Effect of Chemically Amendments of Litter on the Performance Index and Economic Parameters of Commercial Broiler Chicken

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Abstract: The experiment was conducted to study the effect of chemically amendments of litter on the performance index and economic parameters of commercial broiler chickena at poultry research station (PRS), College of Veterinary Science and Animal Husbandry, Anand, Gujarat. A total of one hundred forty-four (144) straight run day old commercial broiler chicks were distributed randomly into six treatment groups. Each treatment group consisted of four replications, each of 6 chicks leading to 24 chicks per treatment. The experiment was conducted in two different seasons. Experiment-I was conducted in the winter season (WS), (December-January) and experiment-II was conducted in the rainy season (MS), (August- September) for six weeks of duration. The six treatment was divided as follows: T_1- rice husk litter material (control group); T_2- amendment with alum @ 90 g/sq.ft.; T_3- amendment with boric acid (H_3BO_3) @ 24 g/sq.ft.; T_4- amendment with sodium bisulphate ($NaHSO_4$) @ 25 g/ sq.ft.; T_5- amendment with commercially available probiotic product @ 1 g/sq.ft; T_6- amendment with commercially available *Yucca schidigera* liquid solution @ 1.0 ml/ sq.ft. The litter amendment (T_2 to T_6) was done on the 1st, 15th, and 29th days of the experiment period. The mean production efficiency factor during experiment-I (WS) was found 285.66 ± 10.83, 335.75 ± 6.75, 318.09 ± 12.82, 323.78 ± 11.43, 291.97 ± 14.50, and 320.07 ± 12.32 in T_1, T_2, T_3, T_4, T5, and T_6, respectively at the end of the experiment (42nd day). The mean production efficiency factor was significantly ($P<0.05$) higher in T_2 followed by T_4, T_6, T_3, T_5, and T_1. During experiment-II (MS), the mean production efficiency factor with T_1, T_2, T_3, T_4, T_5, and T_6 was 304.68 ± 26.06, 356.10 ± 16.18, 349.10 ± 12.07, 329.46 ± 21.89, 307.30 ± 17.34 and 350.63 ± 11.88, respectively. The difference was found non-significance among different treatment groups. The pooled mean production efficiency factor was 295.17 ± 18.41, 345.92 ± 8.48, 333.59 ± 2.89, 326.62 ± 11.72, 299.64 ± 7.37, and 335.35 ± 8.47 in T_1, T_2, T_3, T_4, T_5, and T_6, respectively. The difference was found significantly ($P<0.05$) higher in T_2 followed by T_6, T_3, T_4, T_5, and T_1. The Interaction between year (Y×T) and treatment was found non-significant for the mean production efficiency factor. The benefit-cost ratio at the end of experiment-I (WS) was found to be 1.24, 1.27, 1.26, 1.27, 1.22, and 1.26 in T_1, T_2, T_3, T_4, T_5, and T_6, respectively. The highest benefit-cost ratio was observed in T_2 followed by T_6, T_4, T_3, T_1, and T_5. During experiment-II (MS) the benefit-cost ratio was found 1.02, 1.05, 1.04, 1.03, 1.01, and 1.04 in T_1, T_2, T_3, T_4, T_5, and T_6, respectively. The highest benefit-cost ratio was observed in T_2 followed by T_3, T_6, T_4, T_1, and T_5. Based on the overall result of the present experiment, it can be concluded that the broiler birds reared on rice husk litter material amended with alum @ 90 g/sq.ft have significantly ($p<0.05$) higher performance index and benefit-cost ratio were observed than the control and other treatment groups.

Keywords: Performance index, Economic parameters, Commercial, broiler chicken

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1. Introduction

The Indian poultry industry has emerged as the most dynamic and fast-expanding segment of the agro-animal-based industry. Population growth, rapid urbanization, altered lifestyles, shifting food habits, and increased per capita income, all contribute to the increasing demand for poultry products. As a result, the broiler industry is one of the most successful and valuable agricultural businesses.

Most broilers are raised on litter, and they spend most of their time in close contact with litter material. Hence, litter quality has a major effect on the performance and health of broilers (Nagaraj *et al.,* 2007). The poultry litter used for broiler raising is a source of released ammonia and its amelioration is a principal factor that influences the health status and performance of birds (Rashid *et al.,* 2017). In the management of deep litter housing systems, the type and quality of litter material play a critical role. (Skrbic *et al.,* 2012 and Bjedov *et al.*, 2013). The addition of various chemicals on litter material improved the bird production performance and welfare parameters because of better litter conditions and minimum microorganism levels. Many litter materials have been used to reduce litter pH, moisture, and ammonia volatilization and increase nitrogen percentage. (Nagaraj *et al.,* 2007). The emission of NH_3 from livestock operations has become a serious public concern due to its negative impacts on the environment, the animal industry, health, and the safety of people working in livestock facilities (Ritz *et al.,* 2004). It has been recommended that the NH_3 level of a poultry house should not exceed 25 ppm. The level of NH_3 in a poultry house is determined by factors that influence the formation of ammonia, such as litter pH, moisture level, ambient temperature, and relative humidity, as well as factors that influence the removal of NH_3, such as ventilation rate. (Elliott and Collins, 1982 and Singh *et al.,* 2009). Caked litter increases the ammonia level, thus negatively affecting the broiler's health, welfare, growth performance, and carcass quality (Miles *et al.,* 2004).

Aluminum sulfate ($Al_2(SO_4)_3$), as an amendment for poultry litter, acidifies the litter to convert the volatile ammonia (NH_3) produced in a litter to nonvolatile ammonium ions (NH_4^+) and it is cost-effective in the broiler industry. (Gilmour *et al.,* 2004). Sodium bisulphate eliminates ammonia by converting litter ammonium to ammonium sulphate and acidifies the litter by lowering its pH (Sahoo *et al.,* 2017). *Yucca schidigera* plant extract is mostly used as natural medicine, as a flavor enhancer, and as a foaming agent in the food and beverage industries as an additive for feed in the poultry, swine, and cattle industries. It is an herbaceous plant with a high concentration of saponin steroids, which bind ammonia (Cheeke *et al.,* 2006).

Many previous studies used only a few compounds to investigate the influence of litter amendment. However, no definitive conclusion could be made, particularly in the context of India.

2. Materials and Methods

2.1 Experimental Programme

A total of 144-day old commercial straight-run broiler chicks from a single hatch were acquired from "commercial hatcheries." Anand, Gujarat was used for the experiment. Chicks were weighed individually, winged banded, and distributed randomly to six treatments group; each treatment group included four replicates with six chicks in each

Table-1: The composition of the feed formula was used in experiment-I (WS) and II (MS)

Sr. No.	Ingredients	Broiler Pre-Starter (kg)	Broiler Starter (kg	Broiler Finisher (kg)
1	Maize	56.000	57.000	60.000
2	SOYA 45%	37.600	35.500	30.000
3	DORB	1.500	1.190	2.190
4	LSP Powder	1.370	1.360	1.360
5	DCP	0.960	1.000	1.000
6	Broiler Vitamin	0.050	0.050	0.050
7	Vitamin B_{12}	0.010	0.010	0.010
8	Trace Minerals	0.100	0.100	0.100
9	Choline Chloride 60%	0.100	0.100	0.100
10	Lysine	0.050	0.050	0.050
11	Methionine	0.150	0.130	0.130
12	Phytase	0.010	0.010	0.010
13	Enzyme	0.050	0.050	0.050
14	Salt	0.250	0.250	0.250
15	Soda Bicarbonate	0.100	0.100	0.100
16	Liver tonic	0.100	0.100	0.100
17	Immunomodulator	0.050	0.050	0.050
18	Toxin Binder	0.100	0.100	0.100
19	Anticoccidial	0.050	0.050	0.050
20	Probiotic	0.050	0.050	0.050
20	Emulsifier	0.050	0.050	0.050
21	Oil	1.300	2.700	4.200
	Total (kg)	100.00	100.00	100.00

replicate. Treatment includes; T_1 (Control) : Rice husk (Litter material), T_2 : Amendment with Alum @ 90 g/sq.ft., T_3 : Amendment with Boric acid (H_3BO_3) @ 24 g/sq.ft., T_4 : Amendment with Sodium Bisulphate ($NaHSO_4$) @ 25 g/sq.ft., T_5 : Amendment with Commercially available probiotic product @ 1 g/sq.ft,, T_6 : Amendment with Commercially available *Yucca schidigera* liquid solution @ 1.0 ml/sq.ft.

The birds were raised in a deep litter type of housing system. The fresh rice husk was used as litter (bedding) material during the rearing of broiler birds. The litter amendment (T_2 to T_6) was done on the 1st, 15th, and 29th days of the experimental period. The feed was prepared as per the nutrient specification for the broiler recommended by BIS (2007) standard. The experimental study was conducted at the Poultry Research Station (PRS), College of Veterinary Science & Animal Husbandry, Anand Agricultural University, Anand, Gujarat.

The experiment was conducted in two different seasons. Experiment-I was conducted in the winter season (WS), (December-January) and experiment-II was conducted in the rainy season (MS), (August- September) for six weeks of duration.

The average maximum and minimum temperatures throughout the winter season were 27.08 and 14.40 °C, respectively, with maximum and minimum humidity of 84.31 and 49.03 %, respectively. The average maximum and minimum temperatures for the summer season were 32.25 and 14.40 degrees Celsius, respectively, with maximum and minimum humidity of 84.31 and 49.03 percent, respectively.

The floor space per bird was given as @ 0.5 ft^2 for 1-2 weeks of age, 1.0 ft^2 for 3-4 weeks of age, and 1.5 ft^2 for 5-6 weeks of age. All experiment groups were raised under similar environmental and management conditions except for the litter amendment. Rice husk was used as litter material. A digital hanging balance was used

to calculate the weight of the litter, and the same amount of litter was used in each replicate. A thickness of 5 to 7 centimeters was maintained throughout the experiment. Proper spreading and timely stirring of the litter material were done to keep the thickness uniform. Vaccination was done at timely intervals to maintain healthy flocks. Biosecurity measures were strictly kept in place throughout the experimental period. At the entrance of the experimental shed liquid, phenyl solution was added daily as biosecurity measures.

2.2 Broiler performance index

The Production Efficiency Factor (PEF) was also known as the European Production Efficiency Factor (EPEF). Production Efficiency Factor was calculated by using the following formula:

$$\text{European efficiency factor} = \frac{\text{Livability (\%) x Average Body Weight}}{\text{Mean age x Feed Conversion Ratio}} \text{ X } 100$$

2.3 Economics Benefit-cost ratio (BCR)

The cost of feeding involved per kilogram of live broiler bird was worked out for each treatment. The average feed consumption for each pre-starter, starter and finisher period for every treatment was multiplied by the cost of production of each of these feed types to give the period-wise feed cost involved. (Table-1) Adding up the feed cost involved in each phase developed the total feed cost involved per treatment. The total feed cost involved per treatment when divided by the average body weight of the birds per treatment resulted in the figure of the cost of feed per kilogram of broiler bird. The benefit was calculated as per the selling of birds. The benefit-cost ratio was calculated by expenses and benefits. The cost of various chemicals in the experiment, and the cost of feed ingredient have been depicted in Table-1 and Table-3, respectively.

Table 1: Cost of various chemicals of experiment

Sr. No	Chemicals	Cost/Kg
1	Alum	19
2	Boric Acid	81
3	Sodium Bisulphate	36
4	Probiotic Product	1350
5	*Yucca schidigera* added product	1700

Table 2: Cost of feed (Rs/100 Kg) during the different feeding phases

Experiment	Treatments	Cost (Rs/100kg)		
		Pre-Starter	Starter	Finisher
Experiment-I	**T_1-T_6**	2880.00	2985.00	3078.00
Experiment-II	**T_1-T_6**	4818.00	4935.00	4872.00

Table 3: Cost of various feed ingredients of experiment-I (WS) and II (MS)

Sr. No.	Ingredients	Name	Cost/kg	
			Exp.-1	Exp.-2
1	Maize	Maize	14.77	20.77
2	SOYA 45%	Soybean DOC	33.99	71.09
3	DORB	DORB	13.65	12.73
4	LSP Powder	LSP Powder	3.46	3.46
5	DCP	DCP	33.00	33.00
6	Broiler vitamin	Previte++1/Breevit	1,450.00	1570.00
7	Vitamin B_{12}	Merivit-100	110.00	115.20
8	Trace Minerals	Provit TMN-V	100.00	110.00
9	Choline Chloride 60%	Choline Chloride 60%	95.00	95.00
10	Lysine	L-lysine	185.00	185.00
11	Methionine	Met-Amino	236.00	236.00
12	Phytase	NR-Phytase 5000/Phycad-5k	145.00	145.00
13	Enzyme	Poultase/Econase	140.00	140.00
14	Salt	Salt	3.00	3.00
15	Soda Bicarbonate	Alkacarb	32.00	32.00
16	Livertonic	Zigbir	119.70	106.88
17	Immunomodulator	Zist	168.00	247.00
18	Toxin Binder	Niltox-E	55.00	55.00
19	Anticoccidial	Anacox	132.00	132.00
20	Emulsifier	Lipifier	326.00	326.00
21	Oil	Vegetable Oil	130.00	172.66

2.4 Statistical Analysis

The data were analyzed using Completely Randomized Design as per Snedecor and Cochran (1994). Means of replicates under each treatment were considered for analysis. The structure of analysis of variance (ANOVA) is given below.

3. Results and discussion

3.1 Performance Index

3.1.1 Production Efficiency Factor

The mean production efficiency factor was calculated at the end of the experiment (42^{nd} day).

The mean production efficiency factor during experiment-I (WS) and experiment-II (MS) has been presented in Table 4. This difference in experiment-I (WS) was found significantly ($p<0.05$) higher in T_2 followed by T_4, T_6, T_3, T_5, and lower in T_1. But difference among different treatment was found non-significant in experiment- II. The pooled mean production efficiency factor has been presented in Table 4. It was significantly ($p<0.05$) higher in T_2 followed by T_6, T_3, T_4, T_5, and lower in T_1. The Interaction between year (Y×T) and treatment was found non-significant for the mean production efficiency factor.

The present results were in agreement with the finding of Bjedov *et al.* (2013), Chakravati *et al.* (2019) reported that the performance index (PI) of broiler chickens was significantly ($p<0.05$) higher in various concentrate alum amendments (0.085, 0.090, and 0.095 kg/bird) treatments compared to the untreated group. This was also supported by Mohammed (2019).

Table 4: Mean ± SE of production efficiency factor of broilers in different treatments at end of the experiment

[a,b,c] Mean bearing with different superscripts within a column differ significantly (p<0.05)

3.2 Economics

Economics was calculated in terms of a benefit-cost ratio (BCR). A benefit-cost ratio is a monetary or qualitative measure that shows the ratio between benefits and expenses. The benefit-cost ratio was calculated at the end of the experiment. The benefit-cost ratio has been presented for experiment-I (WS) and II (MS) in Table 2 and 3 respectively.

For the experiment-I (WS) and experiment-II (MS), the net profit (Rs/bird) and benefit cost ratio was depicted in Table-5 and 6, respectively. During experiment-I (WS) and experiment-II (MS), net profit and benefit-cost ratio was found higher in T_2 followed by T_6, T_4, T_3, T_1, and lower in T_5.

The benefit-cost ratio was higher in experiment-I (WS) due to decreased feeding costs in various phases, however in experiment-II (MS), increased feed costs were detected, resulting in a lower benefit-cost ratio.

Present results were in obedience to the results of Taboosha (2017) found that the economic

Treatments		Experiment-I (WS)	Experiment-II (MS)	Pooled (WS+MS)
T_1		285.66^{c}±10.83	304.68±26.06	295.17^{b}±18.41
T_2		335.75^{a}±6.75	356.10±16.18	345.92^{a}±8.48
T_3		318.09^{abc}±12.82	349.10±12.07	333.59^{a}±2.89
T_4		323.78^{ab}±11.43	329.46±21.89	326.62^{ab}±11.72
T_5		291.97^{bc}±14.50	307.30±17.34	299.64^{b}±7.37
T_6		320.07^{abc}±12.32	350.63±11.88	335.35^{a}±8.47
	SEm	11.70	18.15	11.19
T	**CD at 5%**	34.74	NS	31.70
	SEm	-	-	15.27
Y X T	**CD at 5%**	-	-	NS
	CV %	7.49	10.98	6.61

efficiency was least in the untreated litter amendment group and better in the 495 g of alum/m^2 litter amendment group and also supported by Mohammed (2019).

These findings were contradictory to the present study by Oliveira *et al.* (2015), who found that the control group's economic efficiency (%) was higher than that of the other litter treatment groups.

4. Conclusions

The present experiment concluded that the European efficiency index and benefit-cost ratio were higher in the alum amendment @ 90 g/sq.ft group compared to the control group.

Table 5: The benefit-cost ratio in different treatments at the end of experiment-I (WS)

	Particulars		T_1	T_2	T_3	T_4	T_5	T_6
A	Chick cost (Rs/bird)		28.00	28.00	28.00	28.00	28.00	28.00
	Feed consumptions (g/bird)	Pre-starter	455.71	448.38	436.58	431.63	441.53	437.17
		Starter	1164.71	1182.96	1151.53	1161.55	1176.32	1201.46
		Finisher	2063.12	2109.63	2101.42	2122.73	2064.63	2128.39
		Total	3683.54	3740.97	3689.53	3715.91	3682.48	3767.02
	Cost of feed (Rs/kg.)	Pre-starter	28.80	28.80	28.80	28.80	28.80	28.80
		Starter	29.85	29.85	29.85	29.85	29.85	29.85
		Finisher	30.78	30.78	30.78	30.78	30.78	30.78
B	Feed cost (Rs/bird)		111.39	113.16	111.63	112.44	111.38	113.97
C	Litter amendment cost (Rs/bird)		0.00	5.13	5.83	2.70	4.05	5.10
D	Miscellaneous cost (Rs/bird) (Labour/Light/Vaccination)		8.00	8.00	8.00	8.00	8.00	8.00
	Total cost (Rs/bird)		147.39	154.29	153.46	151.14	151.43	155.07
E	Body weight (Kg/bird)		2.15	2.30	2.27	2.25	2.17	2.30
F	Cost (Rs/Kg) body weight		68.55	67.08	67.60	67.17	69.78	67.42
G	Selling price /kg of birds		85.00	85.00	85.00	85.00	85.00	85.00
	Total income from selling of birds (Rs/bird)		182.75	195.50	192.95	191.25	184.45	195.50
H	Net profit (Rs/bird)		35.36	41.21	39.49	40.11	33.02	40.43
I	Net profit (Rs/ kg) body weight		16.45	17.92	17.40	17.83	15.22	17.58
	Benefits cost ratio		1.24	1.27	1.26	1.27	1.22	1.26

Table 6: The benefit-cost ratio in different treatments at the end of experiment-II (WS)

	Particulars		T_1	T_2	T_3	T_4	T_5	T_6
A	Chick cost (Rs/bird)		12.00	12.00	12.00	12.00	12.00	12.00
	Feed consumptions (g/bird)	Pre-starter	557.60	556.04	563.21	555.58	562.29	554.50
		Starter	1389.33	1419.33	1405.29	1377.42	1374.63	1428.96
		Finisher	1945.17	1989.00	1963.42	1922.17	1932.04	1962.42
		Total	3892.10	3964.38	3931.92	3855.17	3868.96	3945.88
	Cost of feed (Rs/kg)	Pre-starter	48.18	48.18	48.18	48.18	48.18	48.18
		Starter	49.34	49.34	49.34	49.34	49.34	49.34
		Finisher	48.72	48.72	48.72	48.72	48.72	48.72
B	Feed cost (Rs/bird)		190.18	193.72	192.13	188.38	189.04	192.83
C	Litter amendment cost (Rs/bird)		0.00	5.13	5.83	2.70	4.05	5.10
D	Miscellaneous cost (Rs/bird) (Labour/Light/Vaccination)		8.00	8.00	8.00	8.00	8.00	8.00
	Total cost (Rs/bird)		210.18	218.85	217.96	211.08	213.09	217.93
E	Body weight (Kg/bird)		2.27	2.43	2.40	2.31	2.28	2.41
F	Cost (Rs/Kg) body weight		92.56	89.94	90.81	91.55	93.40	90.44
G	Selling price /kg of birds		94.00	94.00	94.00	94.00	94.00	94.00
	Total income from selling of birds (Rs/bird)		213.46	228.73	225.63	216.72	214.46	226.52
H	Net profit (Rs/bird)		3.28	9.88	7.67	5.65	1.36	8.59
I	Net profit (Rs/ kg) body weight		1.44	4.06	3.19	2.45	0.60	3.56
	Benefits cost ratio		1.02	1.05	1.04	1.03	1.01	1.04

References

[1]. BIS. (2007). Bureau of Indian Standards (IS 1374: 2007). Poultry Feeds – Specification. (Fifth Revision).

[2]. Bjedov, S., Zikic, D., Peric, L., Dukic S., & Milosevic, N. (2013). Effect of different litter treatments on the production performance of broiler chickens. Biotechnology in Animal Husbandry, 29(4), 625-630.

[3]. Chakravati, R. K., Pramanik, P. S., Singh, K. D., Singh, M. K., & Manoj, J. (2019). Effect of litter treatment on growth, carcass traits, and immunity status of broiler chickens. Indian Journal of Poultry Science, 54(2), 151-154.

[4]. Cheeke, P. R., Placente, S. & Oleszek, W. (2006) Anti-inflammatory and anti-arthritic effects of Yucca schidigera: a review. Journal Inflammation, 29, 3-6.

[5]. Elliott, H.A. & Collins, N.E. (1982). Factors affecting ammonia release in broiler houses. American Society of Agricultural Engineers, 25 (2), 413-418.

[6]. Garrido, N. M., Skjervhein, M., Oppegaard, H., & Sorum, H. (2004). Acidified litter benefits the intestinal flora balance of broiler chickens. Applied and Environmental Microbiology, 70 (9), 5208-5213.

[7]. Gilmour, J. T., Koehler, M. A., Cabrera, M. L., Szajdak, L., & Moore, P. A. (2004). Alum treatment of poultry litter: Decomposition and nitrogen dynamics. Journal of Environmental Quality, 33(1), 402-405.

[8]. Miles, D. M., Branton, S. L., & Lott, B. D. (2004). Atmospheric ammonia is detrimental to the performance of modern commercial broilers. Poultry Science, 83(10), 1650–1654.

[9]. Nagaraj, M., Wilson, C. A. P, Saenmahayak, B., Hess, J. B., & Bilgili, S. F. (2007). Efficacy of a litter amendment to reduce pododermatitis in broiler chickens. Journal of Applied Poultry Research, 16 (2), 255-261.

[10]. Oliveira, M. C., Goncalves, B. N., Padua, G. T., Silva, V. G., Silva, D. V. & Freitas, A. M. (2015). Treatment of poultry litter does not improve performance or carcass lesions in broilers. The Revista Colombiana de Ciencias Pecuarias, 28 (4), 331-338.

[11]. Rashid, A., Banday. M. T., Adil. S., Khan, A. A., Saim Qureshi, S., Madeeha Untoo, M., & Ashraf, P. (2017). Effect of chemically treated litter on ammonia emission, performance and carcass characteristics of broiler chicken. Journal of World Poultry Research, 7(2), 88-93.

[12]. Ritz, C. W., Fairchild, B. D., & Lacy, M. P. (2004). Implications of NH3 production and emissions from commercial poultry facilities: A review. Journal of Applied Poultry Research, 13(4), 684-692.

[13]. Sahoo, S. P., Kaur, D., Sethi, A. P. S., Sharma, A., Chandra, M., & Chandrahas, (2017). Effect of chemically amended litter on litter quality and broiler performance in winter. Journal of Applied Animal Research, 45(1), 533-537.

[14]. Singh, A., Casey, K. D., & King, W. D. (2009). Efficacy of urease inhibitor to reduce NH3 emission from poultry houses. Journal of Applied Poultry Research, 18(1), 34-42.

[15]. Skrbic, Z., Pavlovski, Z., Lukic, M., Petricevic, V., & Milic, D. (2012). The effect of lighting program and type of litter on production and carcass performance of two broiler genotypes. Biotechnology in Animal Husbandry, 28 (4), 807-816.

[16]. Snedecor, D. W., & Cochran, W. G. (1994). Statistical methods. 9th Edition. Lowa State University. Press, Ames, Lowa, USA.

[17]. Taboosha, M. F. (2017). Effect of reusing litter on productive performance, carcass characteristics and behavior of broiler chickens. International Journal of Environment, 6(2), 61-69.