



Impact of reusage of alternative litter treatments on overall growth performance & welfare of broiler chicks

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ABSTRACT

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Bedding material maintained previously under three conditions viz., fresh, heat treated and acidified litter using Sodium bisulfate as abatement, was reused to study the impact of re-usage on growth, health and welfare of subsequent batch of broiler chicks. All the three types of litter materials were dried using sun drying and deep stacking procedure. A Control group (without undergoing any litter treatment) and two treatment groups:- Used Heat Treated Litter (UHTL) and Used Sodium bisulfate Treated Litter (USBTL) respectively were randomly assigned to 180 day-old commercial broiler chicks with equal body weights. All of the reused litter groups' birds outperformed each other in terms of growth, feed intake, FCR, and other parameters. USBTL group showed significantly ($p < 0.05$) highest value (1687g) followed by UHTL (1656g) and Control (1596g) being the lowest. No significant ($p < 0.05$) difference was obtained with respect to in house ammonia (in ppm) among the litter treated groups. From a statistical perspective the reused litter groups outperformed the Control group ($p < 0.05$). However, a non-significant ($p > 0.05$) difference was found with respect to carcass characteristics of broiler chicks and microbial load of litter materials. Recycled litter materials were found to have a positive impact on the overall growth performance, carcass features, health, and welfare of broiler chicks, which made the practice cost-effective and provided a way for broiler farmers to raise chicks economically.

Keyword: Reused litter, Litter quality, Ammonia, Microbial load, Carcass trait

INTRODUCTION

One of the most significant and rapidly expanding subsectors of global agriculture is the poultry industry. Production inputs have been in constant demand in broiler industry, one such is litter material. It is one of the essential and necessary conditions for rearing broilers, particularly in the deep litter system of housing (Farghly *et al.*, 2018). Litter is a mixture of feathers, excreta, leftover feed, wasted water, and bedding material from intensive chicken farming. The quality of the bedding material has a considerable impact on the physical traits (growth and biometry), health, carcass quality and welfare in poultry birds. A dry, absorbent bedding material that can handle developed moisture and excrement of the birds and is considered to be an ideal litter material.

Litter being the absolute necessity in the modern poultry farming, faced serious challenges because of its huge demand due to its energy source usage in different industries and scarcity of natural resources (Gonc'aves *et al.*, 2013). The cost of bedding materials has increased for producers of poultry as a result. This circumstance has prompted poultry farmers and academics to warrant the technological interventions on bedding material for its optimum efficiency for utilisation. One of these practices entails reusing litter for more than one cycle as

opposed to completely clearing out the litter and replacing it with freshly procured high-cost bedding material.

In modern commercial poultry operations, it is common practice to reuse litter for various flocks. Due to four key factors viz. reduced production costs, limited sources of litter, sustainable environment along with spent litter disposal problem, broiler litter reuse has been a prevalent technique in the poultry industries of the United States and Brazil. To lower the bacterial and viral loads, litter can be composted internally using a process called windrow composting. This technique involves creating a temperature beyond 50°C to countdown bacterial load and diminishes the majority of viral infections (Bernhart, *et al.*, 2010). Recent studies also suggested a three-to-five-day composting method in-house, proved a reduction in bacterial load with increased performance (Saravanan and Sharmilaa, 2018). Reuse of the poultry bedding provides a litter of higher nutrient (protein) content, thus providing us scope for integrated farming by using it as a protein source for cattle feed (Ngodigha & Owen, 2009). In the light of above, to explore physical method of litter processing in comparison to chemical-based amendments (Sandhu *et al.*, 2019) and further for reuse, the goal of the current study was to evaluate alternative litter treatments and to evaluate the broiler performance through their reusage.

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MATERIALS AND METHODS

Ethical approval

The Institutional Animal Ethics Committee, GADVASU, Ludhiana, Punjab-141004, India, granted the necessary approval for the entire experiment's planning and execution (Permission no: GADVSAU/2021/IAEC/62/22).

Research Methodology

Birds were previously raised upon 3 different kinds of litter materials viz., fresh paddy husk, heat treated paddy husk at 120°C & paddy husk treated with sodium bisulfate at 25gm/ sq. ft. The litter materials devoid from healthy chicks obtained from the first experiment were scrapped out by spade and were laid upon large polystyrene sheets for stacking and sun drying purpose. After drying of the litter materials, various small clumps of litter materials were broken manually and the larger clumps were thrown, so that it would be of favourable size while laying of the litter; and it would also be a favourable bedding material fit for the welfare and comfort of the birds. Then the litter was collected and stored in Poly-Vinyl Chloride (PVC) drums, and was used in the 2nd week after rearing birds on corrugated cardboard sheets for first week. Hence, it included two treatment groups including T1 (Used Heat Treated Litter-UHTL) & T2 (Used Sodium bisulfate Treated Litter-USBTL) and one T0 (Control group - Fresh Paddy Husk Litter). 180-sexed day-old healthy 'VENCOB-430' broiler chicks hatched on 21st April, 2022 procured from M/s Venky's (India) Ltd and were randomly and uniformly assigned among the litter groups. Birds were fed a basal diet consisting of maize and soybean meal that was prepared

in accordance with ICAR 2013 guidelines (Babu *et al.*, 2023) and used a variety of locally sourced components fortified with additives as per standard protocol (Table 1).

The experiment was carried out at Shed No. 6 of the Poultry Research Farm of the College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University in Ludhiana. Brooding chicks were reared under standard temperature and humidity conditions during first two weeks. With the aid of a thermos hygrometer and data recorder (SIKA Electronics, MH 3350), temperature and humidity records were made in triplets on a single day, at 9:00 am, 12:00 pm, and 3:00 pm. According to Mader *et al.* (2006), the following formula was used to calculate the Temperature and Humidity Index (THI):

$$THI = (0.8T_{db}) + [(RH/100) (T_{db} - 14.4)] + 46.4$$

Where

T_d = dry bulb temperature (°C)

RH = relative humidity expressed as a decimal

Ammonia concentration (ppm) in each pen was recorded individually at the level of bird's height at twice a weekly interval from 3rd week onwards using a portable Tinsel[®] pro ammonia gas detector meter with minimum sensitivity of 1ppm NH₃.

For the purpose of obtaining secondary data for the computation of weight gain, feed/gain in body weight, energy efficiency ratio (energy intake/gain in live weight), and protein efficiency ratio (gain in live weight/protein intake) during each phase, the biweekly physical traits in the form of live weight and average feed intake per treatment were measured, Sahoo *et al.* (2015).

Pooled sampling was used to collect litter samples from six distinct places in each pen for bacterial load estimate using the Spread Plate Technique (Thomas *et al.*, 2012 in the second, fourth, and sixth weeks of the trial. HiMedia[®] Mumbai's Mac Conkey agar was selected to differentiate between lactose fermenters and non-lactose fermenters. Lactose fermentation is represented by pink colonies, whereas non-lactose fermentation is exhibited by yellow or white colonies. Calculations were performed using Brain Heart Infusion agar media (HiMedia[®] Mumbai) to determine the total number of bacteria (White colonies). Calculating the colony forming units (CFU) per gramme from the original aliquot/sample involved calculating the average number of colonies for a certain dilution factor.

Every two weeks, faecal samples from each pen were collected and examined for Eimeria oocysts in order to calculate the parasite load. The samples were examined under a microscope. A faecal investigation was performed on fresh faecal material that was collected immediately following defecation. The faeces sample was subjected to a qualitative analysis using the simple floatation method. The number of oocysts per microscopic field was

Table 1: Ingredient and chemical composition of broiler rations used in experiment (ICAR-2013)

Ingredient	(Kg/100kg)		
	Pre-Starter	Starter	Finisher
Corn yellow	53.8	55.4	61.0
Soybean meal	34.5	33.2	28.0
Rice polish	5.0	5.0	5.0
Oil	2.7	3.0	3.0
Dicalcium phosphate	2.5	3.0	3.0
Limestone powder	1.0	1.0	1.0
Common salt	1.0	1.0	1.2
Additives	0.27	0.26	0.27
Methionine	0.025	0.016	0.017
Calculated Chemical Composition			
CP%	22.03	21.55	19.56
ME, kcal/kg	3055.30	3053.20	3116.00
Lysine %	1.20	1.10	0.95
Methionine %	0.61	0.60	0.53
Calcium	1.13	1.03	1.01
Available phosphorous	0.67	0.56	0.47

counted using the Mc Master method (Bhatia *et al.*, 2010).

For calculating the litter pH and litter nitrogen, 10 gram of litter sample was collected at weekly intervals from each individual pen in a 100 ml beaker, followed by addition of 50 ml of distilled water and then mixed thoroughly with a glass rod. For thirty minutes, the sample was kept at room temperature. Following that, a calibrated pH metre (BOECO Germany PT-380, pocket pH tester) was used to measure the pH. The nitrogen content of the litter was estimated using the AOAC International standard (2005) technique (Proch *et al.*, 2021).

For evaluation of carcass traits, four birds from each treatment of equal body weight were randomly picked and fasted overnight, and were slaughtered at 42nd day of experimental period. They were completely bled, scalded at 53°C for 75 seconds and de-feathered by hand picking. The dressed carcass was cut into different prime cut parts. The weight of inedible parts/offal was recorded. The giblet weight and eviscerated yield were recorded. The data were expressed on per cent of total live weight basis for comparison.

With SPSS Version 16.0, a statistical analysis of the gathered data was carried out. Duncan's multiple range test (Duncan 1995) was used to compare means of pooled data using one-way analysis of variance (Snedecor and Cochran 1994) at a level of significance ($p \leq 0.05$).

RESULTS AND DISCUSSION

In the shed, the mid of experiment, mean temperature and relative humidity were 34.6°C and 31.5%, respectively. Due to progressing summer season, there was a steady increase in temperature and drop in relative humidity during the time of the experiment. The average THI was calculated using the temperature and average RH measurements from the shed, and the results showed that it was 80.4 for the finisher phase, 79.5 for the starter phase, and 78.6 for the pre-starter phase. As the mean temperature increased, a rising trend in THI was noted.

In-house ammonia concentration

Table 2 presents the ammonia concentration data for the various treatment groups. Level of ammonia in the poultry shed was almost negligible up to 3rd week of the experiment. However, from 3rd week onward ammonia gas was detected in minute concentration which gradually increased in all the treatment groups, which was recorded significantly higher ($p < 0.05$) in UHTL followed closely by USBTL while lowest in the Control groups. Towards the end of the trial, however, all the litter groups had similar values of ammonia level with non- discernible difference ($p > 0.05$) between the litter groups. Increased ammonia level is due to wet litter in broiler house, letter wetting was avoid in the experiment. Our results corroborated with the earlier researches

(Youins *et al.*, 2016 and Taboosha, 2017).

Table 2: In house ammonia among different litter treatment groups

Week	Ammonia level (ppm) (Mean±S.E)		
	CONTROL	UHTL	USBTL
3 rd week	0.67 ^a ±0.33	1.67 ^b ±0.67	1.33 ^{ab} ±0.33
4 th week	4.33±0.67	4.75±0.75	4.50±0.88
5 th week	8.5±0.48	8.75±0.86	8.67±0.88
6 th week	15.67±0.67	16.67±0.67	16.33±0.88

^{a,b} Means with different superscripts in a row differ significantly ($p < 0.05$)

Growth performance

At the time of purchase, the average initial live weight of day-old broiler chicks was 44.55 g. According to the growth statistics, the average weight gain in the UHTL and USBTL groups during the first growth phase was 1.70% and 1.37%, respectively, based on the information shown in Table 3. The overall feed intake and body weight gain was found to be significantly ($p < 0.05$) high among the chicks reared upon USBTL group, with Control group having the lowest values, whereas UHTL group being the intermediate between them. The chicks raised on recycled heated litter group (1656 g) and the Control group (1596 g) had final body weights that were significantly ($p < 0.05$) higher than the chicks raised on reused acidified litter group (1687 g). The aggregate FCR statistics showed that the FCR values

Table 3: The phase wise and overall production indices of broiler chicks under different litter treatment groups

Phase	Treatments (Mean±S.E)		
	CONTROL	UHTL	USBTL
Initial mean body weight (g)			
-	44.55±0.00	44.55±0.00	44.55±0.00
Final mean body weight (g) (42 days)			
-	1596.08 ^b ±23.72	1655.89 ^{ab} ±25.19	1686.94 ^a ±21.17
Average Weight Gain (g)			
Phase I	224.40±4.73	228.98±4.56	228.10±3.97
Phase II	481.76±54.11	505.66±33.09	513.70±22.70
Phase III	844.24±43.47	876.97±39.29	901.43±41.40
Overall	1550.40 ^{b±} 30.25	1611.62 ^{ab±} 32.63	1643.23 ^{a±} 35.22
Average Feed Intake (g)			
Phase I	241.19±4.18	246.35±4.83	244.09±3.90
Phase II	980.53±13.62	952.72±40.07	886.51±89.80
Phase III	1640.41±30.58	1529.43±36.99	1485.01±130.26
Overall	2862.14 ^{a±} 15.70	2728.51 ^{b±} 22.25	2615.62 ^{b±} 77.42
FCR			
Phase I	1.075±0.017	1.076±0.009	1.070±0.009
Phase II	2.106±0.21	1.894±0.068	1.712±0.11
Phase III	1.963±0.13	1.754±0.08	1.655±0.14
Overall	1.93 ^b ±0.03	1.77 ^{ab} ±0.08	1.66 ^a ±0.07

PER			
Phase I	4.224±0.06	4.220±0.03	4.242±0.15
Phase II	2.272±0.22	2.460±0.08	2.750±0.14
Phase III	2.630±0.03	2.936±0.20	3.173±0.31
Overall	2.24±0.10	2.30±0.02	2.39±0.03
FER			
Phase I	3.286±0.05	3.288±0.02	3.270±0.02
Phase II	3.879±0.43	3.564±0.18	3.264±0.10
Phase III	3.581±0.22	3.346±0.24	3.056±0.41
Overall	6.78±0.33	6.55±0.07	6.33±0.08
Survivability (%)			
Phase I	100±0.00	100±0.00	100±0.00
Phase II	100±0.00	100±0.00	100±0.00
Phase III	96.66±0.33	96.66±0.33	96.66±0.33
Overall	96.66±0.33	96.66±0.33	96.66±0.33

^{a,b}Means with different superscripts in a row differ significantly (p<0.05)

for each group ranged from 1.66 to 1.93. In comparison to the Control, the USBTL and UHTL showed a statistically significant (p<0.05) increase in feed utilisation efficiency. Compared to the Control groups, the treatment groups showed greater weight gain, indicating improved feed and protein efficiency in the litter amendment groups (UHTL and USBTL). The percentage survivability was also found to be numerically same among the different treatment groups. Our study was in disagreement with previous workers having non-significant changes in body weight of broiler raised on freshly used litter and reused litter (Abougabal, 2019 and Younis *et al.*, 2016). Similarly, Taboosha, (2017) and Garceis-Gudin^o *et al.*, (2018) found a same production performance for chicks raised on fresh litter and reused litter. However, the study follows in agreement with Kalita *et al.* (2012) and Abougabal, (2019) where they observed that there was no discernible variation in the weekly FCR of broiler chicks.

Litter quality

The data for nutritive value of litter has been given in Table 4. When comparing the pH values of the Control group and the recycled litter groups, there was a significant (p<0.05) difference among them. This may be due to the use of fresh paddy husk as compared to the reused litter obtained after rearing a batch of chicks upon it, which had a previous load of faecal droppings upon it. At the end of the second and fourth week of the trial, samples, the per cent available nitrogen values obtained from proximate analysis, a direct indicator of the crude protein% in the litter content, was statistically (p<0.05) higher in the USBTL and UHTL groups than in the Control group (Table 4). However, the nitrogen level had significantly (p < 0.05) differed values among all the three litter groups at the end of the experiment,. In comparison to the UHTL group, the USBTL group continuously maintained a higher nitrogen level (p>0.05). Throughout the trial, it was discovered that the nitrogen load residue from the previously utilised litter was still present. The increased crude protein percentage may have resulted from the UHTL and USBTL groups having greater levels of nitrogen in their bodies. Throughout the study, there was a rising trend in the overall ash percentage of the litter samples (Table 4). The USBTL group constantly maintained a statistically (p<0.05) higher values from UHTL & Control groups throughout the trial. The result of moisture level was found in agreement with Madrid *et al.* (2012) where alum treated litter had higher dry matter percentage compared to the Control.

Litter microbial load

The data on microbiological count is depicted in Table 5. The microbiological evaluation of litter samples revealed bacterial count almost close values, which might be due to Controlled conditions of the moisture & pH created through the processing of litter material before starting of experiment. The processing of litter material

Table 4: Evaluation of litter quality under different treatment groups

Period(week)	Parameters	Treatments (Mean±S.E)		
		CONTROL	UHTL	USBTL
End of 2 nd week	pH	6.01 ^a ±0.03	6.28 ^c ±0.01	6.14 ^b ±0.009
	Moisture, %	10.06 ^a ±0.71	12.37 ^b ±0.59	12.04 ^b ±0.02
	Ash, %	18.38 ^b ±0.14	18.46 ^b ±0.29	20.81 ^a ±0.31
	N, %	2.10 ^b ±0.12	2.27 ^{ab} ±0.03	2.38 ^a ±0.05
End of 4 th week	pH	6.15 ^a ±0.04	6.66 ^c ±0.03	6.40 ^b ±0.03
	Moisture, %	13.60 ^c ±0.46	15.20 ^b ±0.00	12.00 ^a ±0.69
	Ash, %	19.27 ^{c±} 0.10	19.97 ^{b±} 0.26	21.55 ^a ±0.24
	N, %	2.52 ^b ±0.12	2.73 ^a ±0.04	2.80 ^a ±0.05
End of 6 th week	pH	6.73 ^a ±0.02	6.84 ^b ±0.01	6.76 ^a ±0.01
	Moisture, %	29.00 ^b ±0.86	20.40 ^a ±0.40	20.60 ^a ±0.17
	Ash, %	19.29 ^{b±} 0.81	19.13 ^{b±} 0.58	22.85 ^a ±0.23
	N, %	3.15 ^c ±0.04	3.29 ^b ±0.04	3.71 ^a ±0.04

^{a,b,c}Means with different superscripts in a row differ significantly (p<0.05)

Table 5: Microbial and coccidia load of different litter treatment groups

Period (week)	Parameters	Treatments (Mean±S.E)		
		CONTROL	UHIL	USBTL
End of 2 nd week	<i>E.coli</i> , CFU in log 10	4.59±0.11	4.87±0.06	4.83±0.13
	<i>Salmonella</i> and <i>Salmonella</i> like microbes, CFU in log 10	4.24±0.24	4.37±0.11	4.32±0.16
	TBC, CFU in log 10	7.08 ^a ±0.05	7.73 ^b ±0.1	7.54 ^b ±0.09
	Parasitic Count, Oocysts/gm	875.00±85.39	925.00±47.87	900.00±91.28
End of 4 th week	<i>E.coli</i> , CFU in log 10	5.22±0.25	5.53±0.17	5.31±0.17
	<i>Salmonella</i> and <i>Salmonella</i> like microbes, CFU in log 10	4.54±0.06	5.14±0.14	4.71±0.24
	TBC, CFU in log 10	8.08±0.20	8.55±0.33	8.12±0.12
	Parasitic Count, Oocysts/gm	2000.00 ^b ±40.20	1550.00 ^{ab} ±22.17	1250.00 ^a ±28.86
End of 6 th week	<i>E.coli</i> , CFU in log 10	5.25±0.77	5.79±0.37	5.50±0.60
	<i>Salmonella</i> and <i>Salmonella</i> like microbes, CFU in log 10	4.35±0.35	4.57±0.27	4.39±0.39
	TBC, CFU in log 10	8.22±0.04	8.37±0.06	8.34±0.04
	Parasitic Count, Oocysts/gm	3550.00 ^a ±76.32	3875.00 ^b ±82.60	3475.00 ^a ±77.17

^{a,b} Means with different superscripts in a row differ significantly (p<0.05)

under different treatment groups was subjected to heap stacking and sun drying as prescribed by Bernhart *et al.* (2010). The data indicated that regardless of treatment groups, the microbial count had an upward tendency with advancing age. Throughout the duration of the experiment, the UHTL's greater bacteria count persisted. In comparison to Control, both of the reused litter groups (USBTL and UHTL) showed higher plate counts for *E. coli*, *Salmonella*, and Total Bacterial Count (TBC), but the difference was not statistically significant (p>0.05). This might be because litter gradually achieved higher temperature during deep stacking and heat treatment while sun drying, thus providing unfavourable environment to the microbes to increase in their number. Hence a less value in all the microbial count was found in the 2nd week sampling of this experimental trial as compared to previous trial. In the 2nd week of sampling a statistically (p<0.05) lowest value was found in the Control group, than the rest of reused litter groups with respect to Total Bacterial Count (CFU in log 10 values).

The results on parasite count developed as the age of the bird increased, regardless of any litter categories, whether new or reused. In the first sampling of 2nd week, numerically lower value was found in the Control group but of non-significant difference between the litter groups. In the 4th week although statistical (p<0.05) difference was found among Control group and USBTL groups but no statistical difference was found in UHTL group as compared to rest two treatments. In the last week, the UHTL group had a statistically significant (p<0.05) difference in parasitic count than the other two groups; whereas, statistically similar values were recorded for the same under USBTL and Control groups.

Carcass quality

Table 6 presents information on the dressed yield and cut-up portion of the meat in each of the treatment groups. The values of the carcass trait yield are nearly identical across all treatment groups. In the UHTL group, evisceration and edible percentage were found to be numerically slightly greater than in the USBTL and Control groups. All the data found non-significant among the treatment groups. The percentage of breast and thigh was found to be numerically higher in USBTL group as compared to rest treatment groups. The drumstick yield

Table 6: Effect of different litter treatments on carcass parameters of broiler chicks

Parameters	Treatments (Mean±S.E)		
	CONTROL	UHIL	USBTL
*Eviscerated	64.08±1.13	64.75±1.39	64.23±0.82
Weight, %			
*Giblet, %	4.69±0.20	4.20±0.14	4.31±0.13
**Wings, %	10.96±0.65	10.61±0.78	9.33±0.21
**Neck, %	5.24±0.27	4.33±0.22	4.44±0.28
**Breast, %	29.23±0.54	30.69±1.88	31.18±0.89
**Back, %	19.97±0.51	20.96±0.54	20.08±0.64
**Thigh, %	17.51±0.68	17.00±0.59	17.98±1.19
**Drumstick, %	17.06±0.74	16.38±0.21	16.97±0.33
**Fat, %	1.86±0.62	2.21±0.44	2.75±0.23
*Edible, %	68.77±0.94	68.96±1.28	68.54±0.76
*Inedible, %	31.22±0.94	31.04±1.28	31.45±0.76

Mean values bearing different superscripts in a row differ significantly (p<0.05)

* Percentage of body weight

** Percentage of eviscerated weight

was slightly better in the Control group. Our results were in same line with the earlier researchers (Kalita *et al.*, 2012, Yamak *et al.*, 2014, Taboosha, 2017, Abougabal, 2019 and Chakravati *et al.*, 2019) where slaughter and carcass characteristics were non-significant in chickens reared on fresh litter and used litter.

CONCLUSION

In a nutshell, poultry production is presently based on recycling of litters and is advised worldwide due to the following reasons: it lowers litter costs, reduces downtime, takes advantage of seasonal bedding unavailability or scarcity, promotes environmental sustainability, and is more difficult to handle and dispose of used litter. Our studies revealed that reusage of previously treated litter groups have an impeccable impact on body weight, efficiency of converting feed in the form of energy and protein, better litter quality, almost same bacterial and coccidia load thus, making the litter materials suitable for reusage and rearing successive batch of chicks. The validated litter treatments under the present study may be implemented on the used litter instead of fresh litter to further improvise growth, health and economic implications of broiler farming. Furthermore, the testing of used litter may be extended up to two successive batches to establish the reusage of the litter.

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