a	4.54 a	4.54 a	4.88 a

The same letter notation in the direction of the column indicates an effect that is not significantly different ($P < 0.05$).

electrolyte balance of 150 mEq/kg, at 2444 and 1699 mL, respectively, although both were not significantly different (P>0.05).

Table 6: Effect of electrolyte balance of rations on drinking water consumption.

Electrolyte Balance mEq/kg ration	Water Consumption mL/ day/kg$^{.75}$
100	2444 a
150	1699 a
200	1457 a
250	1482 a
300	1634 a
350	1302 a

Description: The same letter notation in the direction of the column shows an effect that is not significantly different (P <0.05).

The acid-base process of the electrolyte balance can explain the difference in the impact of electrolyte balance on drinking water consumption. To maintain homeostasis, the body employs many physiological adaptations. One of these is maintaining an acid-base balance. Without pathological states, the body's pH ranges between 7.35 to 7.45, with the average at 7.40. A pH below 7.35 is acidemia, and a pH above 7.45 is alkalemia (Ewart, 2020; Rodenburg *et al*., 2015). The previous study (Yalcinkaya *et al*., 2008; Muhammad *et al*., 2023) shows that the addition of Na (without Cl) in the diet increases HCO_3 and plasma pH, known as alkalosis, while the addition of Cl (without Na) decreases HCO_3 and pH together, known as acidosis. The low electrolyte balance has a higher Cl concentration, so the chance of acidosis is higher.

Conversely, a high electrolyte balance is associated with elevated sodium (Na) concentrations, which increases the likelihood of alkalosis. On the other hand, acidosis can lead to an increase in ammonium (NH_4) levels, which can escape from the kidneys. Sodium bicarbonate ($NaHCO_3$) helps reduce the excretion of NH_4 in urine, while hydrochloric acid (HCl) has the opposite effect (Muller *et al*., 2022; Tanuwiria *et al*., 2023). The NH_4 is a by-product of protein metabolism; ducks increase their water consumption under acidic conditions when a low electrolyte balance is present. This increased drinking helps remove NH_4 metabolites through urine.

CONCLUSIONS AND RECOMMENDATIONS

Ducks fed a ration with an electrolyte balance of 250 mEq/kg perform better in energy metabolism (EM), metabolizable energy (MEn), nitrogen retention, body weight, and feed conversion. However, these ducks show poor resistance to stress. In contrast, ducks with the best stress resistance are those fed an electrolyte balance of 100 mEq/kg.

Further research should be conducted on diets with an electrolyte balance of 250 mEq/kg at various levels of Na concentration in the diet, with a focus on cell physiology, such as membrane fluidity and its relation to ostmotic pressure. This level could be further tested for its wider effects on performance.

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NOVELTY STATEMENT

Duck farming in Indonesia has been experiencing consistent growth year after year. Research on this topic is expanding rapidly, particularly in husbandry management and alternative protein and energy sources. Meanwhile, many farmers are shifting from extensive farming systems in paddy fields to more intensive farming practices. This change has increased stress among ducks, reducing their opportunities to swim and play in water. Consequently, studying the electrolyte balance in their diet has become a vital focus of this research.

AUTHOR'S CONTRIBUTIONS

The preparation and writing of this article have been carried out jointly by the entire research team (listed as the authors of this article), proportionally according to their respective competencies.

Conflict of Interest

The authors have stated that they have no conflicts of interest with any parties, including those related to royalties, data ownership, and others.

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