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The utilization of water hyacinth (*Eichhornia crassipes*) and narrowleaf cattail (*Typha angustifolia*) as an alternative litter material on growth performance of broilers

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Abstract The findings suggested that water hyacinth and cattail litter can be a viable alternative to rice husk as a litter material for broiler production. The results indicated that there were not significant differences in growth performance of broilers when using water hyacinth and cattail litter compared to rice husk. The discovery was significantly found in rice husk to be costly, particularly in certain seasons or regions, and may impact the cost of broiler production. Moreover, the combined material of water hyacinth and cattail (in a ratio of 1:1) resulted in better growth performance ($p<0.05$) than rice husk while not causing any negative effects on broiler health. It showed that the combined material may provide a more cost-effective and sustainable option for broiler litter material. Overall, using water hyacinth and cattail litter either alone or in combination may offer a promising alternative to rice husk for broiler production. By using this alternative material, poultry producers can potentially reduce production costs, particularly when rice husk is expensive or scarce. Therefore, these results may provide useful insights for poultry producers looking to minimize production costs while maintaining broiler health and growth performance.

Keywords: Bedding materials, Footpad dermatitis, Fecal score, Lesser bulrush, *Pontederia crassipes*

Introduction

World population is continuously increasing, and the demand of meat is correspondingly higher. Broiler production is an important meat production. Even though broilers have short raising time and high food consumption rate

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(FCR), to meet consumer demands, the all-in all-out system is used. That is, only broilers from the same hatch are raised at a time. So, farming system needs to be more effective than before. Litter management is one important factor that affects the condition of the broiler housing.

A good litter requires moisture absorbent, be able to absorb ammonia from faeces to prevent ammonia volatilization. Besides this, it should also prevent proliferation of microorganism which influences poultry health, mortality rate, growth rate, and carcass quality. Rice husk is one of the most common litter materials used in poultry farming. However, rice husks are also used in biofuel productions and the number of rice husks produced depends on the season. So, they are not enough for broiler farming hence they become more expensive. The rise of the rice husks price increases the cost of broiler production. Therefore, the alternative material that is as effective as rice husk to be used as litter in the poultry farming is needed. An appropriate litter must keep the floor dry and clean. It must be able to absorb moisture from faeces and water spills near the water line. The moisture is then released from the litter into the air and removed by the ventilation system of the farm. Furthermore, good litter must not promote bacteria proliferation and ammonia production. Ultimately, this will keep broilers clean and healthy. In addition, the litter should also be locally available, inexpensive, light, and non-toxic. Another important quantity of a good litter is that it should not form caking as this leads to an increase of ammonia level, which has adverse effects on broiler health (Kristensen and Wathes, 2000).

Water hyacinth (*Eichhornia crassipes*) is a weed that spreads rapidly, leading to several serious problems such as navigation, irrigation, and power generation (Malik, 2007). It has spongy and bulbous stalks which contains air-filled tissues that keep it afloat. Water hyacinth was expected to be a good at absorbing water in the poultry farm and hence a good litter. Furthermore, cattail (*Typha angustifolia*) is another common aquatic weed, found on wetland. It belongs to the Typhaceae family. It can be aggressive in their competition with other native species. It has insulating and buoyancy properties. Additionally, its long tapering leaves have smooth margins, and they are somewhat spongy. Cattail could also be an alternative poultry litter.

The study aimed to evaluate the potential of water hyacinth and cattail as an alternative to rice husk as a litter material for broiler production.

Materials and methods

Ethical approval

The study was conducted following the guidelines in "The Ethical Principles and Guidelines for the Use of Animals for Scientific Purposes", edited by the National Research Council of Thailand. The study was approved by the Animal Care and Use Committee, King Mongkut's Institute of Technology Ladkrabang (Approval number: ACUC-KMITL- RES/2022/001).

Litter materials and experimental design

The study was designed to test 4 different sets of litter materials: rice husk, water hyacinth, cattail, and a 1:1 combined litter of water hyacinth and cattail. The size of rice husks was in the range of 0.12-0.85 mm. Water hyacinth and cattail were collected from ponds around King Mongkut's Institute of Technology Ladkrabang, and they were cut into 1.5-2.5 cm long using a cutting-chopping machine. Then, they were dried in the sun for at least 7 days. The moisture was reduced to 10-15%.

After the preparation, the litter materials were added into 3 m^2 pens (1.5m wide and 2m long). Each pen contained 50 kg of litter materials (8-10 cm deep). Each set of litter materials was added to 6 replicates. A number of 720 one-day-old male broilers (Cobb500) were randomly allocated to pens with a completely randomised design (CRD). Each replicate had 30 broilers. The stock density was 10 broilers/m^2.

Chicken and management design

The broilers were raised in close-sided pens with different litter materials. Each pen was equipped with a bell drink and a tube feeder. Ad libitum feeding was used, and it was divided into two phases corresponding to their ages: starter period (1-21 days) and finisher period (22-35 days). They were fed by feed pellet.

Performance measurement

To study the growth performance, the amount of feed intake and the weights of the chickens were collected on day 1, day 21, and day 35 of the trial. This information was then used to calculate body weight gain, food consumption rate (FCR), and feed cost per gain.

Litter characteristic and moisture content

The characteristic of the litter was determined by visual inspection on day 1, day 21, and day 35. A 4-point scale was used (ranging from 0 to 3), with 0 =

dry, 1 = slightly moist/caked, 2 = moister/caked, and 3 = wet. Additionally, the moisture content was also investigated. Litter samples of approximately 1.5 kg were collected in plastic bags from 5 locations per pen. Each sample was weighed before and after being dried in a forced air oven at 105°C for 24 h (Barker *et al.*, 2013), and the difference in weight was calculated.

Footpad dermatitis and fecal scoring system

Two broilers were randomly selected from each pen on day 21 and day 35. Their two feet were determined for footpad dermatitis incidence using the scoring system according to Krautwald-Junghanns *et al*. (2011). The scoring system ranges from 0 to 4 based on the size and the appearance of the lesions. Each score refers to the following: 0 = no lesions, 1 = minimal alterations and several necrotic scales, 2 = moderate alterations, necrotic lesions up to 2 cm in diameter and ablation of the horny layer of the epidermis, 3 = pronounced alterations, necrotic lesions over 2 cm in diameter, deep lesions of the plantar skin and extensive ablation of the epidermis with crater formation, and 4 = plantar abscess. Furthermore, another scoring system was used to determine the characteristics of faeces with 0 = the presence of large corn particles, 1 = excess moisture, 2 = a characteristic green coloration with orange mucus, and 3 = watery and poor formation to the faeces (Teirlynck *et al*., 2011).

Statistical analysis

The growth performance data was analysed using the SAS statistics (SAS Institute, Cary, NC). The experimental unit for statistical analysis was the individual replicate pen of broilers. Statistical differences in the results between rice husk (the control) and other litters were determined using the one-way ANOVA. The significant difference between means was measured using the Duncan's New Multiple Range Test (DMRT), and the p-value of 0.05 was used as a criterion of statistical significance.

Results

The broilers were raised for 35 days in 4 different litter conditions: rice husk, water hyacinth, cattail, and combined litter (1:1 water hyacinth and cattail). The results showed that the combined litter can be used as an alternative litter. It was also found that the growth performance of the chickens raised on the combined litter was better than the broilers raised on rice husk.

The body weight gain of the finisher-period chickens (22-35 days) raised on the combined litter (water hyacinth and cattail with the ratio of 1:1) was the highest (1357.97g) (Table 1). This number was significantly (P<0.05) more than the body weight gain of the chickens raised on rice husks only (1264.75g) and water hyacinth only (1248.46g). Similarly, the average daily gain of the broilers raised on the combined litter (96.99g) was significantly (P<0.05) greater than the broilers raised on rice husk (90.34g) and water hyacinth (89.18g).

Throughout the 35-day experiment, the feed conversion ratio (FCR) of the broilers raised on the combined litter was the lowest value (P<0.01).

Table 1. Effects of litter material on the performance of 35-day broilers

Measurement	Litter Materials				SEM	P value
	Rice Husk	Water Hyacinth	Cattail	Combined Litter		
Body Weight (g)						
0 days	43.59	43.03	43.58	44.03	0.31	0.289
21 days	971.17	954.33	923.66	935.66	14.08	0.552
35 days	2235.92	2202.80	2251.22	2293.63	17.39	0.131
Body Weight Gain (g)						
0-21 days	927.58	911.30	880.07	891.64	14.16	0.546
21-35 days	1264.75^{a}	1248.46^{a}	1327.56^{ab}	1357.97^{b}	16.74	0.046^{*}
0-35 days	2192.33	2159.76	2207.63	2249.61	17.31	0.136
Feed Intake (g/bird)						
0-21 days	1650.33	1611.81	1612.46	1584.54	34.85	0.346
21-35 days	2121.44	2139.71	2037.67	2048.15	31.07	0.332
0-35 days	3771.77	3751.53	3650.13	3632.69	48.49	0.296
AD Feed Intake (g/bird**)**						
0-21 days	78.59	76.75	76.78	75.46	1.66	0.346
21-35 days	151.53	152.84	145.55	146.29	2.22	0.332
0-35 days	107.76	107.18	104.28	103.79	0.78	0.291
Average Daily Gain (ADG**)**						
0-21 days	44.17	43.39	41.91	42.46	0.67	0.546
21-35 days	90.34^{a}	89.18^{a}	94.62^{ab}	96.99^{b}	1.20	0.046^{*}
0-35 days	62.63	61.70	63.07	64.27	0.49	0.136
Feed Conversion Ratio **(**FCR)						
0-21 days	1.79	1.77	1.83	1.78	0.04	0.885
21-35 days	1.68^{B}	1.71^{B}	1.53^{A}	1.52^{A}	0.03	0.009^{**}
0-35 days	1.72^{C}	1.73^{B}	1.65^{AB}	1.61^{A}	0.02	0.009^{**}
Feed Cost per Gain (FCG)						
0-21 days	24.77	24.37	25.21	24.58	0.55	0.886
21-35 days	22.78^{B}	23.26^{B}	20.81^{A}	20.62^{A}	0.38	0.009^{**}
0-35 days	23.53^{BC}	23.71^{C}	22.57^{AB}	22.08^{A}	0.26	0.010^{**}
Survival rate (%)						
0-21 days	100.00	99.44	99.44	99.44	0.23	0.765
21-35 days	96.67	96.07	96.67	97.03	0.64	0.919
0-35 days	96.66	95.55	96.11	96.66	0.67	0.879

* ^{a,b} Means within a column with different superscripts are significantly different (P < 0.05)

** $^{A, B}$ Means within a column with different superscripts are highly significantly different (P < 0.01)

During the starter period (1-21 days), the footpad dermatitis incidence and the fecal score of the broilers raised on the combined litter, which were similar to the broilers raised on rice husk, were lower than the broilers raised on water hyacinth and the broilers raised on cattail. These results showed that the health of broilers raised on the combined litter and rice husk were better than the broilers raised on water hyacinth and cattail. The only group of broilers that had severe footpad dermatitis (score 4) was the broilers raised on cattail (1.36%). In addition, the litter characteristic and water content of the combined litter, which were similar to rice husk, were better than water hyacinth and cattail. These results showed that the environment of the broilers raised on the combined litter and rice husk were better than the other.

On day 35, the footpad dermatitis incidences of the broilers raised on four types of litter were slightly different. However, the results showed that 86.26% of broilers raised on rice husk had footpad dermatitis score 3 (41.00%) and score 4 (45.26%), which were higher than broilers in other groups. Furthermore, the percentage of the broilers raised on cattail with the most severe footpad dermatitis (score 4) (5.04%) was greater than other groups of broilers. Additionally, cattail also had higher moisture content and more caking characteristic than other types of litter.

Table 2. Effects of the utilization of hyacinth and cattail as a substitute for rice husks on the fecal score, litter characteristic score and moisture content of litters (%)

Litter material	Fecal Score (%)				Litter Characteristic Score (%)				Moisture Content (%)
	0	1	2	3	0	1	2	3	
Day 1									
Rice Husk	100	0	0	0	100	0	0	0	10.71
Water Hyacinth	100	0	0	0	100	0	0	0	12.23
Cattail	100	0	0	0	100	0	0	0	12.37
Combine Litter	100	0	0	0	100	0	0	0	12.35
Day 21									
Rice Husk	83.33	16.67	0	0	0	88.33	16.67	0	33.84
Water Hyacinth	66.66	16.67	16.67	0	0	88.33	16.67	0	34.68
Cattail	83.33	0	16.67	0	0	66.67	16.67	16.67	36.41
Combine Litter	100	0	0	0	0	100	0	0	33.92
Day 35									
Rice Husk	100	0	0	0	0	16.67	88.33	0	37.72
Water Hyacinth	100	0	0	0	0	33.33	33.33	33.33	42.81
Cattail	50	16.67	33.33	0	0	16.67	50	33.33	45.31
Combine Litter	100	0	0	0	0	16.67	66.67	16.67	42.94

Table 3. Effects of the utilization of hyacinth and cattail as a substitute for rice husks on the footpad of broilers (%)

Litter material	Score 0	Score 1	Score 2	Score 3	Score 4
Day 21					
Rice Husk	41.11	42.78	15.00	1.11	0.00
Water Hyacinth	20.92	22.89	35.08	21.11	0.00
Cattail	10.57	21.26	40.33	27.28	1.36
Combine Litter	24.75	34.02	35.67	5.56	0.00
Day 35					
Rice Husk	3.43	10.31	41.00	45.26	0.00
Water Hyacinth	10.00	21.17	38.96	29.87	0.00
Cattail	7.26	22.74	39.13	25.83	5.04
Combine Litter	6.83	18.50	47.51	25.45	1.71

Discussion

Choosing a good alternative litter material that is effective, cheap, and locally available can play an important role in reducing broiler production cost. Moreover, it must not be harmful to broiler health, and should promote growth performance. Since litter is not often changed and the raising time of broilers is quite short, most of their lives are spent in their pen with the same set of litter. Therefore, litter quality is important as it can affect broilers welfare and their growth performance. Furthermore, using poor quality litter can affect broilers negatively. Poor litter can develop bacterial growth, odours, fly proliferations and dirty feathers. It may also cause problems on their feet and legs, breast blisters, and respiratory infection in broilers. Footpad dermatitis is a skin condition which causes necrotic lesions on plantar surface of footpads in broilers and turkeys. This condition is usually associated with wet litter (Shepherd and Fairchild, 2010) and high ammonia concentrations (Dunlop *et al*., 2016). The wound on their footpads could range from superficial to deep. Deep wound could lead to abscesses and thickening of underlying tissues and structures (Greene *et al*., 1985). There are several scales that are used to determine lesion severity including a 3-point scale (Bilgili *et al*., 2006), a 7-point scale (Ekstrand *et al*., 1997), and a 5-point scale (Krautwald-Junghanns *et al*., 2011).

When litter is dry, it works effectively. Droppings are broken down into small pieces and they are coated with litter and dust. This increases the surface area of the droppings. Hence, moisture loss is accelerated, and the stickiness of the litter is reduced (Dunlop and Stuetz, 2015). However, when the litter becomes wet, its effectiveness reduces. Since the wet litter surface forms cake, the droppings stay on the surface of the cake, and the moisture is not transferred to the litter underneath the surface. Consequently, the droppings remain wet for longer, and the broilers can be in contact with them, which this was hypothesised to cause footpad dermatitis (Jensen *et al*., 1970). In addition, footpad dermatitis can also be induced by high concentration of ammonia which can result from wet litter due to high bacterial activity (Elliott and Collins, 1982). High level of ammonia can be dissolved in moisture, and this results in irritant alkaline solution. This solution can induce footpad dermatitis (Tucker and Walker, 1992). Moreover, the aqueous ammonia solution can corrode respiratory lining of broilers, resulting in weakened immunity. Consequently, the broilers could be infected by bacteria, especially *E. coli* (Maliselo and Nkonde , 2015).

Birds excrete unused nitrogen as uric acid ($C_5H_4N_4O_3$) which can be decomposed into ammonia gas according to equation [1] and [2] (Maliselo, and Nkonde ,2015).

$$C_5H_4N_4O_3 + O_2 + H_2O \xrightarrow{\text{uricase,allantoinase,allantoicase}} 2(NH_2)_2CO + C_2H_2O_3 + H_2O_2 + CO_2 \quad [1]$$

$$2(NH_2)_2CO(\text{urea}) + H_2O \xrightarrow{\text{urease}} 2NH_3 + CO_2 \quad [2]$$

The reactions in equation [1] and [2] require several favourable conditions. One of them is moisture content. High concentration of ammonia gas causes negative effects on birds. It is suggested that in poultry house, the concentration of ammonia should not exceed 25 ppm. When it is above this level, the chicken growth performance is negatively affected. Body weight gain, feed intake and feed conversion rate are reduced (Beker *et al*., 2004; Miles *et al*., 2004; David *et al*., 2015; Wei *et al*., 2015).

Muchtasjar *et al.* (2021) used phytoremediation to treat wastewater of Batik production by using water hyacinth and water lettuce. The amount of ammonia and chromium were evaluated. It was reported that water hyacinth could reduce ammonia by 78.36%.

In conclusion, rice husk can be substituted by the combined litter (1:1 water hyacinth and cattail). Since rice husk can be expensive and competitive in some seasons, this alternative material should help reducing the broiler production cost. By considering the footpad dermatitis incidence and the characteristics of faeces, the combined material neither reduced growth performance of broilers, nor negatively affected their health. Contrary to our beliefs, it promoted better growth performance compared to rice husk. Moreover, because of the air-filled tissue and spongy characteristic structure of water hyacinth, the litter was soft, compressible, lightweight, good moisture absorbent, and free from dust and mould contaminant. Due to its absorbency, it can help absorbing water from the environment which results in low ammonia production, and hence mitigate the adverse effects on the broilers. Furthermore, cattail is also a good water absorber, as reported by Maizatul *et al.* (2012) who studied morphology and water absorption of single fibre and leaf of Typha latifolia. It was found that the top part and the bottom part of the leaf absorbed 79.79% and 66.63% of water respectively. In addition, this can reduce the problems due to an abundance of water hyacinth, the invasive plant that has caused many problems to aquatic animals and transportation. Although cattail is not as aggressive as water hyacinth, this fast-growing and invasive plant also damages the ecosystem.

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