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Growth Performance, Carcass Traits, and Economic Aspects of Pekin Duck Growing in Dhamrai Area of Bangladesh

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ABSTRACT

White Pekin ducks are a valuable addition to the poultry industry in Bangladesh with their adaptability, rapid growth rate, and excellent meat quality. This study aimed to evaluate the growth performance, meat quality, and socio-economic aspects of White Pekin ducks in the Dhamrai area of Bangladesh. The study was carried out between January and April 2024 by distributing a total of 250 one-day-old Pekin ducklings among 25 selected farmers. Farmers were chosen based on their willingness, capacity, and adequate housing facilities to observe the growth characteristics, carcass traits, and economic values of Pekin ducks. The farmers were mainly middle-aged (46 years) with an average family size of 4.16 and had farming experience of 9 years. Livestock and poultry rearing were the primary occupation for 72% of farmers, and Pekin duck farming was pursued for both household consumption and extra income. The ducks showed consistent growth, increasing from 53.17 g at day-old to 1812.82 g at 9 weeks, with an average daily gain of 82.97 g. At the marketing age (10 weeks), the average dressing percentage was 74. The carcasses of male and female ducks differed slightly in terms of organ and fat distribution, with males generally had heavier internal organs and giblets, while females had slightly higher fat (2.10%). The nutrient content of breast and thigh muscles showed differences in water and fat content, with males generally having a higher dry matter of 29.13%. The Benefit-Cost ratio of Pekin duck farming was 1.59; however, the majority of farmers faced constraints due to higher feed prices and a lack of quality ducklings for Pekin duck production. Therefore, improving management practices, biosecurity measures, and access to better inputs could enhance the profitability and sustainability of Pekin duck farming.

Keywords: Benefit-cost ratio, Carcass trait, Dressing percentage, Growth performance, Pekin duck

INTRODUCTION

White Pekin ducks originated from China and have become widely popular across the world (Elkin, 2007) due to their remarkable adaptability to diverse environments, including the varied climate of Bangladesh (Ahmed et al., 2021). White Pekin ducks are characterized by their pure white feathers, orange to yellowish bills, shanks, and webbed feet. Pekin ducks are highly prized for their premium-quality meat and are widely raised on commercial duck farms (Ghosh et al., 2022). Global duck meat production in 2023 was dominated by China, with 3.6557 million metric tons, which is significantly higher than in other countries. Myanmar and France followed at 0.22251 and 0.20553 million metric tons, respectively (ReportLinker Research, 2023). White Pekin duck meat has gained significant popularity among urban consumers across various regions of Bangladesh, driving the growth of value-added, ready-to-eat duck products and expanding the frozen meat sector in the metropolitan areas. In India, traditional duck farmers, particularly women's self-help groups in rural areas, are rapidly adopting White Pekin duck farming, driven by robust market demand, convenient forward marketing linkages, and promising economic returns (Ghosh et al., 2021). In many regions of Bangladesh, duck farming is often favored over chicken farming due to lower disease outbreaks, reduced mortality

rates, and simpler feeding management. Recently, the rise in duck rearing and production, particularly white Pekin duck farming, has been driven by a growing number of women farmers in villages and peri-urban areas of Bangladesh, who are increasingly drawn to its promising potential (Islam et al., 2016). Under the traditional backyard duck farming system in lowland Hoar, Flood-prone, and Coastal areas, ducks are primarily reared on rice bran-based diets with limited supplementary green feedings, which often fall short of meeting the proper nutritional needs of ducks. To minimize the high costs of commercial feeds, many village duck farmers rely on a single, cost-effective feeding approach, using a mixture of rice bran, broken rice, and other locally available feed ingredients throughout the entire life cycle of ducks (Mavromichalis, 2014). It is widely recognized that management practices and feeding conditions are essential factors influencing the growth and meat characteristics of food animals (Mir et al., 2017). Management practices and feeding conditions influence the growth patterns and meat quality by affecting various metabolic pathways (Lebret, 2008; Park et al., 2018) either alone or in combination. The meat quality of Pekin ducks is a crucial consideration, as their meat is typically sold in the frozen sector in packaged form. Prolonged storage can lead to lipid oxidation, which may affect the taste and texture of the meat (Biswas et al., 2019). Meat production mainly relies on commercial strains of Pekin duck that vary in growth performance, carcass conformation, and meat quality. Furthermore, large differences exist in their housing conditions that affect welfare, growth, and carcass characteristics. Meat-producing duck strains exhibit rapid growth as a result of genetic selection, efficient housing systems, and superior nutrition. Several strains of Pekin ducks are frequently utilized in commercial meat production because of their impressive growth rates, efficient feed conversion, desirable body conformation, and high 'dressing %' (Starcevic et al., 2021). Pekin ducks are typically slaughtered between 6 and 8 weeks of age, by which time they have completed their rapid growth phase and reach an average weight of approximately 3.5 kilograms (Kokoszynski et al., 2019a). However, the emphasis on selecting for rapid growth and high meat yield may negatively influence meat quality (Kwon et al., 2014). Since duck meat production has intensified in recent decades, there is a growing demand to develop production systems that not only support optimal animal welfare but also ensure the delivery of excellent-quality meat (Chen et al., 2015). Pekin ducks are highly susceptible to environmental stress, which is significantly influenced by their housing conditions. Additionally, high stocking density can impair the growth performance, health, and welfare of Pekin ducks (Xie et al., 2014). Numerous studies have been conducted to examine the growth performance and meat quality of various commercial Pekin duck strains (Kwon et al., 2014; Kokoszynski et al., 2019b). Although substantial literature exists on numerous aspects of white Pekin duck production in the confined rearing system under the commercial feeding regime, there is limited research regarding the growth performance and meat quality of this duck breed raised in a backyard farming system (Steczny et al., 2017; Rabbani et al., 2019). The present study could explore the growth pattern, meat quality, and profitability of raising white Pekin ducks in existing backyard farming conditions with locally available ingredients-based feeding management. Therefore, this study aimed to investigate the growth performance, meat quality, socio-economic aspects, profitability, and constraints regarding White Pekin duck farming under existing backyard farming conditions in the Dhamrai area of Bangladesh.

MATERIALS and METHODS

Ethical approval

This study was conducted in strict accordance with established ethical guidelines for animal research and welfare. Ethical approval was obtained under the "Establishment of 'BLRI Technology village' at BLRI Regional station" project from the Ethics Committee of the Bangladesh Livestock Research Institute (BLRI), ensuring that all procedures involving animal care and handling complied with the standards set forth by the World Organization for Animal Health (OIE) for the ethical treatment of animals in research.

Study area and time

The present research was carried out at the "BLRI Technology Village" (Shraifbag) of the Dhamrai area in Dhaka district under the Dhaka division of Bangladesh. Dhamrai Sub-district is located about 40 kilometers northwest of the capital city of Dhaka. Dhamrai Sub-district has an area of 307.41 square kilometers, located between 23°49' and 24°03' north latitudes and between 90°01' and 90°15' east longitudes. Figure 1 represents the geographical location of the experimental site of Dhamrai Sub-district, Dhaka, Bangladesh. The experimental and data collection period was considered from the first of January to the 30th of April 2024.

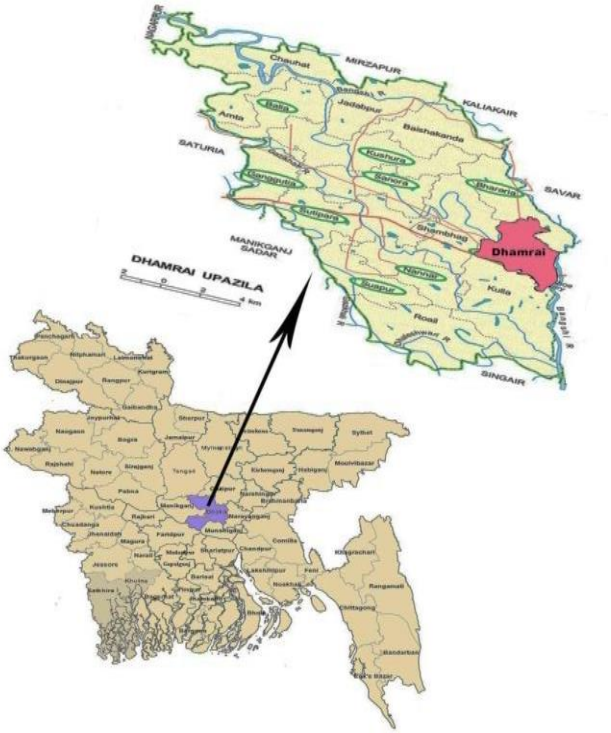

Figure 1. Geographical location of the study site, Dhamrai Sub-district, Dhaka, Bangladesh

Study population and design

A total of 25 farmers were selected based on their financial capacity, housing facility, adequate feed resources, and willingness to rear Pekin Duck, etc. A total of 250 one-day-old Pekin ducklings were collected from the Poultry Production Research Division by the coordination of the Farming System Research Division, BLRI, Savar, Dhaka. One farmer was selected from the total, based on his ability to provide sufficient brooding space and electricity supply. The brooding of White Pekin ducklings was conducted from day-old to 6 days of age under controlled environmental conditions to ensure optimal growth and health during the critical early stages. The ducklings were housed in well-ventilated, clean, and dry brooders equipped with adequate heating sources to maintain a consistent temperature range of 32-35°C during the first three days, gradually reducing to 28-30°C by the sixth day. The floor was covered with absorbent bedding material to prevent moisture accumulation and reduce the risk of infections. A 24-hour light cycle was maintained to encourage early feeding and activity. After completing the brooding up to 6 weeks of age, a total of 250 Pekin ducklings were distributed among the selected 25 farmers to assess the growth performance, carcass traits, and economic values of Pekin ducks at the community level. Farmers reared Pekin ducks on a semi-intensive system with scavenging feeding management, where they supplied only a limited amount of locally available concentrate feed ingredients as a feed supplement from their household or purchased from the local market. Figure 2 shows the feeding and rearing management of Pekin ducks at Dhamrai Sub-district, Dhaka, Bangladesh. All farmers were interviewed with a structured questionnaire to assess the socio-economic conditions, rearing facilities, profitability, and constraints associated with Pekin duck rearing.

Data collection and recording

Data were collected and recorded on feed ingredients offered/day, body weight (gm), daily weight gain (gm) on a weekly basis from day old to nine weeks, and the market age of Pekin ducks was considered at 10-12 weeks. Four male and four female Pekin ducks were randomly selected from experimental farmers' households for this study and slaughtered to observe the physical quality as well as the carcass characteristics. Ducks were slaughtered manually at 10 weeks of age. In the beginning, the live weight (gm) was measured for each duck through a digital weight balance, and then slaughter was performed according to the standard procedure to ensure minimal pain and distress following the Halal method as customary in a Muslim country. The Halal approach ensured that the animals were slaughtered with the utmost care and respect, in compliance with ethical and religious standards. All procedures were carried out by trained personnel to maintain high ethical standards and ensure compliance with veterinary guidelines. Then the data were recorded on slaughtered weight (gm), Carcass weight (gm), Edible carcass weight (gm), muscle, bone, and Skin weight (gm) of Breast, Thigh (Thigh with drumstick), and lumbosacral region. The weight (gm) of edible parts and inedible parts, giblets, abdominal fat, skin, as well as other by-products of Pekin duck, was also recorded. The muscles from the Breast and Thigh region (50 gm) from each portion of both sexes (two males and two females) were considered as samples for laboratory analysis to determine the nutrient composition. Then the laboratory analysis was performed on nutrient composition, and the data were used for statistical analysis.

Economic assessment

The parameters on the nutrient composition (Dry matter, water content, crude protein, crude Fat, ether extract, and Ash) of the meat sample were calculated as per the standard methods (Proximate analysis). Proximate analysis was employed to assess the nutrient composition

of the samples, following the standard procedures outlined by the Association of Official Analytical Chemists (AOAC, 2005). Moreover, carcass traits were recorded for the whole carcass and individual cut-up parts. The 'dressing %' was calculated by the following formula.

Dressing (%) = Dressed weight / Live weight × 100

For calculating the Net return, the following formula was used.

Net return = GR - GC; Where GR: Gross return, GC: Gross cost

Here, GC = TFC + TVC; Where TFC: Total fixed cost and TVC: Total variable cost

To calculate the Benefit-cost ratio, the following formula was used.

$$\text{Benefit-cost ratio} = \frac{\text{Gross Return (GR)}}{\text{Gross Cost (GC)}}$$

The gross return indicates the average return from the raising of Pekin Ducks, including the family consumed duck value and the sold value of ducks. Gross cost includes the total cost of Duck rearing, such as feed cost, veterinary cost, housing cost with 10% depreciation, cost of family labor involved, transportation cost, miscellaneous cost, etc. The benefit-cost ratio was a relative measure employed to compare the benefit to the cost. It assisted in analyzing the financial efficiency of the Pekin duck farms.

Statistical analysis

Initially, collected and recorded data were entered, sorted, compiled, and analyzed by using a Microsoft Excel worksheet. Descriptive statistics including frequency distribution, percentage, mean value and standard error of mean were considered to test the differences among the variables of feed supplying amount (gm/day), growth performance at different ages (gm/day), the cost involved in rearing and management practices (USD), fresh and slaughtered weight (gm), carcass weight (gm), nutrient compositions of meat under the basic economic performance indicators using SPSS (Statistical Package for the Social Science) Software, IBM Corporation, version-25.

RESULTS

Socio-economic demography of Pekin duck raising farmers

Table 1 represents the demographic and family-related characteristics of Pekin duck-raising farmers, where the mean age was 46.12 ± 2.58 years, indicating the farmers were in their mid-life stage. The farmer's family composed an average of 4.16 ± 0.19 members, with the number of earning members of 1.16 ± 0.07, and most households had slightly more than one individual contributing to the family income. A moderate level of farming experience was observed at 9.08 ± 1.43 years within the sample population.

The distribution of respondents across different educational levels, occupations, training facilities, and purposes of Pekin duck rearing is presented in Table 2. The data reflected a diverse range of educational backgrounds, where the highest percentage, comprising 36% of the farmers, had completed Secondary School Certificate (SSC) education, followed by two groups, each representing 24% attained a Higher Secondary Certificate (HSC) level, and another had education below the SSC level. The lowest percentage (16%) had completed only primary education in the study area.

The majority of farmers (72%) were engaged in livestock and poultry rearing as their primary occupation. A smaller portion of farmers (16%) was involved in business activities. Agriculture was the primary occupation for only 8% of the respondents, while only 4% identified as day laborers. Regarding secondary occupation, a significant proportion (52%) was involved in agriculture, 12% were also engaged in livestock rearing and day labor. Business was an occupation for 16% of the farmers, and 8% practiced fish farming as their secondary occupation.

A combination of family need and extra income was the most common practice by 40% of the farmers, whereas 32% reared ducks for extra income, and 28% kept ducks primarily to meet family needs in the study area. Overall, 88% of the respondents had received training, whereas 64% of farmers attended training on livestock and poultry farming from the Bangladesh Livestock Research Institute (BLRI), and 24% got training organized by the Department of Livestock Services (DLS), Bangladesh. Moreover, 12% of the respondents did not receive any formal training related to duck rearing.

Table 1. Family status of Pekin duck raising farmers at Dhamrai Sub-district, Bangladesh, during 2024

Parameters	Mean ± SE (n = 25)
Age of the farmer	46.12 ± 2.58
Family size	4.16 ± 0.19
Earning member	1.16 ± 0.07
Farming experience	9.08 ± 1.43

SE: Standard error, n: Number of observations

Table 2. Education, occupation, rearing purpose, and training status of farmers at Dhamrai area, Bangladesh, in January to April 2024

Educational level	**Percentage (n)**	**Primary occupation**	**Percentage (n)**
Primary	16.00 (4)	Agriculture	8.00 (2)
Below SSC	24.00 (6)	Livestock and poultry rearing	72.00 (18)
SSC	36.00 (9)	Day labor	4.00 (1)
HSC	24.00 (6)	Business	16.00 (4)
Total	100.0 (25)	Total	100.00 (25)
Purpose of Pekin duck rearing		**Secondary occupation**	
Family need	28.00 (7)	Agriculture	52.00 (13)
Extra income	32.00 (8)	Fish farming	8.00 (2)
Family needs and extra income	40.00 (10)	Livestock rearing	12.00 (3)
Total	100.0 (25)	Day labor	12.00 (3)
Training facility		Business	16.00 (4)
DLS	24.00 (6)	Total	100.00 (25)
BLRI	64.00 (16)	-	-

*SSC: Secondary school certificate; HSC: Higher secondary school certificate; DLS: Department of Livestock Services; BLRI: Bangladesh Livestock Research Institute; n: Number of observations

Table 3. Housing facility and rearing system of Pekin duck at Dhamrai area, Bangladesh, from January to April 2024

Housing facility	**Percentage (n)**	**Rearing system**	**Percentage (n)**
Separate duck house	84.00 (21)	Scavenging	12.00 (22)
Same house with chicken	16.00 (4)	Semi-intensive	88.00 (3)
Housing material		**House cleaning practice**	
Tin and wood	60.00 (15)	Water	40.00 (10)
Bamboo and tin	24.00 (6)	Water and broom	24.00 (6)
Brick	16.00 (4)	Water and disinfectant	36.00 (9)
Floor type		Total	100.00 (25)
Wood	84.00 (21)	-	-
Brick	16.00 (4)	-	-
Total	100.00 (25)	-	-

Housing and rearing management

The housing facilities and rearing systems for Pekin ducks are shown in Table 3. A majority percentage (84%) of the duck farmers provided shelter to their Pekin ducks in a separate house, while 16% were kept in the same house with chickens. The materials used for constructing the duck houses varied, where 60% of the houses were made of tin and wood, 24% of farmers' duck houses were made of bamboo with tin, and 16% were made of brick. The floor types of the housing structures included 84% of wood and 16% of brick or concrete floors. In terms of the rearing system, most of the farmers adopted semi-intensive rearing management and allowed ducks to scavenge in the ponds near their household, while 12% of respondents raised Pekin ducks under the scavenging system. Water was the most common cleaning method for house cleaning practices, used by 40% of the farmers. Other cleaning methods included the use of both water and a broom (24%) and water combined with disinfectant (36%).

Concentrate feed supplements are provided by the farmers

Most of the farmers did not follow any specific diet for duck production under traditional rearing and feeding management in Bangladesh. They mainly depended on natural feeding sources for feeding their ducks under the scavenging rearing system. However, they provide the minimum proportion of locally available concentrate feed ingredients 2-3 times a day. Table 4 shows the frequency and percentage of concentrate feed ingredients provided by farmers to their Pekin ducks at different growth stages. At the early stage, rice was the most commonly used feed

component, whereas 80% of farmers offered broken rice to their ducks, followed by rice polish 72%, whole rice 48%, wheat 36% and maize provided by 20% of the duck farmers. Boiled rice was supplied by a smaller proportion of farmers (16%), while 44% of farmers provided ready feed, and all farmers (100%) used common salt in the duck diet. At the growing stage, there was a noticeable shift in feed preferences. The use of rice increased to 84%, while rice polish (80%) remained a common choice; broken rice was used by 60% of farmers. The frequency of ready feed, wheat, and maize bran usage slightly decreased to 36%, 28%, and 20%, respectively, due to fluctuating market prices and the seasonal availability of these feed ingredients in the local market. Notably, a vitamin-mineral premix was incorporated by 20% of farmers at the growing stage. The distribution of feed ingredients highlights the farmers' adaptability in adjusting the duck feed formulation as the ducks progressed through different growth stages.

Growth performance

Figure 3 shows the growth performance and average daily gain of Pekin ducks in the study area. The average body weight of day-old ducklings was 53.17 ± 0.41 gm. Ducks gained an average of 17.37 gm per day during the first week, with their body weight reaching 121.63 ± 1.67 gm. Throughout the second to ninth week period, the Pekin ducks exhibited increasing average body weight (gm) of 340.77 ± 12.32, 505.62 ± 12.45, 648.36 ± 17.46, 771.67 ± 23.97, 957.66 ± 26.98, 1223.94 ± 36.35, 1517.58 ± 37.04, and 1812.82 ± 49.91 gm, respectively. Moreover, the average daily gain (gm) from the first to the ninth weeks of age was observed at 17.37 gm, 48.68 gm, 35.23, 46.62, 52.23, 57.80, 65.84, 74.79, and 82.97 gm, respectively. Pekin ducks exhibited a remarkable growth performance, characterized by a steady weekly increase in both body weight and daily weight gain.

Table 4. Concentrate feed supplement provided by the farmers to their Pekin ducks at Dhamrai, Bangladesh, from February to April 2024

Feed ingredients	Frequency (n)	Percent at early stage (0-8 weeks)	Frequency (n)	Percent of growth stage (9-12 weeks)
Rice	12	48.00	21	84.00
Broken rice	20	80.00	15	60.00
Boiled rice	4	16.00	5	20.00
Rice polish	18	72.00	20	80.00
Wheat bran	9	36.00	7	28.00
Maize crushed	5	20.00	5	20.00
Vitamin-mineral premix	-	-	5	20.00
Ready feed	11	44.00	9	36.00
Salt	25	100.00	25	100.00

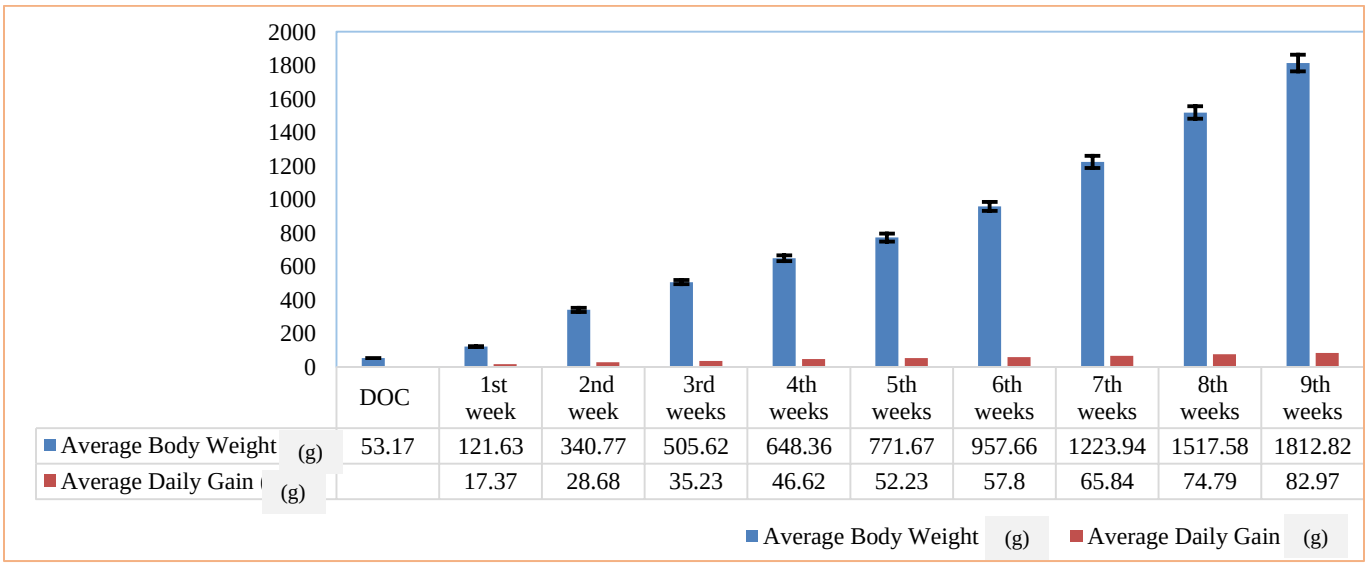

Figure 3. Growth performance (Mean ± Standard Error) and average daily gain of Pekin Duck at Dhamrai area of Bangladesh in 2024.

Figure 2. Feeding and rearing management of Pekin ducks at Dhamrai Upazila, Dhaka, Bangladesh in 2024

Health and biosecurity management of Pekin ducks

Table 5 shows the health and biosecurity management of Pekin ducks and reveals that 84% of farmers followed regular vaccination protocols, with 48% vaccinating at 21 days of age and 36% at 28 days. About 56% of farmers reported their ducks were free from disease. Moreover, farmers experienced Duck Plague and Duck Cholera at 8%, because farmers reared Pekin ducks only up to reach their marketing age (12 weeks), while 16% Duck Brooder Pneumonia and 12% other diseases. Biosecurity management practices indicated that 88% of farmers' ducks came into contact with wild birds. Nearly 52% of farmers isolated sick ducks in a separate shed, while 20% kept them in the same shed, another 20% opted to slaughter the sick ducks, and 8% of farmers sold their sick ducks to the local consumers. Excrement management was usually practiced by 100% of farmers, and they performed regular cleaning. About 32% of farmers disposed of excreta by dumping it with soil, 28% used it as fish feed, 20% threw it into the water, and another 20% used it as fertilizer in their household crop and vegetable garden. In terms of dead duck disposal, 44% of farmers practiced burning, 24% threw it into the water, 20% threw it into open fields, and 12% burned it. As the Sharifbag village has already been declared as the "BLRI Technology Village" which is located under Dhamrai Sub-district. So, the treatment of sick pekin ducks was primarily handled by veterinary experts from the Bangladesh Livestock Research Institute (68%), with a smaller proportion treated by veterinary hospitals (12%) and quacks (12%) or managed by the farm owners themselves (8%).

Table 5. Health and biosecurity management of Pekin duck at Dhamrai area, Bangladesh, from January to April 2024

Parameters	Frequency (n)	Percentage
Followed vaccination regularly	21	84.00
Age at vaccination		
21 days	12	48.00
28 days	9	36.00
Disease outbreaks		
Duck plague	2	8.00
Duck cholera	2	8.00
Duck brooder pneumonia	4	16.00
Others	3	12.00
Free from disease	14	56.00
Biosecurity management		
Contact with a wild bird	22	88.00
Sick duck management		
Kept in the same shed	5	20.00
Kept in a separate shed	13	52.00
Slaughtered	5	20.00
Sold a sick duck	2	8.00
Regular cleaning of excrement	25	100.00
Method of excreta management		
Throw it into the water	5	20.00
Used as a household fertilizer	5	20.00
Dumping with soil	8	32.00
Used as fish feed	7	28.00
Death duck management		
Throw in field	5	20.00
Buried	11	44.00
Burnt	3	12.00
Throw in water	6	24.00
Treatment facilities for ducks		
By a veterinary expert from BLRI	17	68.00
By the veterinary hospital	3	12.00
By quack	3	12.00
By own self	2	8.00

BLRI: Bangladesh Livestock Research Institute; n: Number of observations

Carcass characteristics of Pekin ducks

The carcass characteristics of Pekin ducks at their marketable age (10 weeks) are given in Table 6. The overall live weight of the Pekin duck was 2017.50 ± 44.63 gm, where the live weight of 2025.50 ± 61.48 gm was observed for males and 2009.50 ± 73.98 gm for females. Higher blood (7.50 ± 0.28 ml) but lower feather (152.50 ± 4.78 gm) weight was found for males; lower blood (7.00 ± 0.91 ml) and higher feather (157.50 ± 4.78 gm) weight were observed in female Pekin ducks. Sex had a minimum effect on dressing weight, and the overall dressing weight of the Pekin duck was 1494.12 gm. Results from the study revealed that male ducks possessed the more weighted head, wing, shank, heart, gizzard, liver, lungs, intestine and giblets was of 85.00 ± 1.91 gm, 146.75 ± 8.23 gm, 45.75 ± 1.43 gm, 21.00 ± 1.78 gm, 74.50 ± 3.47 gm, 55.75 ± 2.46 gm, 24.00 ± 2.27 gm, 118.00 ± 3.34 and 295.50 ± 9gm, respectively. Although almost similar, the duck-bill 24.50 ± 0.88 gm and spleen (1.00 ± 0.00 gm) weight was measured in male and female ducks. However, a higher fat percentage on body weight (2.10%) was observed in female Pekin ducks than in males (1.97%). In this study, 74% of dressing weight was accounted from the overall live weight with 3.98% head, 1.21% bill, 6.84% wing, 2.22% shank, 2.04% fat, 0.96% heart, 3.61% gizzard, 2.71% liver, 0.05% spleen, 1.11% lungs, 5.76% intestine, and 14.50% giblet weight were also measured from the overall weight.

Major tissue component of Pekin duck

Table 7 shows the different tissue components of Pekin ducks at the Breast, Leg quarter, and Lumbosacral parts of the body. The tissue components of the whole carcass of male and female Pekin ducks were divided into three categories: Breast part, Leg quarter, and Lumbosacral part. From these three different components, the muscle of males (430.75 ± 16.99 gm) and females (414.75 ± 21.48 gm) covered the maximum portion of the total carcass as Pekin was popular as a meat type duck whereas skin weight ranked second (353.25 ± 24.00 gm; 335.75 ± 13.22 gm) and bones covered the third one (257.5 ± 7.28 gm; 251.25 ± 18.69 gm). Muscle and skin from the breast part generally covered the maximum portion of the total carcass, which was found to be 194.75 ± 11.96 gm, and 167.75 ± 13.79 gm in males, respectively, and 188.25 ± 13.63 gm and 154.5 ± 3.41 gm in females Pekin duck, respectively. However, bones of the lumbosacral part covered the maximum portion, where 257.5 ± 7.28 gm in male and 251.25 ± 18.69 gm in female ducks.

Nutrient composition of Pekin ducks' breast and leg quarter muscle

Table 8 represents the measured percentage of nutrients from both male and female Pekin ducks' thigh and breast muscles. Drakes exhibited a higher dry matter of 29.13% compared to ducks' 24.14%, indicating lower water content in drake thigh muscle. Conversely, ducks generally showed higher water content in both thighs at 75.86% and breast muscles at 77.12% compared to drakes. Crude protein levels were similar between drakes and ducks across both muscle types, with slight variations observed. Crude fat content was notably higher in thigh muscles, exhibited at 12.59% in drakes and 14.88% in ducks, than in the breast muscles of drakes (5.12%) and ducks (5.10%). Additionally, ether extract values were higher in thigh muscles (2.74% in drakes and 2.13% in ducks) than in breast muscles of drakes (0.42%) and ducks (0.48%). Ash content was slightly elevated in thigh muscles, with values of 3.86% in drakes and 4.00% in ducks, compared to 3.60% in drakes and 3.33% in ducks' breast muscles, respectively.

Benefit-cost ratio of Pekin duck raising farmers

Table 9 represents the benefit-cost ratio (BCR) of Pekin duck farming in the Dhamrai area of Bangladesh. The various cost components for Pekin duck rearing up to their marketing age (12 weeks) were calculated, including 17.93 USD for feed cost, veterinary expenses of 2.80 USD, housing cost with 10% depreciation of 3.82 USD, the cost involved in family labor engaged 11.38 USD, transportation cost 2.060 USD, and miscellaneous expenses of 1.20 USD. The total cost incurred by farmers was observed at 38.99 USD. The income generated from the Pekin duck farming operation was also assessed, with the average value of family-consumed ducks at 10.97 USD and the value of sold ducks at 51.09 USD, resulting in a total income of 62.05 USD with a calculated Net income of 26.06 USD. The BCR was determined as 1.59, which reflected the efficiency of the duck farming operation and indicated that for every unit of currency spent on duck farming, a return of 1.59 units was generated.

Operational constraints in Pekin duck farming

Farmers faced operational constraints in Pekin duck rearing that were primarily related to the high price of feed, reported by 88% of farmers, followed by the lack of quality ducklings (72%) and the unavailability of ducklings at all times (60%). Attacks by predatory animals were a concern for 52% of duck farmers, while 40%

mentioned the high price of ducklings as a limiting factor. Disease outbreaks were reported as a constraint by 36% of farmers, and 24% reported the lack of vaccines and treatment facilities. About 20% of farmers noted that the profitability of Pekin duck farming was not always guaranteed due to fluctuations in feed prices, unavailability of quality ducklings, market price volatility for duck meat and eggs, often reduced profit margins, the lack of efficient marketing and distribution channels, which significantly impacted the production costs. These factors were ranked by frequency and identified the challenges in Pekin duck farming presented in Table 10.

Table 6. Carcass characteristics of Pekin duck at 10 weeks of age at Dhamrai Sub-district, Bangladesh, in April 2024

Parameters (g)	Drake		Duck		Overall	
	Mean ± SE	Percentage	Mean ± SE	Percentage	Mean ± SE	Percentage
Live wt.	2025.50 ± 61.48	100.00	2009.50 ± 73.98	100.00	2017.50 ± 44.63	100.00
Feather	152.50 ± 4.78	7.53	157.50 ± 4.78	7.84	155.00 ± 3.27	7.68
Blood	7.50 ± 0.28	0.37	7.00 ± 0.91	0.35	7.25 ± 0.45	0.36
Dressing weight	1494.25	73.77	1494.00	74.35	1494.12	74.06
Head	85.00 ± 1.91	4.20	75.50 ± 1.32	3.76	80.25 ± 2.09	3.98
Bill	24.50 ± 1.65	1.21	24.50 ± 0.95	1.22	24.50 ± 0.88	1.21
Wing	146.75 ± 8.23	7.25	129.25 ± 3.19	6.43	138.00 ± 5.25	6.84
Shank	45.75 ± 1.43	2.26	43.75 ± 2.05	2.18	44.75 ± 1.22	2.22
Fat	40.00 ± 3.39	1.97	42.25 ± 6.35	2.10	41.13 ± 3.36	2.04
Heart	21.00 ± 1.78	1.04	17.75 ± 0.85	0.88	19.38 ± 1.10	0.96
Gizzard	74.50 ± 3.47	3.68	71.25 ± 3.25	3.55	72.88 ± 2.28	3.61
Liver	55.75 ± 2.46	2.75	53.50 ± 1.55	2.66	54.63 ± 1.41	2.71
Spleen	1.00 ± 0.00	0.05	1.00 ± 0.00	0.05	1.00 ± 0.00	0.05
Lungs	24.00 ± 2.27	1.18	20.75 ± 1.54	1.03	22.38 ± 1.41	1.11
Intestine	118.00 ± 3.34	5.83	114.25 ± 5.51	5.69	116.13 ± 3.06	5.76
Giblet wt.	295.50 ± 9.20	14.59	289.50 ± 9.49	14.41	292.50 ± 6.22	14.50

SE: Standard error, wt.: Weight, g: Gram

Table 7. Tissue component of breast, leg quarter, and lumbosacral parts of Pekin ducks at Dhamrai area, Bangladesh in April 2024

Parameters (g)	Pekin drake (Mean ± SE)				Pekin duck (Mean ± SE)			
	Breast part	Leg quarter	Lumbosacral part	Total	Breast part	Leg quarter	Lumbosacral part	Total
Muscle	194.75 ± 11.96	90.0 ± 2.55	146.00 ± 2.48	430.75 ± 16.99	188.25 ± 13.63	83.50 ± 5.60	142.75 ± 2.28	414.75 ± 21.48
Skin	167.75 ± 13.79	137.5 ± 5.80	48.00 ± 4.41	353.25 ± 24	154.5 ± 3.41	128.75 ± 7.22	52.50 ± 2.59	335.75 ± 13.22
Bones	92.50 ± 2.75	52.75 ± 2.28	112.25 ± 2.25	257.5 ± 7.28	90.50 ± 5.90	51.25 ± 1.49	109.50 ± 3.30	251.25 ± 18.69

SE: Standard error, g: Gram

Table 8. Nutrient composition of thigh and breast muscle of Pekin ducks reared at Dhamrai, Bangladesh, in April 2024

Parameters (%)	Drake		Duck	
	Thigh muscle	Breast muscle	Thigh muscle	Breast muscle
Dry matter	29.13	24.38	24.14	22.88
Water	70.87	75.62	75.86	77.12
Crude protein	17.57	16.90	17.36	16.70
Crude Fat	12.59	5.12	14.88	5.10
Ether extract	2.74	0.42	2.13	0.48
Ash	3.86	3.60	4.00	3.33

Table 9. Benefit-Cost ratio of Pekin duck farmers at Dhamrai Sub-district, Bangladesh, from January to April 2024

Parameters	Values (USD)
Feed cost	17.94
Veterinary cost	2.61
Housing cost with 10% depreciation	3.82
The cost of family labor involved	11.39
Transportation cost	2.60
Miscellaneous	1.20
Total cost	39.01
The family consumed duck value	10.97
Sold duck value	51.11
Total income	62.08
Net income	23.07
BCR	1.59

BCR: Benefit-cost ratio, USD: United States Dollar

Table 10. Major operational constraints of Pekin duck-rearing farmers at Dhamrai, Bangladesh, during January to April 2024

Parameters	Frequency (n)	Percent	Ranking
Higher feed price	22	88.00	I
Lack of quality duckling	18	72.00	II
Unavailability of ducking at all times	15	60.00	III
Attacked by a predatory animal	13	52.00	IV
The high price of ducking	10	40.00	V
Outbreak of disease	9	36.00	VI
Lack of vaccine and treatment facilities	6	24.00	VII
Profit not guaranteed	5	20.00	VIII

DISCUSSION

According to Rahman et al. (2020), the majority of Pekin ducks raising farmers were over 40 years old, accounting for 46% while 37% were in the middle-aged group (ranging from 25-49 years) in the Bhola district of Bangladesh. In the study of Rahman et al. (2009), a nearly similar result was observed, where 39% of farmers were from the middle-aged category. The mean age of duck-raising farmers of 33 and 36 years with the observation of Afrin et al. (2016), where Jha et al. (2015) also mentioned 52% of young-aged farmers, followed by 36% of middle-aged and 12% of old farmers.

Rahman et al. (2020) categorized the family size of Pekin duck-rearing farmers in the Bhola district, where most of the farmers (50%) belonged to medium family sizes, with 40% having small and 0nly 10% having large family sizes. Rahman et al. (2009) reported that about 50% of farmers had large families, with an average household size of 07 members per family. A relatively higher average family size (5.8) than the current study of duck-rearing farmers in the Kishoreganj district was reported by Afrin et al. (2016).

In terms of education, Rahman et al. (2020b) reported that about 43% of the duck farmers in the Bhola district were illiterate, 33% completed primary education, and 24% of the respondents received a secondary level of education. Around 30% of duck farmers attained a primary level of education, 18% and 9% had received a secondary and higher education in the Noakhali and Lakshmipur districts of Bangladesh stated by Rahman et al. (2009). According to Jha et al. (2015), a literacy rate of 48% was recorded, with 28% of farmers receiving primary education. About 20% of farmers received primary education, which was higher, and only 5% had higher secondary or above educational level, which seemed to be lower than the current study reported by Parvez et al. (2020). Afrin et al. (2016) stated that 44% of duck farmers completed their secondary education, 28% completed the primary level, and only 18% completed their higher secondary education in the Kishoreganj district. The current study area may have offered better access to

secondary and higher education, reflecting a higher percentage of farmers with SSC or HSC qualifications. In contrast, other regions might have faced challenges in educational systems, socio-economic constraints, and regional disparities, leading to higher illiteracy rates or lower levels of formal education among farmers.

Rahman et al. (2020) mentioned that approximately 67% of the Pekin duck farmers in the Bhola district were housewives, 23% were occupied in business, and 10% provided service along with agriculture. Afrin et al. (2016) mentioned that 42% of farmers adopted duck farming as their primary occupation. About 25% of farmers were involved in duck farming with several supplementary occupations in the Kishoreganj district stated by Parvez et al. (2020), which was lower than the current study. Rahman et al. (2020) found that all of the respondents (100%) in the Bhola district did not have scientific knowledge of Pekin duck farming. Afrin et al. (2016) reported that 73% of duck-raising farmers did not receive any training in the Kishoreganj district. However, a higher percentage of trained farmers was observed in the current study area. In the findings of the current study, some differences may be attributed to several factors, including the geographical locations, years of study, variations in the sample populations, and farmers' resource availability compared to those in previous studies.

In the study of Rahman et al. (2020), a slightly higher percentage of Pekin duck-rearing farmers (100%) practiced a semi-intensive rearing system in the Bhola district of Bangladesh. About 90% farmers utilized tin and bamboo/betel nut shed houses, which was higher than the current study. About 56.57% of farmers cleaned duck houses 10-15 times in a month, 33.33% followed cleaning practices 5-10 times in a month, and only 10% of farmers cleaned duck houses regularly, which supported the present findings. Around 50-60% of farmers practiced regular cleaning of poultry houses, and 30% followed house cleaning once a week, reported by Alam et al. (2014). Rahman et al. (2009) stated that the majority of the farmers (67.5%) mainly utilized ponds as the scavenging place for ducks, which was well consistent with the present findings. They also mentioned that 93.5% of farmers provided a separate housing facility at a corner of their premises. Approximately 65.5% of duck houses were constructed of tin and wood. In the findings of Jha et al. (2015), it was reported that ducks were raised only on natural feed resources during the rainy season and reared under a scavenging management system. They also stated that 50% of houses were constructed with tin and wood, followed by 30% of straw-bamboo made, only 8.50% used bamboo, and 11.50% provided houses made with soil and other materials. The results from the study of Jha et al. (2015) were closely in agreement with the observation of the present study and explained that the majority of the respondents utilized tin and wood-made houses, which were relatively permanent and long-lasting, as well as lower-cost involvement, which supported the present study. Farmers in the current study area mostly used cost-effective housing materials for constructing duck houses, because most of the farmers did not have enough economic solvency to provide bricks or concrete housing facilities for their Pekin ducks.

Rahima et al. (2023) reported that about 97.64% of farmers raised their poultry (Indigenous and Sonali chickens) in semi-scavenging conditions. The majority of respondents (88.82%) utilized tin and bamboo for constructing poultry houses, while a minimum proportion of farmers (11.2%) reared poultry without ensuring adequate housing facilities. These findings strongly aligned with the current outputs. Additionally, they reported that 73.53% of farmers usually cleaned poultry houses, which was supported by the results of the current study. These variations may have arisen due to differences in knowledge and farming practices, the availability of housing materials and resources in the findings across the above studies.

In the case of feeding management, Rahman et al. (2020) reported that 20% of the farmers provided natural feed, which was comparatively lower than the results of the current study. However, the study agreed with the present result, where they mentioned that about 80% depended on supplemental feed for Pekin duck-rearing. Farmers were provided supplemental feeds, particularly in the form of wheat bran (74%), commercial feed (13%), and rice polish (13%). Additionally, 87% of the farmers utilized feed ingredients from domestic sources. In a study by Jha et al. (2015), they mentioned that 46.50% of duck farmers did not offer any supplemental feed ingredients to their ducks. However, a different observation was seen in the current study, where 100% of farmers were provided additional feed during the entire study period. Parvez et al. (2020) explained that 50% of farmers provided supplemental feed ingredients to optimize the egg production of ducks. The major ingredients of additional feeds were paddy, a mixture of rice and broken rice and a combination of rice polish and wheat bran, and a mixture of different feed materials, which strongly supported the present findings. Zahan et al. (2016) mentioned that nearly 67% of respondents feed their ducks with rice polish and wheat bran. According to the study of Rahima et al.

(2023), approximately 84.71% of duck-raising farmers utilized whole rice as a supplement feed, followed by boiled rice, paddy, broken rice, wheat, and commercial ready-made feed. These findings were almost in agreement with those of the current study. However, a higher percentage of duck-rearing farmers selected locally available feed ingredients and used paddy, rice, and rice bran as a supplemental feed for Pekin duck rearing in the Dhamrai area of Bangladesh. Several variations in outputs were observed due to the study location, financial capability, and proper knowledge of farmers on daily feed requirements and supply were different in the present study compared to the above studies.

Rahman et al. (2020) conducted a study on Pekin ducks in the Bhola district of Bangladesh where they observed the average body weight (gm) of 60.43 ± 2.08, 113 ± 2.65, 282.87 ± 9.26, 743.5 ± 26.48 and 1885 ± 34.56, respectively at day-old-ducklings with 7 days, 15 days, 30 days and 60 days of age. According to Bhuiyan et al. (2005), the live weight of the Pekin duck was 1763 gm at 9 weeks, and they also suggested that the Pekin breed was superior to both Muscovy and Deshi white ducks in the Sylhet area of Bangladesh. The superior growth performance could be attributed to the fact that the Pekin ducks consumed varying amounts of fallen grains from the paddy fields along with earthworms and small insects during grazing, which helped to meet their daily protein and energy requirements in the body and gain desirable growth in the Pekin ducks. In the study conducted by Rabbani et al. (2019), the growth performance of meat-type Pekin ducks reared under a complete confinement system for 56 days was evaluated by feeding four different diets with varying nutrient concentrations and observed that the mean body weight (gm) of 1530.91, 1546.35, 1518.62 and 1595.13 which were in strong agreement with the findings of the present study. Ghosh et al. (2022) mentioned an impressive mean body weight of 2.003 kg attained by Pekin ducks at 56 days of age under backyard farming conditions. They also observed that the average daily weight gain (ADG) of White Pekin ducks was highest during the 43-56-day period, followed by the 29-42-day period. The mean ADG (gm) for male and female hybrid SM3 Heavy Pekin ducks was 70.9 and 68.9 from up to 49 days of age, reported by Steczny et al. (2017). Alsaffar et al. (2023) mentioned that the body weight (gm) of blue and yellow beak Pekin ducks at 6 weeks of age was 2720.7 ± 80.84 and 2631.14 ± 21.75. Starcevic et al. (2020) reported the ADG (gm) of STAR 53 medium and SM3 heavy hybrids of Pekin duck up to 7 weeks of age of 177 and 184, under a semi-intensive management system. The variations in data may have arisen from differences in the duck breeds, the duration of the growth periods, the specific feeding regimes, feed quality, housing, and genetic differences in duck populations across the above studies.

Approximately 80% of the Pekin duck-raising farmers were not conscious of duck diseases reported by Rahman et al. (2020). Alam et al. (2014) mentioned some common diseases, including Duck plague, Duck cholera, and Limber neck poisoning in duck farms in the Mymensingh district of Bangladesh. Jha et al. (2015) explained that the majority of the farmers had incomplete ideas and limited knowledge about duck diseases. A nearly similar finding was observed by Rahima et al. (2023) in the case of Pekin ducks mentioned that Duck plague and Duck cholera were the more frequent duck diseases. They also reported that a relatively lower proportion of respondents (30.50%) did not practice the scheduled vaccination under backyard poultry production, and only 8.82% of farmers vaccinated their poultry.

Regarding treatment sources, 56.67% of farmers had received treatment from a Local Service Provider (LSP), 33.33% from Non-Government Organization (NGO) workers, and 10% from Upazilla Veterinary Hospitals, which were consistence with the current results. A nearly similar output was observed in the present study, where they reported that approximately 90% of the respondents maintained a regular vaccination schedule in the Bhola district. According to Rahman et al. (2009), 85% of farmers in the Noakhali and Lakshmipur districts of Bangladesh did not practice scheduled vaccination against duck diseases. In the study of Zahan et al. (2016), it is mentioned that 60% of farmers regularly vaccinated their ducks. About 65% of the respondents in the Sylhet area of Bangladesh were not aware of the importance of vaccination, and they did not even vaccinate their ducks regularly, whereas only 14.50% followed the regular vaccination schedule stated by Jha et al. (2015). The variations in the results between the present study and the previous findings could have arisen from several factors, including differences in educational opportunity, lack of awareness, and access to resources among farmers in different regions.

Rabbani et al. (2019) reported nearly similar findings compared to the current study, where they mentioned the dressing percentage of 64.50, 64.60, 64.47, and 64.85% for meat-type Pekin ducks reared under concentrate-based four different diets in a complete confinement system up to 56 days of age. Ghosh et al. (2022) calculated the dressing percentage of White Pekin ducks and found the

average dressing percentage of 57.9% which was lower than the earlier studies of Kokoszynski et al. (2019). In the study of Steczny et al. (2017), they mentioned relatively higher average live weight (gm) and carcass weight (gm), wings (%) at 49 days old male (3518 ± 19.3, 2465 ± 15.7 and 12.6 ± 0.2) with female (3433 ± 18.3, 2418 ± 11.4 and 12.2 ± 0.3) in hybrid SM3 heavy Pekin ducks. However, a closely similar value for dressing percentage was observed at 70.1 ± 0.2 and 70.4 ± 0.2. A nearly similar proportion of gizzard, liver, heart, and spleen in hybrid SM3 heavy male and female Pekin ducks was also reported by Steczny et al. (2017) compared to the present study. Alsaffar et al. (2023) stated nearly similar dressing percentages, and the percentage of liver, gizzard, heart, and head of Blue and Yellow beaked Pekin ducks at 6 weeks of age were 72.62, 71.66, 2.60, 2.76, 2.86, 2.96, 0.66, 0.67, 3.94, and 3.91, respectively. According to the findings of Starcevic et al. (2020), the weight of the wings of STAR53 (261 gm) medium and SM3 (269 gm) heavy hybrids of Pekin ducks under a semi-intensive management system was relatively higher compared to the present findings. The breed differences, environmental conditions, such as climate and farming practices, along with the availability of feed ingredients, could have influenced the variations in carcass characteristics and overall yield. Thus, these factors collectively led to differences in the findings between the present study and the above-mentioned findings.

Starcevic et al. (2020) mentioned comparatively higher values than the present findings for breast weight (gm) and drumstick with thigh (gm) of 606, 697, 427, and 419 in STAR 53 medium and SM3 heavy hybrids of Pekin ducks under a semi-intensive management system. According to the study results of Lukaszewicz et al. (2011), duck meat was found to have a higher nutritive value, with the chemical composition of the breast muscle revealed slightly higher protein (20.9-22.2%) and fat content (2.3-3.9%) where the percentage of water content (74.7-75.1) was also closely similar compared to the present results. Conversely, the water (72.5-75.1%) and protein content (18.0-18.9%) of leg muscle were slightly less; however, a higher percentage of fat content (4.6-7.2%) was observed compared to breast muscles. These results were in agreement with the observations of the current study. In the study of Kokoszynski et al. (2020), the nutrient content of Muscovy and Mule ducks was calculated and found that nearly similar water (70.9-72.1%) with higher protein (24.7-27.2%), and less fat content (1.0-1.4%) of their breast and leg muscles than in the present study. In another study by Khaziev et al. (2018), they showed a higher dry matter, protein, and fat content in the breast muscles of Mule ducks compared to Muscovy ducks, both were mostly popular for meat production. Breed-specific differences in muscle development and fat deposition may have accounted for the higher fat content exhibited in the breast and thigh muscles of Pekin ducks in the current study compared to Muscovy and Mule, especially in female ducks. Pekin ducks are known for their rapid growth and higher fat deposition, particularly in meat production, which might result in a higher fat percentage in their muscles. In contrast, breeds such as Muscovy ducks may have a leaner body composition, as evidenced by their lower fat content in muscle tissues.

In a comparative study conducted by Bhuiyan et al. (2005) where they mentioned that the highest production costs were involved in raising Pekin ducks, while Deshi White ducks had the lowest. Nonetheless, Pekin ducks delivered a robust economic return, reflecting a Benefit-Cost Ratio (BCR) of 1.66. Slightly higher average net returns and BCR than the current study from duck rearing were estimated at 400.41 USD and 1.67 in the Haor areas, were reported by Sheheli et al. (2023). The differences in BCR and net income between the studies are likely due to a combination of regional factors, variations in farming practices, input costs, and market conditions in different study locations.

The outbreak of disease was the first-ranked problem, followed by the high price of feed second, Low prices of duck eggs and meat third, irregular supply of ducklings, and inadequate veterinary services for duck rearing in Haor areas mentioned by Sheheli et al. (2023). Infectious disease outbreaks were the most common constraint in duck rearing, of which Duck plague was the most prevalent one, as stated by Khan et al. (2018). The present findings were consistent with those of Alam et al. (2014), who identified conventional rearing methods, feed scarcity, poor housing facilities, disease outbreaks, inadequate access to vaccines and medicine, and attacks by predatory animals as the major challenges for backyard poultry (chicken and duck) farming in Mymensingh district of Bangladesh. Additionally, Rahima et al. (2023) reported that the most common constraints in backyard poultry farming systems were disease outbreaks, followed by the lack of adequate knowledge and predatory animal attacks. The variations in the constraints faced by farmers across different studies likely arise from differences in regional conditions, farm management practices, access to inputs, and local economic factors. These differences highlight the complexity of Pekin duck farming and the

need for tailored solutions based on specific regional challenges.

CONCLUSION

Pekin duck farming, particularly under existing rearing systems in the Dhamrai area of Bangladesh, offers a lucrative opportunity to become economically viable and get an excellent source of additional income for small to medium-scale rural farmers, especially women farmers. The steady growth performance, favorable carcass characteristics, and positive Benefit-cost ratio indicated a promising future for the sector. However, to enhance the sustainability and profitability of Pekin duck farming, addressing operational constraints such as high feed costs, the availability of quality ducklings, and disease control measures should be prioritized. Additionally, further training and improved access to veterinary care and biosecurity measures could help reduce disease risks and improve overall farm productivity. In-depth research into optimizing feeding strategies and improving disease management practices is required to find out both the sustainable and profitable pathway of Pekin duck farming for rural farmers in the study region, as well as a whole in Bangladesh.

DECLARATIONS

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Availability of data and materials

The data are available upon request from the corresponding author.

Ethical considerations

All authors have ruled and agreed on ethical issues, including fabrication of data, double publication and submission, redundancy, plagiarism, consent to publication, and misconduct for this article to be published with a high scientific quality in the present journal.

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Author's contributions

This research was completed in collaboration among all authors. Razia Khatun and Sharmin Sultana conceptualized and designed the study. Sharmin Sultana, Syidul Islam, and Md. Ashraful Islam implemented the experiment in the community of Pekin duck farmers. Sharmin Sultana wrote the research methodology, study protocol, and the manuscript. Syidul Islam and Md. Ashraful Islam assisted in the data collection and formal analysis. Shamin Ahmed reviewed and edited the manuscript for final submission. Razia Khatun provided guidelines for writing the manuscript and financial support for the research. All Authors read and agreed to the final version of the manuscript.

Competing interests

There is no conflict of Interest regarding this research and manuscript.

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