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Utilization of Cabbage Fermentation (Sauerkraut) as a Probiotic Source to Increase Pekin Duck Productivity

(*PEMANFAATAN KUBIS FERMENTASI (SAUERKREUT) SEBAGAI SUMBER PROBIOTIK UNTUK MENINGKATKAN PRODUKTIVITAS ITIK PEKIN*)

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ABSTRACT

The ban on antibiotic growth promoter (AGP) use has encouraged the development of natural probiotics to improve poultry performance, making it necessary to evaluate the potential of sauerkraut as a probiotic. The objective of this study was to determine the benefits of cabbage fermentation (sauerkraut) as a probiotic source to improve the productivity and meat quality of Pekin ducks. This study used a Completely Randomized Design (CRD) with five levels of sauerkraut probiotic doses in drinking water and four replications for each treatment. The treatments consisted of A (0%), B (1.5%), C (3%), D (4.5%), and E (6%) probiotic sauerkraut in ducks drinking water. The sauerkraut probiotic was produced through cabbage fermentation for seven days under anaerobic conditions. The observed parameters included body weight gain, feed intake, feed conversion ratio, carcass weight and meat quality (pH, water holding capacity and cooking loss). The data obtained were analyzed using Analysis of Variance and continued with Duncan's Multiple Range Test to determine the significance of the differences among treatments. The results showed that the addition of sauerkraut probiotic in the drinking water of Pekin ducks had a significant effect ($P<0.05$) on body weight gain, feed intake, feed conversion ratio and carcass weight. However, a non significant effect ($P>0.05$) was observed on meat quality parameters (pH, water holding capacity and cooking loss). It was concluded that the addition of sauerkraut probiotics at the 4.5% level (Treatment D) was the optimal dose. It was able to improve productivity, with body weight gain of 1733.15 g, feed intake of 3848.30 g, a feed conversion ratio of 2.22, and carcass weight reaching 1299.86 g, without giving negative effects on the meat quality of Pekin ducks, with a meat pH of 6.25, water-holding capacity of 45.55% and cooking loss of 34.61%.

Keywords: cabbage fermentation; probiotics; productivity; Pekin duck

ABSTRAK

Larangan penggunaan *antibiotic growth promoter* (AGP) mendorong penggunaan probiotik alami, sehingga penting mengevaluasi potensi sauerkraut sebagai sumber probiotik. Tujuan penelitian ini adalah untuk mengetahui manfaat fermentasi kubis (sauerkraut) sebagai sumber probiotik untuk meningkatkan produktivitas dan kualitas daging itik pekin. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan lima perlakuan dosis probiotik sauerkraut dalam air minum dan empat ulangan per perlakuan. Perlakuan terdiri atas: A (0%), B (1,5%), C (3%), D (4,5%) dan E (6%) probiotik sauerkraut dalam air minum. Probiotik sauerkraut dibuat melalui proses fermentasi kubis selama tujuh hari dalam kondisi anaerob. Parameter yang diamati meliputi pertambahan bobot badan, konsumsi ransum, konversi ransum, bobot karkas, serta kualitas daging (pH, daya ikat air dan susut masak). Data yang didapat dianalisis menggunakan Analisis Ragam dan dilanjutkan dengan uji jarak berganda Duncan untuk mengetahui signifikansi perbedaan antar perlakuan. Hasil penelitian menunjukkan bahwa penambahan probiotik sauerkraut dalam air minum itik pekin memberikan pengaruh nyata ($P<0.05$) terhadap pertambahan bobot badan, konsumsi ransum, konversi ransum dan bobot karkas. Namun, berpengaruh tidak nyata ($P>0,05$) terhadap kualitas daging itik (pH, daya ikat air dan susut masak). Simpulan yang didapatkan bahwa penambahan probiotik sauerkraut pada level 4,5% (Perlakuan D) merupakan dosis optimal karena mampu meningkatkan produktivitas dengan nilai pertambahan bobot badan sebesar 1733,15 g, konsumsi pakan 3848,30 g, rasio konversi pakan 2,22 dan bobot karkas mencapai 1299,86 g, tanpa memberikan efek negatif terhadap kualitas daging itik pekin, dengan nilai pH daging sebesar 6,25, daya ikat air 45,55% dan susut masak 34,61%.

Kata-kata kunci: fermentasi kubis; probiotik; produktivitas; itik pekin

INTRODUCTION

Food is a basic human need, and its fulfillment is part of the larger national development strategy, especially in efforts to improve the quality of life, community productivity and national stability. One important component in sustainable food provision is the availability of affordable, nutritious and accessible animal protein sources for all segments of society. Duck meat is one of the poultry commodities with high economic and nutritional value and it has great potential for development in order to diversify sources of animal protein (Setiawan *et al*., 2024). The meat duck that is gaining popularity among the public is the Pekin duck, because it has several advantages, namely rapid growth with the ability to reach ideal body weight in a relatively short time, making it efficient from a maintenance perspective (Ghosh *et al*., 2022). Additionally, Pekin duck is known for being tender, thick, and having a distinctive flavor, making it popular with consumers (Shin *et al*., 2023).

Productivity and meat quality of ducks, especially Pekin ducks (*Anas platyrhynchos domestica*), at the level of smallholder farmers still face several constraints such as suboptimal growth rate, inefficient feed conversion and less than optimal carcass quality (Wahyuni *et al*., 2017; Al-Dabbagh and Sardary, 2025). The government's and global market's ban on the use of antibiotics as growth promoters (antibiotic growth promoters/AGPs) is increasingly driving the need for safe, effective and environmentally friendly natural alternatives (Abou-Jaoudeh *et al*., 2024). Inappropriate use of antibiotics in poultry feed can increase bacterial resistance, antibiotic residues in poultry meat and imbalances in the normal intestinal microflora (Andriani *et al*., 2020; Abou-Jaoudeh *et al.*, 2024; Liang *et al.*, 2024). There is a need for an alternative to antibiotics so that consumers are protected from the dangers of antibiotic residues when consuming poultry. Probiotics are an alternative to antibiotics, containing live microorganisms consumed by humans, animals and poultry in specific amounts to produce beneficial effects (Krysiak *et al*., 2021). Probiotics are classified as functional foods containing components that improve animal health by manipulating the composition of bacteria present in the digestive tract (Naeem and Bourassa, 2025). One probiotic that can be used is fermented cabbage (*Brassica oleracea*), also known as sauerkraut.

Cabbage fermentation (sauerkraut) is a food product resulting from a natural fermentation process that contains various strains of lactic acid bacteria (Wei *et al*., 2025; Sawant *et al.*, 2025). The sauerkraut liquid obtained from cabbage contains microorganisms including *Lactobacillus brevis, Lactobacillus plantarum, Saccharomyces cerevisiae*, and *Rhizopus oryzae*. The microorganisms found in sauerkraut are probiotic bacteria that can function to maintain the health of the animal's digestive tract (Ari *et al*., 2024; Touret *et al*., 2018). Sauerkraut contains a total of 9.3 x 10^9 CFU/mL of lactic acid bacteria and no pathogenic bacteria such as *Escherichia coli* and *Salmonella* sp., were detected (Laboratory Animal Feed and Technology University of North Sumatra, 2025). Despite its strong probiotic potential, the application of sauerkraut in Pekin duck production systems has not been widely explored. In addition to improving gastrointestinal health, sauerkraut also has the potential to influence meat quality in ducks. Probiotics such as *Lactobacillus* spp., are known to enhance nutrient absor-ption, optimize muscle protein deposition, reduce oxidative stress and increase antioxidant activity, all of which are directly related to better carcass quality, tenderness and meat physicochemical characteristics (Sardar *et al.*, 2024). Therefore, cabbage-based probiotics may contribute not only to improved growth performance but also to superior meat quality in Pekin ducks.

The selection of sauerkraut probiotic doses (0%, 1.5%, 3%, 4.5% and 6%) was based on the high concentration of LAB in sauerkraut, which allows low inclusion levels to produce measurable biological responses in poultry. The 1.5–6.0% range is aligned with previous studies that used effective levels of 1–10% for plant-based fermented liquid probiotics. In addition, preliminary tests indicated that levels above 6% could reduce the palatability of drinking water due to aroma changes, thereby setting 6% as the upper safe limit. This study was aimed to evaluate the effects of different doses of sauerkraut on growth performance, carcass characteristics and meat quality of Pekin ducks. This research is important because it provides a scientific basis for utilizing locally available cabbage fermentation products as natural probiotics, offering a safe alternative to AGPs while also sup-porting waste reduction and sustainable live-stock production.

RESEARCH METHODS

Research Location and Time

This research was conducted at the Animal Science Farm, Faculty of Agricultural and Animal Sciences, Indonesian National Islamic University in Bireuen, Aceh. The production of probiotics from fermented cabbage was carried out in the Agriculture Laboratory, Faculty of Agricultural and Animal Science. The Study was conducted over a period of three months, from June to August 2025.

Research Materials and Tools

The materials used in this study were cabbage, non-iodized table salt, sugar and distilled water. A total of 200 Pekin ducks aged two days were used in this study. The Pekin ducks belonged to the Cherry Valley strain. The commercial feed used for the Pekin ducks is commercial feed. The equipment used consisted of jars for fermentation, droppers for taking the sauerkraut liquid and 20 battery cages made of wood, each cage housing 10 head of ducks. Each cage unit is equipped with a feeding and watering area in every unit. As a heating and lighting device at night, 1 incandescent lamp is used per unit. Ration weighing is done using a

Weston scale with a capacity of 10 kg.

Research Design

This research was conducted using an experimental method with a Completely Randomized Design (CRD) with five treatments and four replications, each replication consisting of 10 Pekin ducks. The treatments given to the experimental ducks were as follows: A) Adding 0% probiotic sauerkraut to drinking water; B) Adding 1.5% probiotic sauerkraut to drinking water; C) Adding 3% probiotic sauerkraut to drinking water; D) Adding 4.5% probiotic sauerkraut to drinking water; E) Adding 6% probiotic sauerkraut to drinking water.

Research Implementation

Procedure Making Probiotic Liquid from Sauerkraut. Sauerkraut probiotic liquid is made from fermented cabbage. The cabbage is first air-dried until wilted overnight and then the outer leaves, damaged parts and core are discarded. It is then washed thoroughly and thinly sliced to a thickness of approximately 2-3 mm. It is mixed with 2.5% salt and 3.5% sugar by weight of the cabbage. Stir until evenly mixed and then transfer to a jar, pressing down to make it compact. Then cover with plastic and secure with the jar lid until it's airtight so no air can get in. Fermentation took place for seven days at room temperature, after which it was stored in the refrigerator.

Preparation of the experimental treatment rations. The ration used in this study was commercial broiler duck feed from one day old to eight weeks old. The research treatment used probiotic sauerkraut that had been prepared in advance. Probiotic sauerkraut is mixed into drinking water at the percentage specified in the experimental design.

Cage Preparation

The cage is cleaned with water and left to dry. After drying, the floor is limed. Then, spraying with antiseptic-disinfectant (Rodalon®, PT Medion Ardhika Bhakti, Bandung, Indonesia) was done inside and around the coop to kill disease-causing germs. After liming and spraying with antiseptic-disinfectant, it's best to keep the coop tightly closed and leave it for a week to maximize its freedom from disease-causing germs. Food and drink utensils are thoroughly washed with running water before use.

Pekin Duck Placement and Treatment Randomization

The pens were numbered 1 to 20, and the treatments were randomly placed within the pens. Ten ducklings were randomly selected, weighed and their average weight was determined as a baseline. Then, two levels below and two levels above the baseline weight were selected. The ducklings were placed in numbered cage units. Each cage unit housed 10 ducklings.

Pekin Duck Maintenance

Pekin duck maintenance was carried out intensively with the provision of rations and sauerkraut probiotics according to treatment, and drinking water was given *ad libitum*. Maintenance is carried out for two months (eight weeks). After eight weeks of rearing, sample collection for carcass analysis was carried out. At the end of the rearing period, four ducks from each pen were selected as carcass samples, resulting in a total of 80 ducks that were humanely euthanized following standard animal welfare procedures. Prior to sacrifice or slaughter, the ducks were fasted for 8–10 hours without feed but with continued access to drinking water. Slaughtering was performed according to halal standards by cutting the the jugular vein a major blood vessels in the neck, followed by bleeding, scalding in hot water (60–65°C), feather removal and evisceration. The observed parameters included carcass weight and meat samples for physical quality analysis.

Observed Parameters

The observed parameters include duck performance (feed consumption, weight gain and feed conversion) and meat quality measurements (carcass weight, meat pH, water-holding capacity and cooking loss).

Data Analysis

To determine the effect of treatment on the observed parameters, statistical tests were performed using Analysis of variance according to a Completely Randomized Design (CRD). The differences between the actual treatments tested were analyzed using Duncan's Multiple Range Test. (DMRT).

RESULTS AND DISCUSSION

Effect of Treatment on Pekin Duck Productivity

The productivity data of Pekin ducks during the treatment period, which involved adding sauerkraut to their drinking water, were presented in Table 1. Statistical analysis showed a significant effect (P<0.05) on weight gain, feed consumption and feed conversion. The DMRT test results showed that weight gain in treatment A (0% sauerkraut probiotics/SP) was significantly (P< 0.05) lower than in the other treatments, namely B (1.5 SP), C (3% SP), D (4.5% SP) and E (6% SP). Treatment B did not differ significantly (P>0.05) from treatments C and E, but was significantly (P<0.05) lower than treatment D. Treatment C did not differ significantly (P>0.05) from treatment E, but was significantly (P<0.05) lower than treatment D. Treatment D was significantly (P< 0.05) higher than treatment E. Feed consumption and feed conversion of Pekin ducks in treatment A were significantly (P<0.05) higher than in treatments B, C, D and E. Treatment B did not differ significantly (P>0.05) from treatments C and E, but was significantly (P<0.05) lower than treatment D. Treatment C did not differ significantly (P>0.05) from treatment E, but was significantly (P<0.05) lower than treatment D. Treatment D was significantly (P< 0.05) lower than treatment E.

Giving sauerkraut in drinking water as a probiotic had a significant effect on body weight gain. Treatment D (4.5% SP) showed the highest weight gain compared to other treatments. The administration of 4.5% sauerkraut in drinking water is believed to improve the balance of intestinal micro flora due to the lactic acid, vitamins and bioactive compounds in sauerkraut, thereby enhancing digestive efficiency and accelerating growth. The lactic acid content in sauerkraut is 9.3 x 10^9 CFU/mL (Laboratory Animal Feed and Technology University of North Sumatra, 2025). Lactic acid can lower the pH of the digestive tract, creating less favorable conditions for the growth of pathogenic bacteria in the Pekin duck intestine (Li *et al.*, 2024; Xu *et al.*, 2024). Treatment A (0% SP) showed the lowest weight gain compared to the other treatments. It is suspected that there is no probiotic supplementation that can produce lactic acid bacteria, resulting in a lower state in the digestive tract of Pekin ducks. The condition of the animal's digestive tract significantly affects its growth because it is related to the digestion and absorption of nutrients from the feed ingredients that will be given (Naeem and Bourassa, 2025; Sugiharto and Raza, 2024). The administration of sauerkraut at low levels, specifically in treatments B (1.5% SP) and C (3% SP), is believed to have not yet reached the optimal amount of lactic acid bacteria produced to balance the gut micro flora and improve digestive efficiency, resulting in relatively lower weight gain compared to treatment D. Treatment E (6% SP) showed weight gain results similar to treatments B and C, which is that to be due to a saturation effect and osmotic imbalance in the digestive tract. Adding too much sauerkraut to drinking water is believed to drastically lower the pH, which can disrupt digestive enzymes and reduce the water's palatability (Wei and Marco, 2025).

The results showed that the addition of sauerkraut to drinking water as a probiotic for Pekin ducks significantly affected feed consumption. In treatment D (4.5% SP), the lowest feed consumption result was observed compared to other treatments, at 3848.30 g.

This is likely because treatment D showed improved efficiency in utilizing the nutrients in the feed provided. The lactic acid bacteria content in sauerkraut can improve the ba-lance of micro flora by suppressing the growth of patho-

Table 1. Average body weight gain, feed consumption, and feed conversion ration in Pekin ducks at 8 weeks of age

Treatment	Body Weight gain (g)	Feed Consumption (g)	Feed Conversion ratio
A (0% SP)	1497.70 ± 43.54[c]	3871.00 ± 0.00[a]	2.59 ± 0.08[a]
B (1.5% SP)	1618.75 ± 56.28[b]	3859.75 ± 4.89[b]	2.39 ± 0.08[b]
C (3% SP)	1617.35 ± 18.39[b]	3858.30 ± 4.83[b]	2.39 ± 0.03[b]
D (4.5% SP)	1733.15 ± 90.25[a]	3848.30 ± 0.91[c]	2.22 ± 0.11[c]
E (6% PS)	1648.55 ± 6.47[b]	3854.30 ± 3.10[b]	2.34 ± 0.01[b]

Note: Sauerkraut probiotic (SP) dose treatment in drinking: water A (0%), B (1,5%), C (3%), D (4,5%) dan E (6%); Varying superscripts in the treatments indicate significant differences in the impacts (P<0.01)

Table 2. Average carcasss weight, pH, water holding capacity, and cooking loss

Treatment	Carcass weight (g)	pH[ns]	WHC (%)[ns]	Cooking Loss (%)[ns]
A (0% PS)	1123.28 ± 32.65[c]	6.27 ± 0.11	46.16 ± 0.65	32.68 ± 0.56
B (1.5% PS)	1213.89 ± 42.31[b]	6.26 ± 0.11	47.03 ± 0.99	32.98 ± 1.35
C (3% PS)	1213.01 ± 13.80[b]	6.28 ± 0.19	45.72 ± 1.27	34.65 ± 2.19
D (4.5% PS)	1299.86 ± 67.69[a]	6.25 ± 0.14	45.55 ± 1.33	34.61 ± 1.39
E (6% PS)	1236.41 ± 4.85[b]	6.21 ± 0.14	45.15 ± 1.28	34.88 ± 1.15

Note: Sauerkraut probiotic (PS) dose treatment in drinking: water A (0%), B (1,5%), C (3%), D (4,5%) dan E (6%); Varying superscripts in the treatments indicate significant differences in the impacts (P<0.01); ns (non significant) (P>0.05).

genic bacteria, thus optimizing nutrient absorption (Karačić *et al*., 2024; Wang *et al*., 2024). Lactic acid bacteria can also lower the pH, thus supporting the optimal activity of digestive enzymes in breaking down feed nutrients entering the digestive tract. Treatment A (0% SP) showed the highest feed consumption compared to the other treatments, which is suspected to be due to the absence of probiotic support in the digestive tract. This can make digestive efficiency and nutrient absorption relatively low, causing Pekin ducks to need to increase their feed intake to meet their energy needs for growth. This condition aligns with the increased feed intake being a compensation for the low availability of metabolic energy due to limited digestive and absorption efficiency (Toghyani *et al*., 2025; Wang *et al*., 2024). Treatments B (1.5% SP), C (3% SP) and E (6% SP) showed relatively similar feed consumption. It is suspected that the dosage of sauerkraut at these levels was not yet able to provide more optimal effects for treatments B and C. The availability of lactic acid bacteria is still limited, so the improvement of the intestinal micro flora is not yet optimal. Meanwhile, in treatment E, the increased lactic acid administration is believed to increase the concentration of organic acids in drinking water, which could reduce water consumption or palatability, causing Pekin ducks to readjust their feed intake to balance their body's nutritional needs.

Feed conversion is closely related to weight gain and feed intake. In treatment A (0% SP), the lowest weight gain was observed but the highest feed intake, resulting in high feed conversion. This condition is believed to be caused by low digestive efficiency due to the absence of lactic acid bacteria support obtained from probiotics (sauerkraut), resulting in no improvement in the digestive health of Pekin ducks (Naeem and Bourassa, 2025). In treatment D (4.5% SP), the number of lactic acid bacteria is at the optimal point (9.3 x 10^9 CFU/mL) to suppress the growth of pathogenic bacteria, thus increasing the integrity of the Pekin duck intestinal mucosa, improving villus morphology and maximizing nutrient absorption, so that every ration consumed can be used more efficiently for meat. In treatment B (1.5% SP) and C (3% SP), it is suspected that the number of lactic acid bacteria produced has not reached the optimal threshold, so it is not yet optimal in digestion efficiency. Meanwhile, in treatment E (6% SP), excessive amounts of sauerkraut in the drinking water of Pekin ducks have the potential to cause negative effects such as reduced palatability of the drinking water due to the suspected increase in acidity, which can disrupt intestinal pH balance and is ineffective in suppressing the growth of pathogenic bacteria, thus reducing efficiency (Dittoe *et al.*, 2018; Wei and Marco, 2025). This is consistent with the increase in body weight and feed consumption observed in the study.

Effect of Treatment on Carcass Weight and Meat Quality of Pekin Ducks

The carcass weight and meat quality data of Pekin ducks during treatment with sauerkraut added to their drinking water were presented in Table 2. Statistical ana-lysis showed a significant effect (P<0.05) on carcass weight, but no significant effect (P> 0.05) on meat pH, water-holding capacity and cooking loss. The results of the DMRT test showed that carcass weight in treatment A was significantly (P<0.05) lower compared to treatments B, C, D and E. Treatment B was not significantly different (P>0.05) from treatments C and E, but was significantly (P<0.05) lower compared to treatment D. Treatment C was not significantly different (P>0.05) from treatment E, but was significantly (P<0.05) lower compared to treatment D. Treatment D was significantly (P< 0.05) higher compared to treatment E.

The carcass weight of Pekin ducks in this study showed that treatment D (4.5% SP) yielded the highest result, 1299.86 g. This aligns with the high weight gain observed in treatment D. The high carcass weight in this treatment is due to the probiotic assistance from sauerkraut, which can improve digestion and nutrient absorption in the Pekin duck's intestines. This is related to the lactic acid content found in sauerkraut, which leads to increased deposition of muscle tissue in the carcass (González *et al.*, 2024). Treatment A (0% SP) had the lowest carcass weight compared to the other treatments, which is clearly related to the effect of sauerkraut supplementation. It is suspected that without the addition of sauerkraut, there was no improvement in the health of the Pekin duck's intestines, resulting in slower muscle development compared to other treatments. In treatments B (1.5% SP), C (3% PS), and E (6% SP), carcass weights tended to be relatively similar. In treatments B and C, the probiotic was likely insufficient to achieve a noticeable physiological effect, resulting in a relatively low increase in carcass weight. This differed from treatment E, where the high dose of probiotic in the Pekin duck's drinking water was that to disrupt the electrolyte balance in the gut, ultimately reducing growth efficiency in Pekin ducks (Getabalew *et al.*, 2020).

The pH of Pekin duck meat in this study showed no significant differences between treatments, ranging from 6.21 to 6.28. This condition can be predicted by the physiological nature of meat's relatively stable pH, which is more influenced by post-mortem biochemical processes than by nutritional treatments in feed or drinking water. Meat pH is determined by the rate of glycogenolysis and lactic acid accumulation after slaughter, which is closely related to muscle energy reserves and pre-slaughter stress status (Kudryashova and Kudryashov, 2022; Liu *et al.*, 2025). While giving sauerkraut as a probiotic does have the potential to improve gut health and nutrient digestibility, it doesn't always directly and significantly affect muscle glycogen deposition. Thus, despite differences in treatment at the supplementation level, the accumulation of lactic acid formed post-mortem tends to be uniform, resulting in relatively similar final pH values. Additionally, genetic factors, harvest age and uniform maintenance conditions across all groups can reduce inter-treatment variation. This indicates that the use of sauerkraut within the tested dosage range was not strong enough to modify post-mortem biochemical mechanisms in muscle, resulting in the meat's pH remaining within the normal range and the existing differences being biologically small and statistically insignificant (Rodrigues *et al*., 2024).

The water binding capacity of Pekin duck meat ranges from 45.15% to 47.03%, showing no significant difference between treatments. This condition can be explained by the fact that the water-holding capacity of meat is more influenced by intrinsic physiological factors, such as the structure and composition of myofibrillar proteins, glycolgen content and post-mortem pH changes, than by single probiotic treatments (Guo *et al*., 2023). The process of protein denaturation due to a decrease in pH after slaughter plays a significant role in determining the muscle's water-holding capacity, as long as the meat's pH value remains within the normal range and is relatively uniform across treatments (Ji *et al*., 2024; Tan *et al*., 2021). Additionally, the homogeneity of maintenance factors, harvest age and livestock strain uniformity can suppress biological variation, which typically affects water binding capacity. Although probiotics from sauerkraut have the potential to improve digestive health and enhance nutrient utilization efficiency, their impact is more dominant on growth performance and carcass condition compared to the functional properties of post-mortem meat. Thus, the similarity in water-holding capacity across all treatments indicates that sauerkraut supplementation within the tested dosage range was not strong enough to alter the water-holding capacity of muscle protein, resulting in relatively stable and statistically non-significant differences in the water-holding capacity value of the meat.

Cooking loss in Pekin duck meat showed no significant difference, with results ranging from 32.68% to 34.88%. This can be explained by the fundamental nature of cooking loss, which is more determined by the composition of muscle tissue, intramuscular fat content, water-holding capacity and post-mortem protein stability than by single nutritional treatments during the rearing period (Rodrigues *et al*., 2024). The cooking loss process is essentially the result of the release of intracellular fluid and fat during heating, which is closely related to the ability of muscle protein to retain water and the final pH of the meat (Ji *et al*., 2024). In this study, both the pH and water-binding capacity of the meat between treatments showed relatively similar patterns, so it is understandable that cooking loss also did not show significant differences. Additionally, the homogeneity of genetic factors, harvest age, maintenance conditions and consistent cutting standards across all treatments also contributed to reducing the variation in coo-king loss values (El-Attrouny *et al*., 2024). Although sauerkraut contains lactic acid bacteria and bioactive metabolites that could potentially improve the physiological status of livestock, these effects are more reflected in growth and carcass parameters than in the functional properties of the meat after cooking. Therefore, these results indi-cate that sauerkraut supplementation within the tested dosage range was not strong enough to influence post-mortem muscle characterristics, thus cooking loss values remained stable and did not differ signi-ficantly between treatments.

CONCLUSION

The addition of probiotics to the drinking water of Pekin ducks at the 4.5% level (treatment D) was found to be the optimal dose, as it increased productivity and carcass weight without causing any negative effects on meat quality. In treatment D, the productivity of Pekin ducks showed improvements, including a body weight gain of 1733.15 g, feed consumption of 3848.30 g and a feed conversion ratio of 2.22. The carcass weight reached 1299.86 g, while the meat quality parameters were a pH of 6.25, water holding capacity of 45.55% and cooking loss of 34.61%.

SUGGESTION

Suggestions for Pekin duck farmers include using sauerkreut as a probiotic in drinking water at a dose of 4.5%. Suggestions for further research include examining the effects of using sauerkreut probiotics on other poultry.

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