

Full Length Research Paper

Impacts of litter type and pre-slaughter feed removal on crop bacterial community in broiler chicken

Moein Bozorgi and Keyvan Khukhan

Faculty of Agriculture, Islamic Azad University, P.O.Box 79085, Tehran, Iran.

Accepted 02 January, 2014

An experiment consisting of two trials was conducted to compare the frequency of occurrence for 8 fungi in six broiler litter materials and to evaluate the impact of litter type and preslaughter feed withdrawal (PFW) on crop bacterioflora of broiler chicken at processing plant. Litter types including rice husk (RH), shredded paper (SP), barley stalks (BS), cow dung (CD), wood shaving (WS) and a mixture of all five litters (MIX) were subjected to microbial decontamination prior to trials using 1 L formaldehyde (20% solution) per each 2 cubic feet and were kept in plastic bags for a period of one week. During the study (8-weeks), a total of 273 samples were taken from various litters at biweekly intervals and examined to monitor the presence of eight fungi species in various litters. At 56d, feeders have been removed from the pens at 0, 2, 4 and 6 h prior to slaughtered birds. Various litters showed significant difference concerning total fungal contamination ($P < 0.05$). The general frequency of eight fungi species studied was significantly differed for litters of concern ($P < 0.01$). The maximum and minimum frequencies were observed for *Aspergillus sp.* and *Fusarium sp.*, respectively. The crop bacterioflora was significantly affected by duration of preslaughter feed withdrawal. The crop bacterioflora of the birds was the normal flora up to 4 h of PFW but afterward *E. coli* was appeared and started to colonize the crop. It was concluded that various litters have significant differences regarding their potential to host different fungal community and count. Shredded paper has the potential for enhancing a fungal community rich with *Aspergillus*, a common hazardous fungus. To prevent the crop of broiler from colonization by feed-borne hazardous bacteria prior to reach at processing plant, the PFW must not exceed 4 h.

Key words: Broiler chicken, crop bacterioflora, litter, fungi, preslaughter feed withdrawal.

INTRODUCTION

One prerequisite for efficient broiler production is suitable litter concerning its chemical and physical characteristics as well as microbial count. Several fungi mold and yeast species contribute in litter microflora. These myco-related organisms impose three major unpleasant impacts on bird's life through uric acid decomposition and ammonia volatilization from litter (Bacharach, 1957; Schefferle, 1965; Burnett and Dondero, 1969 and Vogels and

Vander Drift, 1976), Jones FT, Hagler WM (1982), pathogenic effects on live birds and production of mycotoxins and chemicals with adverse consequences for bird's health (Arafa et al., 1979 and Arafa et al., 1982). Many investigations have described the mycology of poultry litter (Lovett et al., 1971; Bacon and Burdick, 1977 and Timothy et al., 1995). There is no conformity on the number of myco species involved in poultry litter and their population count as they are quite diverged based on litter characteristics and poultry house climate (Thi So et al., 1978; Carter et al., Chen et al. (1979), Chen et al. (1979), 1979, Chen et al. (1979); Malone et al., 1990; Lein et al., 1992).

Preslaughter feed withdrawal (PFW) has become a

*Corresponding author. E-mail: Borormoe111@yahoo.co.uk

routine practice in commercial broiler production in many countries (Hinton et al., 2000). To deny broilers form accessing feed and water ahead of cooping has an obvious impact on voiding of bird's feces and to reduce the risk of cross contamination of external parts during handling, transportation and processing of broilers (Rigby and Pettet, 1980, 1981; Papa, 1991; Northcutt et al., 1997 and Khosravina, et al., 2002). At the same time, such a starvation positively affects colonization of crop by the most hazardous feed-borne pathogens (Soneyenbos et al., 1982 and Corrior et al., 1990; Rameriz et al., 1997). Many studies showed that crop is several times more susceptible to be colonized by pathogens than cloaca, ceca, and intestine (Hargis et al., 1995; Ramirez et al., 1997 and Corrior et al., 1999), and also more prone to rupture during processing than any other potentially contaminant part (Humphery et al., 1993 and Ramirez et al., 1997). It has been revealed that the undesirable impacts of pre-slaughter feed withdrawal are associated with prolonged starvation of birds (Byrd et al., 1998). Experimental results have clearly suggested that time is a vital issue in embracing of preslaughter feed removal (Rameriz et al., 1997).

Meat-type poultry production based on dirt floor rearing compels large quantities of litter materials. Shavings from softwoods have historically been the bedding materials of choice in the most parts of the world. Due to growing demand and development of further processing methods, the availability of wood shavings has ever more been a problem for poultry industry promoting search for alternative litter sources. The fairly inexpensive and locally available by-products such as rice husk, shredded paper, barley stalks, cow dung (Khosravina and Abassi, 2006), leaves, corn cobs (Khosravina, 2006), dried rumen contents, corn-based plant by products (Khosravina and Azarfar, 2006) and Khakshir hay (Khosravina, 2006) were found to have substantial worth as alternative litters. However, the studies on microbial contamination of such substitute litters with special reference to their impact on preslaughter feed removal are scanty.

This study consisting two trials was undertaken to compare frequency of presence for eight naturally-occurred fungi species in the six previously tried types of local and cheap alternative bedding materials (Khosravina and Abassi, 2006) and to evaluate the effect of litter kind and preslaughter feed withdrawal on crop bacterioflora in broiler chicken at processing plant.

MATERIALS AND METHODS

Broilers and housing

Four hundred fifty day-old straight run Arian chicks were provided from a commercial hatchery and randomly allocated to 30 pens (at density of 0.09 m²/bird) in a partially controlled, dirt floor broiler house. Each pen was equipped with one bell waterer and one tube feeder. A 23:1 h light: dark lighting regimen was used through out the experiment. Corn and soybean meal based starter (22% CP, 3100 kcal ME/kg, 1 - 14 d), grower (20%CP, 3100 kcal ME/kg, 15 -

42 d) and finisher (18.2%CP, 3100 kcal ME/kg, 43 - 56 d) diets as well as water were provided *ad libitum*. Five litter materials viz. wood shavings (WS), cow dung (CD), shredded paper (SP), barley stalks (BS), rice husks (RH) and a mixture of identical proportion from all materials (Mix) were subjected to formaldehyde decontamination (1 L 38% commercial solution per 0.054 m³ in plastic bags over a period of one week prior to trials) and introduced into 1 × 2 m pens at an average dept of 5 cm. No litter was added or removed during 56 days of the experiment.

Treatments and data collection

Trial 1: During the study, a total of 273 litter samples were taken at biweekly intervals and monitored for presence of eight fungi species. At each evaluation period, 100 g of well mixed litter from various parts of each pen were placed in a sterile container and transferred to the laboratory. Samples were dried at 85°C over night and blended properly. A random sub sample containing 1 g of well-blended litter was distributed on Potateo-Dextroze-Agar (PDA) cultures media (Dhingra and Sinclair, 1994) and incubated at 23.5°C for 24 h. This is followed by growth of each fungus on PDA media. Subculture preparations were practiced by single sporing and hyphal tip on water agar (WA) media to purify the fungi. Purified cultures were identified based on Nelson et al., (1983) and Ellis (1990). A mercury thermometer was used for temperature measurements. Litter pH testing consisted of weighing 50 g of litter from the top surface of litter and placing in a sterile cup, where it was combined with 100 ml of sterile distilled water. The litter and water solution were mixed thoroughly and allowed to stand for 1 - 2 min. A pH reading (pH tester 1, OAKTON, Model #35624-00) was taken and recorded. Moisture was measured based on weight loss of the 50 g samples heated in oven at 105°C for 24 h.

Trial 2: At 56 days, birds from each pen were randomly divided into 4 groups and each group deprived to access feed at 0, 2, 4 and 6 h prior to slaughter. By slaughtering the birds, crop contents were removed immediately under hygienic circumstances and they were taken to microbiology lab. For each sample, 1 g of crop contents was diluted in 9 ml physiological serum. Then, 200 µL from diluted sample was poured (streak method) on nutrient agar media and incubated at 37°C for 24 h. Finally, microbial population were counted based on colonies count and dilutions made.

Statistical analysis

The General Linear Models procedure of SAS/STAT software program (SAS Institutes, 1998) was used to analyze the data from each trail separately. In the trial 1, analysis of frequency and *chi* squared test (PROC FREQ) was applied for myco-related data to determine the significant difference between frequencies of occurrence for fungi species in a particular litter. Considering all myco data, two-way classification analysis was also adopted for the fixed effects of litter type and fungus species. In trail 2, bacteria contamination data was arranged in a 4×5 factorial arrangement and subjected to ANOVA for fixed effects of litter type, preslaughter fasting time and their interaction. In all ANOVA applications, means were separated by Duncan's Multiple Range and significance was accepted at P < 0.05.

RESULTS

Trial 1

The contingency table of fungus × litter for frequency

Table 1. Contingency table of fungus × litter for frequency analysis of 273 samples of litter.

| Fungi (sp.) | Statistics | Litters* | | | | | | Total** |
|--------------------|-----------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|------------------|
| | | RH | SP | BS | CD | WS | MIX | Num. / freq. |
| Mucor sp. | Frequency | 14 | 9 | 3 | 7 | 5 | 3 | 41 ^a |
| | Cell chi square | 7.56 | 0.1 | 2.46 | 0.001 | 0.08 | 1.73 | 15.02 |
| Pencillium sp. | Frequency | 12 | 8 | 12 | 17 | 6 | 7 | 62 ^a |
| | Cell chi square | 0.31 | 1.48 | 0.11 | 4.11 | 0.8 | 0.67 | 22.71 |
| Aspergillus sp. | Frequency | 10 | 9 | 4 | 10 | 11 | 20 | 64 ^a |
| | Cell chi square | 0.03 | 0.06 | 4.67 | 0.06 | 0.49 | 10.47 | 23.44 |
| Geothrichum sp. | Frequency | 5 | 18 | 8 | 9 | 8 | 5 | 53 ^a |
| | Cell chi square | 1.6 | 5.4 | 0.18 | 0.000 | 0.05 | 1.22 | 19.41 |
| Monobelpharios sp. | Frequency | 2 | 0 | 5 | 0 | 1 | 4 | 12 ^{cb} |
| | Cell chi square | 0.00 | 2.37 | 3.96 | 2.02 | 0.27 | 2.51 | 4.4 |
| Alternaria sp. | Frequency | 1 | 0 | 0 | 1 | 0 | 1 | 3 ^c |
| | Cell chi square | 0.52 | 0.59 | 0.53 | 0.48 | 0.42 | 0.63 | 1.1 |
| Rhizopus sp. | Frequency | 1 | 10 | 15 | 2 | 7 | 2 | 37 ^{ab} |
| | Cell chi square | 4.26 | 0.98 | 11.1 | 2.88 | 0.66 | 2.4 | 13.55 |
| Fusarium sp. | Frequency | 0 | 0 | 1 | 0 | 0 | 0 | 1 ^c |
| | Cell chi square | 0.16 | 0.19 | 3.86 | 0.16 | 0.14 | 0.15 | 0.37 |
| *** | | | | | | | | |
| Total | Number | 45 ^(b) | 54 ^(a) | 48 ^(b) | 46 ^(b) | 38 ^(bc) | 42 ^(b) | 273 |
| | Frequency | 16.5 | 19.8 | 17.6 | 16.8 | 13.9 | 15.4 | 100 |

* RH = rice husks, SP = shredded paper, BS = Barley stalks, CD = cow dung, WS = wood shavings, and Mix = proportional mix of all five litters.

***Frequency of each fungus over pooled litter data.

Overall frequency of fungi occurrence in each litter.

^{a-c} Means with different superscripts within the last column differ significantly ($P < 0.05$). (^{a-}

^c) Means with different superscripts within the last row differ significantly ($P < 0.05$).

analysis of 273 litter samples and results for chi squared test for frequency of occurrence of each fungus in a particular litter in terms of cell chi squared are presented in the Table 1. There was a significant frequency of *Mucor sp.*, *Pencillium sp.*, *Geothrichum sp.*, *Rhizopus sp.* in RH, CD, SP and BS litters, respectively, compared to other fungi species ($P < 0.05$). Frequency of occurrence for *Aspergillus sp.* was significantly greater in mix litter compared with other litters ($P < 0.01$). Irrespective of litter type, the frequency of fungi species in 273 litter samples was significantly diverged with max and min occurrences for *Aspergillus sp.* and *Fusarium sp.*, respectively (23.44 *vr* 0.37%; Table 1). Frequency analysis for fungus contamination of litters using pooled data over fungi species revealed a significant difference of fungus occurrence in various litters concerned ($P < 0.05$). In general, SP and WS hosted the max and min fungi population over the 56 days of trail (19.8 *vr* 13.9 per cent of all fungi observations), respectively.

The mean surface temperature and moisture per cent in a negative association were significantly differed for six types of litter at 56 days ($P < 0.05$). No significant effect of litter type was observed with respect to pH value at the same age ($P > 0.05$; Figure 1). The total fungi frequency in various litters was inconsistently associated with litter characteristics. The non significant coefficients of correlation among this variable and litter surface temperature,

moisture per cent and pH, were 0.794, -0.235 and -0.176, respectively. In detail study of association between each fungus species and litter characteristics, there was only a significant negative correlation (-0.827) between frequency of *Alternaria sp.* and litter temperature.

Trial 2

The mean crop bacterial count for a certain type of litter was not significantly differed at a specific preslaughter fasting time ($P > 0.05$; data presented in the body of Table 2). The pooled data over preslaughter fasting time were not also significantly affected by litter type ($P > 0.05$; the last column in Table 2). Despite of an inconsistent trend of enhancement in microbial count of crop contents, there was not a significant difference for plate counts at various preslaughter feed removals for a particular litter. However, analysis of plate counts for PFW over various pooled litter data revealed a significant impact of PFW duration on mean crop bacterioflora ($P < 0.05$; the last row in Table 2). Increasing PFW time duration caused a clear cut trend of enhancement in bacterial count of crop contents. The crop bacterioflora in birds subjected to 0, 2 and 4 h PFW were normal but afterwards crop colonization was initiated by *E. coli* as a participant in normal flora but an opportunist and potentially hazardous coli form

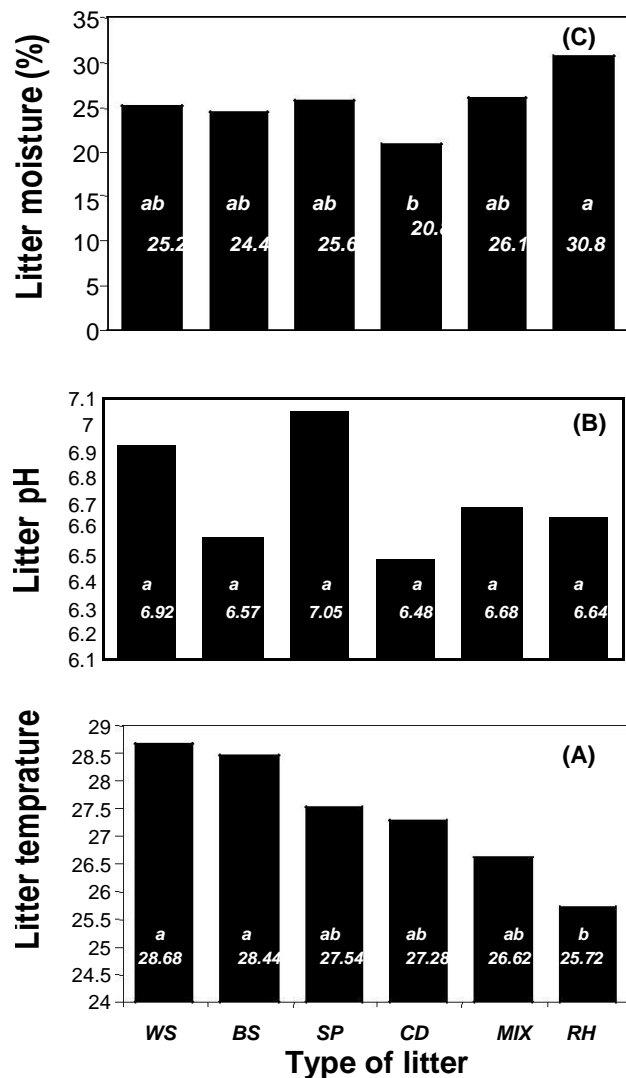


Figure 1. The trend of change in litter temperature at 2 cm depth (A), litter pH (B) and Litter moisture percent (C) at 56 day (WS = wood shavings, CD = cow dung, SP=shredded paper, RH = rice husks, BS = barley stalks and Mix = proportional mix of all five litters).

bacterium.

DISCUSSION

The eight fungi species monitored in this study are mainly among those, which have been reported by many researches. Vogels and Vander Drift (1976) listed 22 fungi species monitored in poultry litter as a few of fungi capable to degrade uric acid in poultry litter. Two species of concern in the current study, *Alternaria sp.* and *Fusarium sp.*, are not among the litter mycoflora of their study. Lovett et al. (1971) isolated 17 fungi species including *Penicillium sp.*, *Scopulariopsis sp.* and *Candida sp.* from poultry litter. They observed *Penicillium sp.* the

dominant fungus in litter until it became alkaline, and then *Scopulariopsis sp.* became dominant. Bacon and Burdick (1977) found 18 species of fungi capable to grow in broiler litter, while Thi So et al. (1978) isolated 17 fungi species from various hard wood bark residues and soft wood shaving litters.

Many attempts have been made to compare different litter materials for fungi counts and diversity. Allison and Jordan (1973) and Merka et al. (1975) expressed caution regarding the use of bark residuals as litter because of possible occurrence of mycoses and production of mycotoxins due to presence of molds in this material. Veloso et al. (1974), Arafa et al. (1979), Lien et al. (1992) in a fair concord with the present study reported diverged fungal species and counts for various broiler litter materials. In the contrary, Bilgili et al. (1999) reported no significant difference in molds count of sand and pins litters (4.93 vs 5.08 log 10 CFU/g). However, wood fibre-based litter materials have been previously documented to contain relatively high fungal populations (Lein et al., 1992; Malone et al., 1990; Thi So et al., 1978; Carter et al., 1979). In all studies, the diverged potential of litters to host various fungi species is attributed to various litter characteristics and especially to moisture level of litter at chick placement. Significant differences of fungus occurrence in various litters concerned in the current study are in fair concord with the relevant literature as they reveal that litter source is an imperative factor in fungi diversity and population in poultry house.

The hosting capacity of a certain litter is obviously differ from others due to different physical and chemical properties at the early days of litter use. As bird's age progresses, increasing decomposition of litters that coincide with accumulation of fecal materials bring about resemblance in features of all the litters. However, the experimental results showed that even at late ages the altered litters still have distinct characteristics (Khosravinia, 2006; Khosravinia and Azarfar, 2006), which could validate their diverged mycoflora. Minor differences in litter attributes such as temperature, caking ability, pH and moisture percent offer different circumstances to various fungi. The litter sources at late ages are still distinct in micro climates, which could be preferred either by certain or a narrow range of fungal species. In this study, six litter sources had significant differences in temperature and moisture per cent at day 56 of the experiment (Figure 1). This could cause the diverged capacities of various litters to host different ranges and populations of fungi, even though there was no significant correlation among these litter characteristics and fungus count. It also must be notified that such correlations, which have been computed based on few figures, are not reliable.

Contamination of raw poultry products by feed-borne pathogens is a serious problem all over the globe. Re-sults from several studies show improper adoption of PFW is one of the major causes for such a risk through enhancing the crop colonization by foregoing feed-borne pathogens. It

Table 2. Effect of litter type and pre-slaughter feed withdrawal time (PFW) duration (hr.) on microbial count of crop contents (log 10 CFU/ gr) at processing plant.

| Litter * | Pre-slaughter feed withdrawal time duration (h) | | | | Polled over time of PSFD |
|-------------------------|---|------------------------------|------------------------------|------------------------------|-----------------------------|
| | 0 | 2 | 4 | 6 | |
| RH | 8.211 ± 0.954 | 7.940 ± 0.413 | 8.761 ± 0.067 | 8.243 ± 0.325 | 8.293 ^a ± 0.231 |
| SP | 8.381 ± 0.395 | 8.444 ± 0.105 | 8.534 ± 0.239 | 8.434 ± 0.205 | 8.448 ^a ± 0.124 |
| BS | 8.962 ± 0.154 | 8.035 ± 0.675 | 8.645 ± 0.092 | 8.547 ± 0.146 | 8.547 ^a ± 0.181 |
| CD | 6.628 ± 1.007 | 8.431 ± 0.140 | 8.267 ± 0.269 | 9.016 ± 0.442 | 8.085 ^a ± 0.331 |
| WS | 6.236 ± 1.252 | 9.064 ± 0.581 | 8.872 ± 0.070 | 8.397 ± 0.262 | 7.854 ^a ± 0.427 |
| MIX | 6.627 ± 1.201 | 8.556 ± 0.227 | 8.805 ± 0.059 | 8.491 ± 0.205 | 8.120 ^a ± 0.347 |
| Pooled over litter type | 7.483 ^(b) ± 0.395 | 8.244 ^(a) ± 0.162 | 8.647 ^(a) ± 0.070 | 8.825 ^(a) ± 0.114 | |

RH = rice husks, SP = shredded paper, BS = Barley stalks, CD = cow dung, WS = wood shavings, and Mix = proportional mix of all five litters. ^a Means with different superscripts within the last column differ significantly ($P < 0.05$).

^(a-c) Means with different superscripts within the last row differ significantly ($P < 0.05$).

pathogens. It has been reported that PFW facilitates the emptying of the bird's gastrointestinal tract before transportation to processing plants. It therefore decreases the amount of feces that the bird excretes during transportation (Rigby and Pettet, 1980, 1981; Papa, 1991) and in turn could reduce cross contamination of external parts of birds by ingesta. Furthermore, emptying birds from fecal materials could reduce pre-mortem fecal excretion during stunning and bleeding operations in processing plant (Papa and Dickens, 1989) and reduces fecal cross contamination during evisceration operations (Wabeck, 1972). However, improper PFW may cause excessive weight loss and muscle glycogen depletion and of greater importance increases feed-borne pathogens in the crop of birds.

Increased incidence of feed-borne pathogens in crop contents is associated with tendency of the birds to consume contaminated rearing house litter during PFW (Barnhart et al., 1999; Corrior et al., 1999). While various bedding materials have diverged potential to host various type and counts of micro organisms, it is expected that the litter source could influence the crop contamination level. The results from the current study revealed that type of litter has no significant impact on microbial counts of the crop contents (Table 2). As it has been discussed above, in correspondence with bird's age, fecal materials accumulate on the floor and reduce the proportion of bedding material in the litter. Furthermore, increasing microbial population decomposes the litters and brings all litter types toward resemblance. This common trend constricts the broad diversity on litter characteristics at the early ages of the birds to a narrow uniformity toward the end of raising period. It seems that in contrast to fungi, such a narrow diversity in litters could not be a major reason for various bacteria to inhabit in different litters. Therefore, the birds reared on various litters are exposed to bedding materials with similar microbial population during PFW. While feed deprived birds are scavenging on various litters, this could not be a source

of different crop microbial count at a same PFW time duration.

However, duration of fasting period could influence the magnitude of litter foraged. The extent of litter particles picked up by bird could be a function of foraging time. The results presented in Table 2 reveal that the microbial count for the crop contents of the birds which has been slaughtered instantly after feed removal (0 PFW time) was constantly lower than longer PFW periods. Analysis of variance for fixed effect of PFW showed a significant influence of increasing PFW periods on microbial counts of crop contents.

The results of the current study with respect to appearance of *E. coli* in 6 h PFW, suggests that the PFW duration must not exceed 4 h. Byrd et al. (1998) in fair accordance with the current study observed no pathogen positive crop content samples by 2 and 4 h feed deprivation. In 5 h PFW, occurrence of *Campylobacter* was started and reached to maximum in 8 h. In contrast to the results obtained in this study, Rameriz et al. (1997) isolated *Salmonella* from the crops of broilers following 8 h of FW in a commercial rearing house. In attempt to bear out the mechanism of such crop colonization, many researchers showed that in full-fed broilers, fermentation of feed in the crop creates conditions that inhibit growth of the pathogenic micro organisms. As the crop empties during PFW, a decrease in anti-Entrobactericase activity occurs. The declined Entrobactericase activity in crop is related to decrease in lactic acid bacteria (Hinton et al., 1999), decrease in the concentration of acetic, propionic and lactic acid in the crop and increase in the pH of its contents (Barnhart et al., 1999; Corrior et al., 1999; Rameriz et al., 1997; Humphery et al., 1993).

Most of the reports emphasize that crop was several times more likely to be contaminated with *Salmonella* than the ceca (Corrior et al., 1999; Ramirez et al., 1997; Hargis et al., 1995). Besides crop is susceptible to rupture more frequently than the ceca or intestine during commercial processing (Humphery et al., 1993 and

Ramirez et al., 1997). Therefore, the importance of human food safety in relation with feed-borne pathogens originated from raw poultry materials urges for more emphasis on crop contamination, especially, in association with PFW.

From the results of this study it could be concluded that various litters have significant difference regarding their potential for total myco contamination. Shredded paper has a potential to host *Aspergillus* as a hazardous fungus. Preslaughter feed removal time is of more importance than litter kind with respect to its impact on crop bacterioflora at processing plant. The adoption of desirable duration of PFW time could significantly reduce the risk of pathogens occurrence in crop and consequently their transmission to raw poultry products. To avoid crop colonization by feed-borne pathogens the PFW must not exceed 4 h.

REFERENCES

- Allison RC, Jordan HC (1973). Criteria and evaluation of hardwood bark as a poultry litter. *For. Prod. J.*, 23: 46-48.
- Arafa AS, Miles RD, Harms RH, Chen TC, Dilworth BC, Day EJ, Difate BC, Rosomer GL, Shaver KJ (1982). The relationship between yeast and mold populations in litter of broilers fed dietary fungistatic compounds. *Poult. Sci.*, 61: 46-51.
- Arafa AS, Miles RD, Harms RH, Chen TC, Dilworth BC, Day EJ, Rosomer GL, Difate BC, Sha Ver KJ (1979). Fungistatic compounds in broiler production. 4. Microbial and physical characteristics of litter. *Poult. Sci.*, 58: 1462.
- Association of Official Analytical Chemists. Official methods of analysis. 12th ed. APAC, Washington, DC. (1975).
- Bacharach U (1957). The aerobic breakdown of uric acid by certain pseudomonads. *J. Gen. Microbiol.*, 17: 1.
- Bacon CW, Burdick D (1977). Growth of fungi in broiler house. *Poult. Sci.*, 56: 653.
- Barnhart ET, Sarlin LL, Caldwell DJ, Byrd JA, Corrier DE, Hargis BM (1999). Evaluation of potential disinfectants for preslaughter broiler crop decontamination. *Poult. Sci.*, 78: 32-37.
- Bilgili SF, Montenegro GI, Hess JB, Eckman MK (1999). Sand as litter for rearing broiler chickens. *J. Appl. Poult. Res.*, 8: 345-351.
- Burnett WE, Dondero NC (1969). Microbial and chemical change in poultry manure associated with decomposition and odor generation. *Animal Waste Management, Cornell University Conference on Agricultural Waste Management*, p. 271.
- Byrd JA, Corrier DE, Hume ME, Bailey RH, Stanker LH, Hargis BM (1998). Incidence of *Campylobacter* in crops of preharvest market-age broiler chickens. *Poult. Sc.*, 77: 1303-1305.
- Carter TA, Allison RC, Mills WC, West JR (1979). Wood chips for poultry litter. *Poult. Sci.*, 58: 994-997.
- Chen TC, Dilworth BC, Day EJ, Arafa AS, Miles RD, Harnes RH, Rosomer GL, Difate VG, Shaver KJ (1979). Fungistatic compounds in broiler production. 2. Effect of feed microflora. *Poult. Sci.*, 58: 1451-1455.
- Corrier DE, Byrd JA, Harges BM, Hume ME, Bailey RH, Stanker LH (1999). Presence of *Salmonella* in the crop and ceca of broiler chickens before and after preslaughter feed withdrawal. *Poult. Sci.* 78: 45-49.
- Corrier DE, Hinton A, Ziprin RL, DeLoach JR (1990). Effect of dietary lactose on *Salmonella* colonization of market age broiler chicken. *Avian Dis.*, 34: 668-676.
- Dhingra, OD, Sinclair JB (1994). Basic plant pathology methods. CRC. Press Ins. p. 434
- Ellis MB (1991). Dematiaceous hyphomycetes. CMI. Kew, Surrey, England. p. 608.
- Hargis BM, Caldwell DJ, Brewer RL, Corrier DE and DeLoach JR. Evaluation of chicken crop as a source of *Salmonella* contamination for broiler carcasses. *Poult. Sci.*, 74: 1548-1552. 1995.
- Hinton AJR, Buhr RJ, Ingram KD (2000). Physical, chemical, and microbiological changes in the crop of broiler chickens subjected to incremental feed withdrawal. *Poult. Sci.*, 79: 212-218.
- Hinton AJR, Buher RJ, Hume ME, Ingram KD (1999). changes in the concentration of metabolic intermediates in the crop of broiler chickens subjected to incremental feed withdrawal. *Poult. Sci.*, 78: 27.
- Humphrey TJ, Baskerville A, Whitehead A, Rowe B, Henley A (1993). Influence of feeding patterns on the artificial infection of laying hens with *Salmonella* enteritidis phase type 4. *Veter. Records*, 132: 407-409.
- Jones FT, Hagler WM (1982). Observations on new and reused litter for growing broilers. *Poult. Sci.*, 62: 175-179.
- Khosravinia H (2006). Chopped hedge mustard (*Sisymbrium officinalis*) residues as litter material for broiler chicken under heat stress condition. *Indian J. Poult. Sci.*, 41: 42-48.
- Khosravinia H (2006). Effect of Oiling and Antimicrobial Spray of Litter on Performance of Broiler Chicken Reared on Leaves and Corn cob Bedding Materials under Heat Stress Condition. *Asian-Australasian J. Ani. Sci.*, 19: 35-42.
- Khosravinia H, Abassi M (2006). Performance of broiler chicken on different litter materials under heat stress conditions. *Indian J. Poult. Sci.*, 41: 49-53.
- Khosravinia H, Azarfar A (2006). Evaluation of wasted corn silage and dried rumen contents as alternative litter for broiler production. *Indian Vet. J.*, 83: 191-195.
- Khosravina H, Munegowda T, Devegowda G (2002). Effect of pre-slaughter feed withdrawal on contamination on broiler meat with feed-borne pathogens. *Indian J. Poult. Sci.*, 3: 211-214.
- Lien RJ, Conner DE, Bilgili SF (1992). The use of recycled paper chips as litter material for rearing broiler chickens. *Poultry Sci.*, 71: 81-87.
- Lovett J, Messer JW, Read RB (1971). The microflora of southern Ohio poultry litter. *Poult. Sci.*, 50: 746-51.
- Malone GW, Tilmon HD, Taylor RW (1990). Evaluation of Kenaf core for broiler litter. *Poult. Sci.* 69: 2064-2067.
- Merka WC, Denton J, Gardner FA (1975). Pine bark and hardwood shavings high in molds. *Poult. Digest*. 34: 403.
- Nelson PE, Toussoun TA, Marasas WFO (1983). *Fusarium* species an illustrated manual for identification. The Pennsylvania State University Press. University Park of London, p. 193
- Northcutt JK, Savage SI, Vest LR (1997). Relationship between feed withdrawal and viscera condition of broilers. *Poult. Sci.*, 76: 410-414.
- Papa CM (1991). Lower gut contents of broiler chickens withdrawn from feed and held in cages. *Poult. Sci.* 70: 375-380.
- Papa CM, Dickens JA (1989). Lower gut contents and defecatory responses of broilers chickens as affected by feed withdrawal and electrical treatment at slaughter. *Poult. Sci.*, 68: 1478-1484.
- Ramirez GA, Sarlin LL, Caldwell DJ, Yazek CR, Hume ME, Corrier DE, DeLoach JR (1997). Hargis BM. Effect of feed withdrawal on the incidence of *Salmonella* in the crops and ceca of market age broiler chickens. *Poult. Sci.*, 76: 654-656.
- Rigby CE, Pettit JR (1980). Changes in the *Salmonella* status of broiler chickens subjected to simulated shipping conditions. *Canadian J. Copm. Med.*, 44: 374-381.
- Rigby CE, Pettit JR (1981). Effects of feed withdrawal on the weight, fecal excretion and *Salmonella* status of broiler chickens. *Canadian J. Copm. Med.*, 45: 363-365.
- SAS Institute(1998). SAS/STAT® Guide for personal computers. Version 6.2 Edition. SAS Institute, Inc., Cary, NC.
- Schefferle HE (1965). The microflora of built up poultry litter. *J. Appl. Bacteriol.*, 28: 403-411.
- Soneyenbos GH, Soerjadi AS, Weinack OK (1982). Gastrointestinal colonization by *Salmonella* and pathogenic *Escherichia coli* in monoxenic and holoxenic chicks and poults. *Avian Dis.*, 26: 566-575.
- Thi So DT, Dick JW, Holleman KA, Labosky P (1978). Mold spore population in bark residues used as broiler litter. *Poult. Sci.*, 57: 870-874.
- Timothy KR, Pancorbo OC, Merka WC, Thompson SA, Cabrera ML, Barnhart HM (1995). Bacterial pathogens and indicators in poultry litter during re-utilization. *J. Appl. Poult. Res.*, 4: 366-373.

- Veloso JR, Hamilton PB, Parkhurst CR (1974). The use of formaldehyde flake as an antimicrobial agent in built up poultry litter. *Poult. Sci.*, 53: 78.
- Vogels GD, Vander Drift C (1976). Degradation of purines and pyrimidines by micro-organisms. *Bacteriol. Rev.*, 40: 403.
- Wabeck CJ (1972). Feed and water withdrawal time relationship to processing yield and potential fecal contamination of broilers. *Poult. Sci.* 51: 1119-1121.