



A QUALITY ENHANCEMENT GREEN STRATEGY FOR BROILER MEAT BY APPLICATION OF TURMERIC (*Curcuma Longa*) POWDER AS LITTER AMENDMENT TO AFFECT MICROBES, AMMONIA EMISSION, PH AND MOISTURE

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ABSTRACT

In multi-cultural Sri Lankan conditions, poultry meat is paramount importance in ensuring food security and improving nutrition. Issues as contact dermatitis and ammonia emission in broiler industry which caused by diminished litter parameters cause reduction of meat quality, profits and environmental conditions. Therefore use of Turmeric (*Curcuma longa*) (TM) powder as an antiseptic litter amendment at several application levels to enhance litter parameters with microbial demolition was attempted. Three months old broiler litter (2 kg) sample was taken and initial pH and moisture was determined. Turmeric was used to mix at levels of 0%, 1%, 3%, 5% and 8% (w/w). After mixing, 150 g of mixed litter was placed in container for each level of the 4 replicates, incubated for 5h and analyzed for Total Plate Count (TPC), Yeast and Mold Count (YMC), total Nematode Count (NC), ammonia emission, pH and moisture. Significant reduction ($p < 0.05$) of total bacteria was seen (20%, 46%, 95% and 96%) when 1%, 3%, 5% and 8% applications of TM. The YMC reduction was also significant ($p < 0.05$) (34%, 41%, 55% and 65%). Total nematode reduction ($p < 0.05$) was 22%, 45%, 62.5% and 70%. A significant ($p < 0.05$) pH reduction with increment of TM also seen (0.1, 2, 3 and 3%). Moisture (%) was increased ($p < 0.05$) (6, 0.78, 19 and 1%). Ammonia emission was significantly decreased ($p < 0.05$) by increased TM (64, 68, 73 and 84%) against control. It was concluded that the bacterial, fungal, nematode counts, pH and Ammonia emission of broiler litter can be significantly reduced with the application of 8% (w/w) of turmeric powder.

Keywords: Turmeric powder; Total Plate Count; Mold Count; Nematode Count; NH₃

INTRODUCTION

Chicken meat is the most popular meat type of Sri Lanka which had a production of 14.45 million MT, exports of 1524.46 MT and per capita availability of 7.09 kg (Department of Animal Production and Health, 2014). Under multi-cultural conditions, poultry meat is paramount importance in ensuring food security and improving nutritional status, because the consumption of the same and the production of poultry for meat are not severely regulated by ethno-religious taboos. As an industry which relies on quality, production and highly perishable nature, the profit maximization is bit challenging. Diseases to live animals and other management costs affect the industry in general. Basically chickens spend their entire life on a litter which has a higher microbial population may lead to contaminated processed carcasses by increasing the microbial load of skin and feathers and providing a source for upper gastrointestinal contamination during pre-harvest feed withdrawal. Pine shavings, peanut hulls, rice hulls, sand or other materials were commonly used as litter materials. Addition of birds onto litter adds large amount of excreta, feathers, feed and water. The quality of the in-house environment is highly dependent upon litter quality because of thousands of birds on thousand tons of litter.

Moreover, the microbes are responsible for production of ammonia in poultry houses which has a global issue of green house gases and also affect badly to performance, health, behavior and welfare of animals. Health and welfare problems accompanying with high NH₃ concentrations include damage to the respiratory tract increased vulnerability to Newcastle disease, incidence of airsacculitis, increased *Mycoplasma gallisepticum* and incidence of keratoconjunctivitis (Katukurunda et al., 2015). High NH₃ concentrations in poultry houses decrease growth rate of birds which reduces meat yield, feed efficiency (Katukurunda et al., 2015), feed conversion and weight gains (Carlile, 1984) which lead to smaller animals and egg production (Katukurunda et al., 2015). Uses of artificial litter amendments to address these problems were seen in the industry which reduces the fertilizer value of litter and increase of operational costs.

The intestinal flora and litter microbes of poultry play a vital role for their growth performance and health. On the other hand, knowledge about these intestinal flora and litter microbial ecology is still limited. Previous explorations which chiefly used culture dependent approaches proved that the common cultural bacteria in small intestine of birds belong to *lactobacilli*, *enterococci*

and *enterobacteria* and in the caecum, principally *lactobacilli*, *enterococci*, *bacteroides*, and *clostridia* (Mead, 1989; Barnes, 1979; Engberg et al., 2000; Salanitro et al., 1978). Some modern molecular studies have dedicated more comprehensive insight into the constitution of the microbial community of poultry ecosystem (Amit-Romach et al., 2004; Lan et al., 2002; Gong et al., 2002; Lu et al., 2003; Zhu et al., 2002). The constitution and composition of litter microbial community is inclined by factors such as temperature, humidity, day length, light color and intensity etc. (Zhu et al., 2002), though Yardimci and Kenar (2008) reported that the effect of stocking density had no significant effect on microbial load and stocking density changing from 10 to 17 birds.m⁻² did not affect microbial count of broiler litters. Therefore, microbial communities which found under different environmental factors in poultry management can have significant differences and deviations among them. Especially in poultry industry, the dietary and environmental factors affect the microbial status of gastrointestinal tracts of birds. Wet or caked litters and other animal management practices affect microbial composition of poultry gastrointestinal tract directly by giving a continuous bacteria source and indirectly by improving the physical condition and immunity (Apajalahti, 2004).

Carr et al. (1990) and Schefferle (1965) reported that the total litter bacteria concentrations fall within the range of 10¹⁰ to 10¹¹ colony forming units per gram (CFU.g⁻¹) of litter. As per the findings of Lu et al. (2003) and Macklin et al. (2005) the total aerobic bacteria counts are lower at 10⁸ to 10¹⁰. These amounts can vary with age of litter and age of birds (Macklin et al., 2005) moreover fresh litter were found to have 10⁵ CFU.g⁻¹, as soon as birds were placed on it, numbers of bacteria amplified by several levels of magnitude to 10⁸.

NH₃ pollution is a major problem cause acid rains and overriding source of NH₃ in Europe is livestock waste (Apsimon et al., 1987). Ammonia is generated during the microbial breakdown of undigested proteins and excretory uric acids which in feces of poultry flock. Conditions that favor microbes will result in boosted NH₃ production. These conditions include warm temperature, pH in the neutral range or slightly higher (around 7.0 – 8.5) moisture and the presence of organic matter (Miles et al., 2004). Rarely the NH₃ concentrations in poultry houses can reach high levels, causing poor poultry performance (Carlisle, 1984). Anderson et al., (1964) concluded that the NH₃ levels low as 20 ppm compromised the immune system of birds, making more vulnerable to respiratory diseases and damaged respiratory systems of animals. By considering all the observations of these negative effects on performance, Carlile (1984) recommended the NH₃ concentrations in poultry sheds should be kept less than 25 ppm. Higher levels of NH₃ may also affect the health of associated workers in these sheds (Donham, 1977) causing a health hazard.

Use of Turmeric (*Curcuma longa*) [TM] as a disinfectant was seen in many cultures especially throughout Asia. Klimešová et al. (2015) reports about the beneficial influence of turmeric on lipid metabolism, anti-hypercholesterolemic effect, anti-lithogenic effect and antioxidant effects in their study. In relation to poultry

studies, turmeric improves feed intake in poultry when used at 0.25% level in feed. Several research studies suggested that turmeric can assist to fight microbial actions. Aqueous extracts of turmeric showed good antimicrobial activity against common bacteria, fungi, viruses, yeast, and round worms. Katukurunda et al., (2015) concluded that the application of turmeric higher than 3% (w/w) basis of poultry litter as an amendment was effective in lowering pH and the NH₃ emission of the litter material. Hossain et al. (2015) concluded that the fresh leaves juice (78.9%) and leaf dust (73.3%) of Turmeric plant inhibited the development of *Ascaridia galli* eggs, one of the most common parasitic roundworms of poultry at 20% w/w concentration. Moreover, Rahman (2002) reported that the highest efficacy against gastrointestinal nematodes in goats by turmeric leaves in alcoholic extracts (100%) than aqueous extract (92%). The overall objective of the study was to investigate the applicability of Turmeric powder as a natural antiseptic litter amendment to diminish microbial populations, ammonia emission rates by antimicrobial effects and wiping out conditions that favor microbes such as pH and moisture to increase the quality of broiler production with comprehensive green alternative.

MATERIAL AND METHODOLOGY

A representative broiler litter sample (±2 kg) was obtained from the broiler unit of the Faculty of Agriculture, University of Ruhuna, Kamburupitiya Sri Lanka, in black poly bag, sealed and well mixed. Turmeric powder available in local market was used to mix with litter (w/w) at 5 different levels; 0%, 1%, 3%, 5% and 8% (Figure 1). After mixing, 150 g of mixed litter was placed in container for each level as 4 replicated samples (5 X 4) and incubated at 30 °C for 5h and analyzed for Total Plate Count (TPC) (Scott et al., 1998) (ISO Standard procedure), Yeast and Mold count (YMC) (Obire et al., 2008) (ISO Standard procedure), total Nematode Count (NC), pH, moisture % and litter ammonia emission rate (Moore et al., 1996) (ISO Standard procedure). The TPC and YMC were determined by using microbial cultures on PCA and PDA media which prepared to ISO standard procedures respectively. Colonies were counted using the colony counter to determine TPC and YMC.

McMaster Worm Egg Counting Slide (Vet Lab Supplies, United Kingdom) and the ISO Standard procedure which described by Vadlejšch et al. (2011) was used to determine NC. Ammonia emissions were determined as described by Moore et al. (1996) (ISO Standard procedure), with modifications and determined the emission as milligrams of NH₃ emitted /kilogram of fresh litter/hour. Complete randomize design (ANOVA) was used with 4 replicates. Data were analyzed using Minitab 17 (2013).

RESULTS AND DISCUSSION

Jingrang et al., (2003) reported that total aerobic bacteria in poultry litter were detected by culture at 10⁹ CFU.g⁻¹ (colony forming units per gram). Majority are gram-positive, and often represented by the *coryneform* bacteria or *Staphylococcus* spp. Fungi and moulds are commonly present (Gaiero, 2014). Dominant genera are *Aspergillus*, *Fusarium*, *Penicillium*, *Mucor*, *Scopulariopsis*, and *Onychocola*. Pathogenic strains like *E.*

coli O157:H7 and *Salmonella*, mostly absent. *E. coli* and *Enterococci* are both found in relatively high in litter (Gaiero, 2014).

Brooks et al. (2010) concluded that around 90% of cultured aerobic bacteria in broiler houses were *staphylococci*.

In this experiment a very significant $p < 0.05$ removal of total bacteria and YMC were found after treatment with different level of application of TM powder (Table 1). The reduction of total bacteria was 20%, 46%, 95% and 96% for 1%, 3%, 5% and 8% applications of TM powder respectively (Figure 1d). The significant reduction of YMC was 34, 41, 55 and 65% from control (Figure 1e). Nematode count reduction $p < 0.05$ was 22, 45, 62 and 70% (Figure 1f). Considering large scale poultry houses, this kind of microbial reduction may help to increase quality of produce which can declined by contact dermatitis problems like foot pad dermatitis, hock burn

and breast blisters. Besides, the quality of chicken meat is now of major importance, since meat is usually consumed as cuts or as processed goods moderately than as whole carcasses (Haščik et al., 2015), these problems largely affect meat weight, meat quality and also animal welfare. Unlike synthetic litter amendments with acidifiers such as alum, sodium bisulfate, calcium sulfate, magnesium chloride (Pokharel, 2010), turmeric powder is a 100% natural produce and this green strategy may result fruitful outcomes to the industry as an antiseptic.

Effect of turmeric at different level of applications with poultry litter for NH_3 emission, moisture % and pH values are shown in Table 1. The pH of all application levels were significantly different with the control. Increasing the level of application of TM shows a significant reduction of pH values from 0.1, 2, 3 and 3% than control (Figure 1a). All TM levels have significant $p < 0.05$ increase of moisture and the 3% level has the lowest increase (Figure 1b).

Table 1 Effect of turmeric at different levels of application with broiler litter for NH_3 emission, moisture%, pH values microbial properties. Values with different letters are significantly different ($p < 0.05$), (↑: Percentage increase and ↓: % decrease than control).

| Parameter | Level of Turmeric application | | | | |
|-------------------|-------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| | 0% | 1% | 3% | 5% | 8% |
| (a) pH | 9.06a ± 0.01 | 8.97b ± 0.01 (↓1%) | 8.81c ± 0.01 (↓2.75%) | 8.73d ± 0.01 (↓3.6%) | 8.75c ± 0 (↓3.4%) |
| (b) Moisture | 51.34e ± 0 | 54.54b ± 0.05 (↑6%) | 51.74d ± 0.02 (↑0.7%) | 61.26a ± 0.01 (↑19%) | 51.94c ± 0.02 (↑1.2%) |
| (c) NH_3 | 0.68a ± 0.27 | 0.24b ± 0 (↓64%) | 0.21b ± 0.01 (↓68%) | 0.18bc ± 0.02 (↓73%) | 0.1c ± 0.05 (↓84%) |
| (d) TPC | 5.75×10^4 a ± 0 | 4.58×10^4 b ± 0 (↓20%) | 3.11×10^4 c ± 0 (↓46%) | 2.45×10^3 d ± 0 (↓95%) | 2.25×10^3 e ± 0 (↓96%) |
| (e) YMC | 4.53×10^4 a ± 0 | 2.99×10^4 b ± 0 (↓34%) | 2.64×10^4 c ± 0 (↓41%) | 2.04×10^4 d ± 0 (↓55%) | 1.57×10^4 e ± 0 (↓65%) |
| (f) NEM | 400a ± 36.9 | 333.5b ± 21.3 (↓22%) | 216.75c ± 21.3 (↓45%) | 150d ± 0 (↓62%) | 116.5e ± 21.3 (↓70%) |

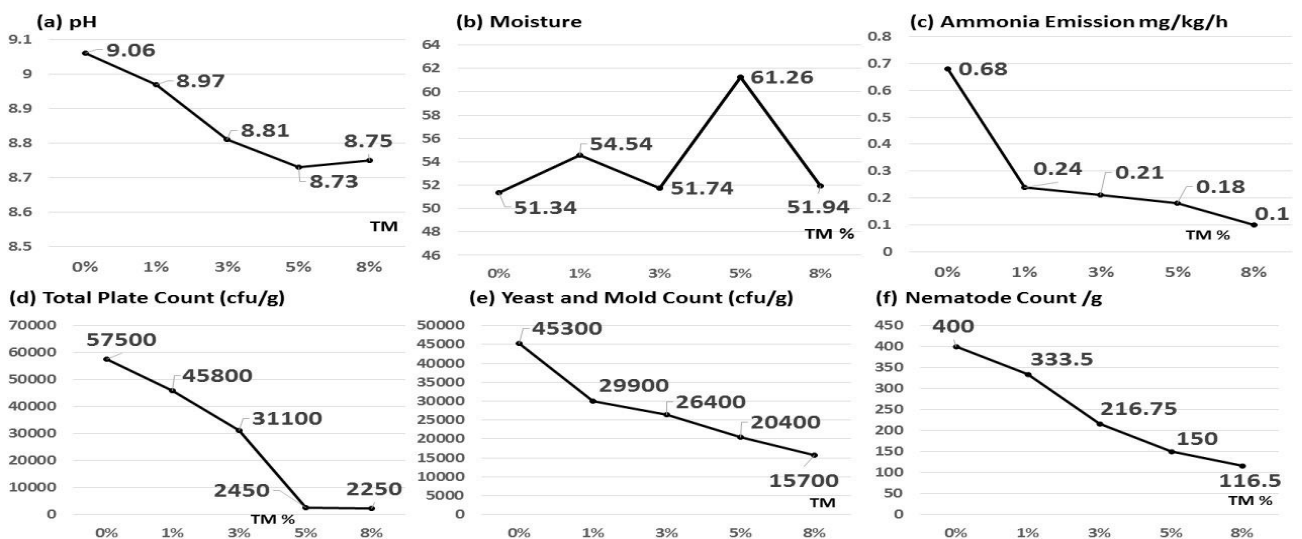


Figure 1 Effect of turmeric at different levels of application with broiler litter (a) pH (b) moisture% (c) NH_3 emission, (d)TPC (e)YMC (f) NC.

Practically lowering of moisture in a litter may cause lowering of NH_3 production (Pokharel, 2010). The emission of NH_3 is lowered with the increase of turmeric levels significantly $p < 0.05$ by 64, 68, 73 and 84% respectively (Figure 1c) and seems the increase of moisture did not affect the microbial count reduction.

Bad litter management conditions such as high moisture and pH levels increase the incidence of footpad dermatitis, hock burning damage and breast blisters which have become serious welfare problems in the industry. These problems primarily affect the surface of the footpad, hock joint and in severe cases extends to breast area and reduces meat quality. Birds accompanied with harsh lesions show slower weight gain and reluctance to move as they are obviously lame and experience pain-induced decline in desire for food (Nagaraj, 2006). Nagaraj (2006) concluded that the presence of ammonia or other chemical substances in litter may play a role in the further development of lesions but does not appear to cause it straightly and lesions enhance in severity as litter moisture increases. Moreover, dietary factors have direct influence on litter qualities. Increased salt diets may increase the water intake of birds and increase the litter moisture content via increased excreta. Some animal owners use higher dietary crude protein levels in diets to get higher growth performance to maximize the profits and eventually increase the nutrient content of litter which favors microbial growth. Hence ultimately these conditions may lead to bad litter quality and problems assorted with birds from increased NH_3 and moisture. Moreover, maintaining litter quality especially in broiler industry is a must to overcome these problems by using litter amendments.

Rothrock et al. (2008) evaluated the effect of alum on the microbial population in litter and concluded that the application of alum shifts the microbial population from bacterially to fungal dominated populations by making litter more acidic. Ammonia emissions depend on how much of ammonia nitrogen in solution counters to generate Ammonia against ionized ammonium (NH_4^+), which nonvolatile and dropping pH in litter can decrease the NH_3 emission by leading the equilibrium among NH_3 and NH_4^+ on the way to the NH_4^+ ions. Pope and Cherry (2000) concluded that sodium bisulfate is highly effective in reducing the ammonia, pH and *E. coli* in commercial facilities. However, Gholap (2012) concluded that the effects of acidified clay and sodium bisulfate on litter characteristics were ineffective in maintaining low ammonia levels after second week of application. Sodium bisulfate was more effective in reducing litter pH compared to acidified clay. Neither of the litter treatments was ineffective in reducing the bacterial counts of litter. Since all these amendments are synthetic, it is better to switch on to environmental friendly low cost alternatives.

Witkowska and Sowińska (2013) concluded that fogging of poultry houses with aqueous solutions of peppermint and thyme oils effectively reduced bacterial contamination in broiler houses. During their experiment, total counts of mesophilic bacteria in barns fogged with peppermint and thyme oils were lower than control. Both oils were effective in reducing bacterial counts, though thyme oil was more effective in lowering coliform bacteria, whereas peppermint oil had a higher inhibitory

effect on *staphylococci* proliferation. Moreover, Inouye et al. (2001, 2003) observed the inhibited growth of selected bacteria and fungi under laboratory conditions when treated with essential oils in vapor and liquid form. Therefore, use of natural antiseptics to reduce litter bacterial counts seems to be possible in various ways. Effect of turmeric at different levels of application with broiler litter was further shown graphically in Figure 1.

Application of turmeric powder to broiler litters is more effective to reduce microbial counts and NH_3 emission with a low operational cost compared to other synthetic litter amendments. This strategy practically suits for small or large scale broiler meat producers to improve the hygiene and quality of their produce. As per demand of poultry meat for its paramount importance in ensuring food security and improving nutrition this strategy will reduce the post-harvest losses of industry. Use of turmeric as a litter amendment may provide a green alternative towards global warming and environmental pollution via reducing ammonia emission in poultry farms. Further researches in this topic is much needed to apply these techniques and strategies in large scale operations thus to maximize profits in the industry and reduce pollution.

CONCLUSION

The bacterial, fungal and nematode counts of broiler litter can be significantly reduced with application of turmeric powder 8% (w/w) as an amendment up to 96, 65 and 70% respectively. The pH values of treatments were significantly reduced but maximum reduction of 3% was seen in 5% (w/w) level. Moisture % was significantly increased than the control along treatments but it did not affect the microbial reduction. Ammonia emission within the treatments were significantly lowered by application of turmeric 8% (w/w) from 64 to 84% along treatments

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