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The Effects of a Mixture of Fermented Duckweed, Water Hyacinth, and Rice Bran on the Growth, Caracass Values, and Bacterial Structure in the Feces of Muscovy Ducks.

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ABSTRACT

The objective of this study was to determine the optimal level of fermented mixture supplementation in the diet of Muscovy ducks to achieve improved growth performance and better health. The experiment was conducted using a completely randomized design with four dietary treatments and five replicates per treatment. The dietary treatments consisted of a basal diet without fermented mixture (F0) and diets in which 10% (F10), 20% (F20), or 30% (F30) of the dietary dry matter was replaced with the fermented mixture. A total of 200 Muscovy ducks, 35 days of age and with an average body weight of 820 ± 30 g, were randomly allocated to the treatments, with 10 ducks per experimental unit and an equal number of males and females. The feeding trial was conducted from 35 to 84 days of age. During this period, the ducks were housed in pens and fed a standard diet containing 16% crude protein and 2,890 kcal/kg metabolizable energy (Table 1). Feed and water were provided ad libitum. The dietary treatments were as follows: F0, basal diet + 0% fermented mixture; F10, basal diet + 10% fermented mixture; F20, basal diet + 20% fermented mixture; and F30, basal diet + 30% fermented mixture.

The results indicated that replacing 20–30% of the dietary dry matter with a fermented mixture consisting of 30% duckweed, 50% water hyacinth, and 20% rice bran improved the growth performance of Muscovy ducks. Furthermore, supplementation with 20–30% fermented mixture increased the population of beneficial microorganisms while reducing harmful microorganisms in duck feces.

Keywords: *Fermented feed mixture; duckweed; water hyacinth; Muscovy ducks; growth; fecal bacteria*

INTRODUCTION

Muscovy ducks, native to South America and domesticated by indigenous populations, are highly valued worldwide for their high meat yield, distinctive flavor, and low-calorie meat (Surai, 2016; Eva C. J. A. et al., 2018). In Vietnam, numerous studies have investigated the effects of different dietary treatments on the growth performance and carcass characteristics of Muscovy ducks (Tu et al., 2012; Linh et al., 2017). Previous studies have demonstrated that Muscovy ducks can efficiently utilize various agricultural byproducts, including brewery waste, duckweed, palm kernel, and Silybum marianum seeds, resulting in improved meat production and greater economic returns for farmers (Tu et al., 2012; Ruben et al., 2020; El-Garhy et al., 2022).

Demann et al. (2023) reported that duckweed exhibited considerable variation in crude protein content, amino acid digestibility, and phosphorus digestibility when evaluated as a high-protein feed ingredient for broiler chickens, indicating that its practical application requires careful attention to nutrient quality and consistency. Duckweed is widely available in tropical farming regions and serves as a valuable source of dietary fiber, while rice bran is an abundant and economical agricultural byproduct suitable for Muscovy duck diets. Sun et al. (2016) reported that supplementation with whole-grain rice bran at levels of 10–18% did not adversely affect growth performance in Muscovy ducks and improved average daily gain during the later growth stage when included at 18%. However, these locally available feed ingredients have several limitations when used directly, including high moisture and fiber contents, elevated fat content, variable nutrient composition, and a high susceptibility to mold contamination during storage.

Fermentation is an effective approach to improving the nutritional value and microbiological quality of local feed ingredients. During lactic acid fermentation, the pH of the feed decreases, organic acid production increases, and the population of beneficial microorganisms is enhanced. In poultry nutrition, fermented feed has been shown to improve nutrient digestibility, promote a balanced gut microbiota, suppress undesirable microorganisms, and enhance growth performance and feed efficiency. However, these effects depend on factors such as animal species, feed substrate, fermentation quality, and supplementation level. Nevertheless, information regarding the use of fermented local feed mixtures based on duckweed, water hyacinth, and rice bran for Muscovy ducks raised under smallholder farming conditions in the Mekong Delta remains limited.

MATERIALS AND METHODS

Experimental animal

The study was conducted from January to May 2026 at a farm in Dong Thanh Commune, Vinh Long Province, Vietnam. A total of 200 Muscovy ducks were obtained from this farm and vaccinated against duck viral hepatitis, fowl cholera, and highly pathogenic avian influenza (H5N1). The ducks were housed in pens with sand-covered floors and rice husk bedding. Each pen measured 3.0 × 1.5 × 0.8 m and accommodated 10 ducks.

Experimental design

The experiment was conducted using a completely randomized design with four dietary treatments and five replicates per treatment. The dietary treatments consisted of a basal diet without fermented mixture (F0) and diets in which 10% (F10), 20% (F20), or 30% (F30) of the dietary dry matter was replaced with the fermented mixture. A total of 200 Muscovy ducks, 35 days of age and with an average body weight of 820 ± 30 g, were randomly allocated to the treatments, with 10 ducks per experimental unit and an equal number of males and females.

The feeding trial was conducted from 35 to 84 days of age. During this period, the ducks were housed in pens and fed a standard diet containing 16% crude protein and 2,890 kcal/kg metabolizable energy (Table 1). Feed and water were provided ad libitum throughout the experiment.

The dietary treatments were as follows:

- F0: Basal diet + 0% fermentation mixture

- F10: Basal diet + 10% fermentation mixture

- F20: Basal diet + 20% fermentation mixture

- F30: Basal diet + 30% fermentation mixture

Preparation of the fermented mixture

The yeast culture consisted of rice flour and *Saccharomyces cerevisiae*, containing 8.9×10^8 CFU/g.

The fermented mixture was formulated on a dry matter basis using 30% duckweed, 50% water hyacinth, and 20% rice bran. Young leaves and stems of water hyacinth were selected, thoroughly washed, and chopped into 2–3 cm pieces before being mixed uniformly with duckweed and rice bran according to the specified proportions.

For each batch, 50 kg of the mixture was supplemented with 500 g of the yeast culture and 1 L of water. The ingredients were thoroughly mixed and allowed to stand for 30 min. The mixture was then placed in airtight plastic bags and fermented at room temperature (27–32°C) for 5 days. After 5 days of fermentation, the mixture developed a pleasant aroma and was used in the feeding trial.

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Item		**Treatment**	
		Before fermentation	**After 5 days of fermentation**
Dry matter (%)		31.2	30.6
Crude protein (% DM)		14.7	15.8
Ether extract (% DM)		4.66	4.88
Crude fiber (% DM)		19.6	18.8
NDF (% DM)		41.2	39.7
ADF (% DM)		26.4	25.1
Ash (% DM)		11.4	11.7
pH		5.98	401
Lactic acid (%)		0.29	2.88
The number of lactic acid bacteria (log CFU/g)		4.76	9.01

Table 1 shows that the nutritional composition of the feed increased after fermentation compared to before fermentation. Crude protein increased from 14.7% to 15.8%. Notably, the number of lactic acid bacteria (log CFU/g) increased significantly from 4.76 to 9.01.

Table 2. Chemical composition (%) and metabolizable energy (ME, kcal/kg DM)

Item	**Treatment**			
	F0	**F10**	**F20**	**F30**
DM	89.4	88.7	87.6	86.5
OM	91.9	90.4	89.5	89.3
CP	16.0	16.2	16.5	16.6
EE	4.45	4.33	4.11	3.89
CF	4.4	5.3	6.1	7.2
Total ash	8.11	9.65	10.5	10.7
ME *(kcal/kg)*	2,890	2,850	2,830	2,805

Source: Janssen (1989)

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Measurements and data collection

Throughout the experimental period, growth performance parameters, including initial body weight, final body weight, body weight gain, feed intake, and FCR, were recorded. Feed intake was determined by measuring the total amount of feed consumed by the ducks in each pen (10 ducks; 5 males and 5 females). Individual body weights were recorded at the beginning of the experiment and subsequently at weekly intervals.

At the end of the 7-week feeding trial, fecal samples were collected to determine the populations of *Lactobacillus, Salmonella* spp., *Escherichia coli*, and *Clostridium perfringens*. Approximately 100 g of fresh feces was collected from the 10 ducks in each experimental pen to obtain a composite sample. The samples were immediately stored under refrigerated conditions and transported to the Biology Laboratory of the Center for Analytical Services, Can Tho City. After homogenization, bacterial populations were determined using the standard plate count (colony-counting) method.

Carcass evaluation

At the end of the experiment, two male and two female ducks were randomly selected from each treatment for slaughter and carcass evaluation. Body measurements were obtained according to the method described by Salomon (1996).

Chemical analyses

The chemical composition of the feed samples was analyzed to determine the content of DM, OM, CP, EE, CF, and ash, following the established AOAC (1990) procedures. Neutral detergent fiber was measured using the method developed by Van Soest et al. (1991), and metabolizable energy was calculated based on Janssen's (1989) formula.

The chemical composition of the feed samples, including DM, OM, CP, EE, CF, and ash, was determined according to AOAC (1990). Neutral detergent fiber was analyzed using the method of Van Soest et al. (1991), and metabolizable energy was calculated according to the equation of Janssen (1989).

Statistical analyses

Data were analyzed using the General Linear Model (GLM) procedure in Minitab version 18.1.0 (Minitab, 2018). Differences among treatment means were evaluated using Tukey's multiple comparison test, with statistical significance declared at $P < 0.05$.

RESULTS

Nutrient and feed intake of Muscovy ducks during growth

Table 3. Daily intakes of feed and nutrient of Muscovy duck (g/duck/day)

	Treatment					
Item	**F0**	**F10**	**F20**	**F30**	**SEM**	P
DM	141.9^{c}	142.2^{b}	144.2^{a}	144.3^{a}	0.89	0.03
OM	130.5^{c}	131.6^{b}	132.9^{a}	133.8^{a}	0.72	0.02
CP	24.13	24.46	24.63	24.99	0.27	0.06
EE	4.28^{c}	4.60^{b}	4.77^{a}	4.82^{a}	0.08	0.01

^{a,b,c} *Mean values with different superscripts within the same row are different at P<0 05,*

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Table 3 shows that the ducks fed the F0 diet consumed significantly lower amounts of DM, OM, CP, and EE per day than those fed the other experimental diets (P < 0.05). Supplementation with the fermented mixture increased nutrient intake, with the highest DM, OM, CP, and EE intakes observed in the F20 and F30 treatments. The DM and CP intakes recorded in the present study were higher than those reported by Pham Tan Nha et al. (2022), who observed DM intakes of 119–125 g/day and CP intakes of 16.6–20.8 g/day in Muscovy ducks.

Effects of fermented mixturein diets on the growth performance of growing Muscovy duck

Table 4. Daily weight gain, final live weight and feed conversion ratio (FCR) of Muscovy duck (g/bird)

Item	Treatment				**SEM**	***p***
	F0	**F10**	**F20**	**F30**		
Initial live weight	820	825	820	817	26.21	-
Final live weight	3,220^{b}	3,205^{b}	3,430^{a}	3,410^{a}	44.13	0.03
Daily weight gain	49.0^{b}	48.6^{b}	53.3^{a}	52.9^{a}	1.12	0.02
FCR	2.90^{a}	2.92^{a}	2.71^{b}	2.72^{b}	0.06	0.01

$^{a.\ b.\ c}$ *Mean values with different superscripts within the same row are different at P<0 05*

Table 4 shows that ducks fed the F0 and F10 diets exhibited significantly lower daily weight gain (DWG) than those fed the F20 and F30 diets (P < 0.05). The DWG recorded in the present study ranged from 49.0 to 53.3 g/duck/day, exceeding the values of 34.4–36.8 g/duck/day reported in previous studies on Muscovy ducks (Pham Tan Nha et al., 2022; Nguyen Thuy Linh et al., 2010). Ducks fed diets supplemented with the fermented mixture (F20 and F30) also had significantly greater final live weights than those in the F0 treatment (P < 0.05), with final live weights ranging from 3,220 to 3,430 g.

The FCR was significantly improved in ducks fed the F20 and F30 diets compared with those fed the F0 and F10 diets (P < 0.05). The FCR values ranged from 2.71 to 2.92, while both the final live weights and FCR were consistent with the findings of Pham Tan Nha et al. (2022).

Table 5. The effect of different levels of fermented feed supplementation on nutrient digestibility in Muscovy ducks.

Item		**Treatment**			**SEM**	***p***
	F0	**F10**	**F20**	**F30**		
DM digestibility (%)	69.4^{c}	71.5^{b}	74.1^{a}	72.6^{b}	0.55	0.01
CP digestibility (%)	64.8^{c}	66.9^{b}	70.4^{a}	67.6^{b}	0.49	0.02
CF digestibility (%)	29.7^{c}	32.8^{b}	36.1^{a}	32.9^{b}	0.81	0.01
OM digestibility (%)	69.1^{c}	72.8^{b}	75.4^{a}	72.6^{b}	0.57	0.03

$^{a\ .b.\ c}$ *Mean values with different superscripts within the same row are different at P<0.05*

Table 5 showed that the digestion of nutrients DM, CP, CF, and OM tended to increase with increasing levels of fermented mixture supplementation in the ducks' diet. The highest digestion was observed in treatment F20.

However, in treatment F30, nutrient digestion showed signs of decreasing. This can be explained by the fact that increasing the fermented mixture increased beneficial gut microorganisms, contributing to increased digestion and absorption of nutrients, leading to a higher digestibility rate. However, increasing the fermented mixture beyond F30 resulted in a decrease in feed quality, which somewhat reduced the digestibility of nutrients DM, CP, CF, and OM.

Effects of fermented mixturein diets on carcass quality of growing Muscovy duck

Table 6. Caracass values and internal organs of Muscovy duck Supplemente Fermented mixturein diets (g/duck)

Item	Treatment				SEM	p
	F0	F10	F20	F30		
Slaughter live weight	3,220^{b}	3,205^{b}	3,430^{a}	3,410^{a}	44.1	0.03
Carcass weight	2312^{b}	2292^{b}	2501^{a}	2479^{a}	21.6	0.01
% Carcass	71.8	71.5	72.9	72.7	0.22	0.68
Breast meat weight	504^{b}	502^{b}	553^{a}	555^{a}	3.34	0.01
% Breast meat	21.8	21.9	22.1	22.4	0.35	0.62
Thigh meat weight	442^{c}	454^{b}	513^{a}	513^{a}	4.06	0.02
%Thigh meat	19.1	19.8	20.5	20.7	0.35	0.55

$^{a.b.c}$ *Mean values with different superscripts within the same row are different at P<0 05*

Table 6 shows that ducks with higher final live weights also had higher slaughter and carcass weights. The eviscerated carcass weight was significantly greater in the F20 and F30 treatments than in the F0 and F10 treatments (P < 0.05). However, carcass yield did not differ significantly among treatments and was comparable to values reported in previous studies. Likewise, breast and thigh meat weights were significantly higher in the F20 and F30 treatments (P < 0.05), whereas their percentages relative to carcass weight did not differ significantly among treatments.

Intestinal microflora

Table 7 shows that, at the end of the 7-week feeding trial, *Salmonella* spp. were detected at very low levels in the feces of Muscovy ducks, particularly in the F20 and F30 treatments. Ducks fed the F20 and F30 diets exhibited the highest populations of *Lactobacillus* and the lowest populations of *Escherichia coli* and *Clostridium perfringens*. Supplementation with 20–30% fermented mixture significantly increased the Lactobacillus population while reducing the populations of *E. coli and C. perfringens* compared with the F0 and F10 treatments (P < 0.05). The F30 treatment showed the lowest populations of *E. coli and C. perfringens*. These findings are consistent with previous studies reporting that fermented feed promotes beneficial intestinal microbiota while suppressing potentially harmful bacteria in ducks.

Table 7. Bacteria density in Muscovy ducks at 12 th weeks age of the experimental

Item	Treatment				SEM	p
	F0	F10	F20	F30		

Lactobacillus (10 CFU/g)	2.18 ^{c}	5.33 ^{b}	6.78 ^{a}	6.99 ^{a}	0.36	0.01
Salmonella spp./25g (+/-)	Positive	Non detected	Non detected	Non detected	-	-
E. coli (10^5 CFU/g)	6.08 ^{a}	2.88 ^{b}	2.01 ^{c}	1.89 ^{c}	0.04	0.02
Clostridium perfringens (10^4 CFU/g)	3.55 ^{a}	2.01 ^{b}	1.98 ^{c}	1.66 ^{c}	0.05	0.01
$^{a, b, c}$ *Means within a row with different superscripts are significantly different (P<0.05)*						

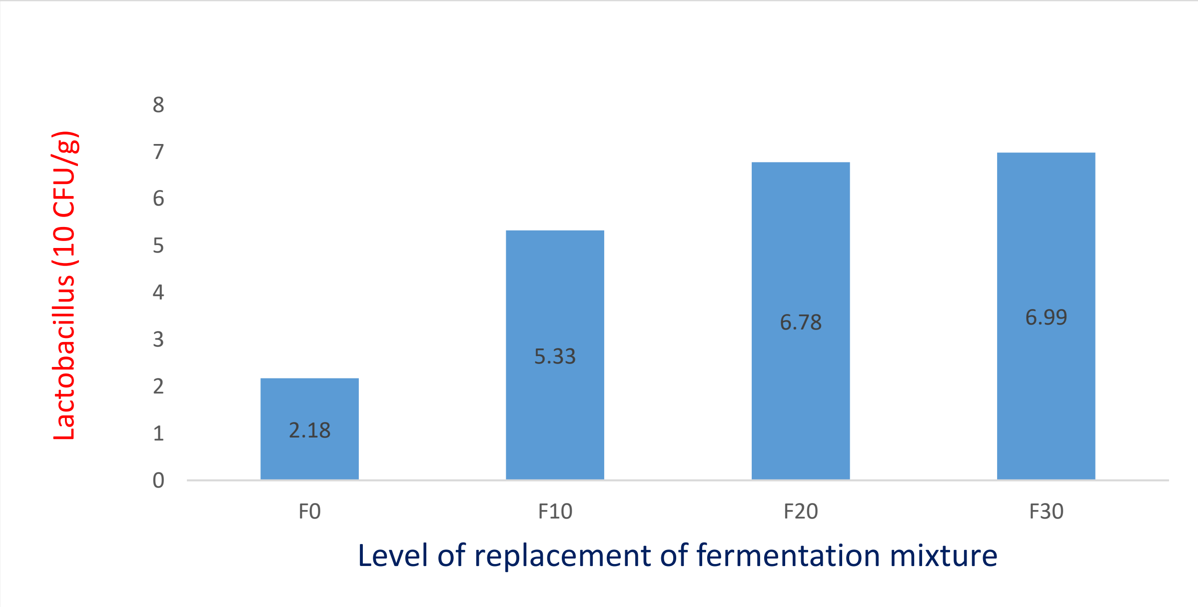

Figure 1. The effect of Fermented mixtureon *Lactobacillus*

Supplementation with the fermented mixture significantly reduced the populations of *Escherichia coli* and *Clostridium perfringens* in the feces of Muscovy ducks. The F30 treatment showed the lowest populations of these harmful bacteria. These findings are consistent with previous studies reporting that fermented feed promotes beneficial intestinal microbiota while suppressing potentially harmful bacteria in ducks.

CONCLUSIONS

Replacing 20–30% of the dietary dry matter with a fermented feed mixture consisting of 30% duckweed, 50% water hyacinth, and 20% rice bran improved the growth performance of Muscovy ducks. Dietary supplementation with 20–30% fermented feed mixture also increased the population of beneficial microorganisms while reducing the populations of harmful microorganisms in duck feces.

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