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COMPARATIVE STUDY ON INDOOR AIR QUALITY BETWEEN CLOSED AND OPEN BROILER ENVIRONMENTS DURING WINTER IN EASTERN REGION, KSA

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SUMMARY

The current field study was applied on two available different broiler environments (closed and open houses) during winter season in two different localities, AlJuaymah (NE) and UmSahik (NW) to Al Dammam city. A total of 20500 and 6850 birds of Rose-308 and Cobb-500 breeds respectively were used to study the effect of different broiler environments on their indoor air quality and the microbial ecology of air and litter started day before baby chicks admission up till marketing. The indoor air parameters included (Ta.C°, RH % ,AV m/sec) , some gases (CO_2 and NH_3 ppm) and microbial load of air and litter (fungal and bacterial colony forming units, cfu counts/m^3 and cfu/ gm respectively).The results revealed the following:- During winter season the closed system seemed to be more suitable for brooding baby chicks regarding to controlled indoor Ta C°, RH % and AV m/sec, despite the expected gases accumulation for keeping warm environment and increased litter microbial load and air fungal load that represent risk factors for both birds and their keeper .The obvious effect of indoor air parameters (positive correlation except CO_2 showed negative one) and litter microclimate on microbial loads in both environments threw light on efforts must be done by owners and ever alerts to follow up , manage and alternate the indoor conditions for controlling indoor microbial niches , starting before chicks admission till marketing to keep indoor and outdoor livings health Open system characterized by significantly lowered indoor air parameters levels Vs closed system Indoor Ta .C° showed positive correlatio with litter f cfu only , While RH %, CO_2 an NH_3 were positively correlated with air and litt microbial load.

INTRODUCTION

The raising poultry in confinement houses dev oped from an economic need for high producti yield utilizing little space and the consequent concentration of their waste products and contaminants mainly gases (Jones et al ; 1984). The concentration of ammonia was differed between sites in the rate of release from the litter as well as the seasonal variations, where it was increased in winter and with age 12-45 ppm Vs summer 2-9 ppm that might be attributed to the lower ventilation rates (ConceiCao et al; 1989 and Redwine et al; 2002). Litter moisture, pH, temperature and ionized ammonia ($NH4^+$) contributed to NH_3 volatilization from litter surface, where the mechanically ventilated houses could be easily monitored than naturally ventilated because of its accumulation near the litter for floor-raised bird and near the air exhaust (Gates et al 2000;NAS, 2002 and Wheeler et al ; 2003). Airborne microorganisms might be liberated directly into the air (fungi, bacteria and viruses) and could transmit for long distances by way of ventilation system into the environment depending upon kinds of microbes, location and the environmental conditions (humidity, temperature) of the samples taken that in turn might affect the respiratory health of people living close to livestock (Theresa and Wathes, 1989 ; Al-Dagal and Daniel 1990; Hartung .1994 and Zucker et al 2000). Winter air in turkey confinement houses contained significantly higher concentration of some fungi and yeast species Vs summer air (Debey et al , 1995) . Ventilation is used to remove noxious gases including ammonia and carbon dioxide as well as moisture in building so altering the microbial ecology water damaged sites (Wayon , 2004 and Nevalnen and Seuri 2005) . Therefore, the current field study was carried out to throw light on the effect of different broiler environments on their indoor air quality including temperature ,relative humidity ,air velocity, some gases as NH_3 and CO_2 and the effects of these parameters on the microbial ecology (fungal and bacterial colony forming units) in air and litter.

MATERIALS AND METHODS

a) Site description:

The current field study was applied on two available different broiler environments (closed and open houses) during winter season in AlJuaym (NE) and UmSahik (NW) localities respectively to Dammam city,KSA

b) Procedure:

Total 6 and 5 available visits (weekly) were done in accordance started day before baby chicks admission up till marketing A total of 20500 and 6850 birds of Rose-308 and Cobb-500 breeds respectively started from day before baby chicks receiving up till marketing .The indoor air parameters were measured and recorded on field (Ta.C RH %) using digital thermo hygrometer and A (m/sec) using anemometer, some gases (CO_2 a

NH_3 ppm) using Kitagawa precision gas detectors (Komyo) pump and specific detecting tubes for each gas (NO .126 SF and NO 105 SD tubes respectively) according to(Lott et al;1998 and Bruzual et al ; 2000). Air microbial loads (f and b cfu counts/m≥) were estimated gravitationally by exposed open plates contained nutrient and sabaroud agar (2 plates from each media/ site/ visit) were located in six fixed sites represented all indoor air volume occupied the house for 15 minutes each (Sauter et al ;1981). The well defined labeled collected air sampled plated were kept in portable fridge (cooler) till back to the college lab. where they were incubated either at 37°C /24 hours (bacterial growth) or 24-37°C / 24-48 hours (fungal growth).The total colony forming units (cfu) were counted used manual colony counter (mini light box, Bel-Art product NO. 37862-0000).The collected data of indoor air parameters and microbial viable counts were subjected to statistical analysis using personal Spss V 10 to get X±SD , correlations (r) and T-test values.

RESULTS AND DISCUSSION

Results in table- 1 showed in closed system, mean values of indoor Ta. C° was 27.94C°± 2.054 & RH% was 57.20± 8.377 and AV was 0.335±0.445 m/sec. The lowered temperature during brooding especially 1st week , less than recommended 34 C° by (Sainsbury , 2000) reflected the efforts should be done during winter to keep required environmental temperature despite the heat control used in this system ,while CO_2 was 903.0±511.0 and NH_3 was 10.179±10.807. These levels looked high and annoying birds (noticed difficult breathing, gasping, collected birds near doors during workers activities) , their keeper and even the researchers which was as a characteristic field feature also as a consequence of reducing ventilation rate to save fuel cost for warming during brooding, this was coincided with explanation of (Bottje et al;1998) especially for ammonia and because man and chicks supposed to be sensitized by level started 5 ppm (Tom Tabler, 2003). Mean indoor microbial load (Table-2) for air f.cfu was $45.35x10^3±40.48$ & air b.cfu was $142.50 x10^3$ ± 217.00 while litter f.cfu was $614.66 x10^3$ ± 5261.29 & litter b.cfu was $9743.35 x10^3$ ± 581.47. Litter had higher microbial load Vs air and the higher loads were at 35 days old for all except air f.cfu was at 28 days old, the association of increased ammonia levels on 21-28 days old with the increased fungal count in air confirmed inadequate ventilation that enclosed the indoor gases not exhaled. On regarding the effect of indoor air parameters on microbial ecology shown in (Table 3), the indoor Ta.°C was positively correlated with air microbial load f & b (P= 0.042 & 0.002 respectively) but negatively correlated with litter f & b (p= 0.109 & 0.066 respectively).Indoor RH% and AV were positively correlated with air f.cfu only (p=0.001&0.015 respectively).Meanwhile, CO_2 gas had no significant effects or correlations with indoor air but with litter f. cfu only(p=0.108), despite NH_3 showed positive correlations with indoor air f & b (P= 0.08 and 0.086) and so with litter b. cfu (P= 0.007). Fungal growth had been demonstrated to occur in broiler litter depending on various environmental factors especially litter microclimate (Schipper et al;1982 and Bacon,1985).

Open ecosystem, (Table 4) revealed that mean indoor Ta.°C was 18.49 ± 2.188 & RH% was 69.31 ± 5.89 and AV was 0.15 m/sec ± 0.087. Indoor CO_2 mean was 447.84 ppm ±105.31 and NH_3 was 3.254 ppm ± 3.32. These results threw light on the severity of cool and highly fluctuated weather on housing broiler in open ecosystem during winter and the health risk for brooded baby chicks and the effect of incomplete thermal insulation on dissipating the indoor air elements and gases to outdoor air compared to the closed system. During 2-5 weeks old advised temperatures must be 27, 24 and 21 °C respectively (Sainsbury, 2000) .The negative effect of Ta. °C on fungal load was partially coincided with results of (Debey et al ; 1995).

Results in (Table 5) clarified that, mean Indoor air f cfu was less(88.20 x10 ≥± 84.42) than litter f cfu (118.94x 10 ≥ ± 251.3) while air b cfu was higher (335.2 x10≥ ± 270.6) than litter b.cfu (147.77x10≥ ± 199.75) ,these differences should be considered regarding the effect of both indoor air and litter microclimate on kind microbial ecology which also related to kind environment.

Data in (Table 6), Indoor Ta .°C showed positive correlation with litter f (p=0.017) and so RH% with air f & b (p=0.039 & 0.012 respectively)..AV had no significant correlation with indoor air and litter microbial loads that might be attributed to the improper and low Av Vs closed system, so air circulation and redistribution of microbial loads were not recognizable between air and litter. Indoor CO_2 was positively correlated with air f & b (p=0.008 & 0.046 respectively) as well as with litter f (p=0.025).On the other hand NH was positively correlated with air f & b (p= 0.00 for both) and with litter f & b (p= 0.002 & 0.00 respectively).These findings might be attributed to the possibility of dispersed contaminated food particles with fungi accompanied humid environment .Ammonia gas generation and emission were mostly result of litter microbial activity and interaction of indoor climatic factors (Weaver and Meijerhof; 1991 and Groot-Koerkamp, 1994). The effect of indoor RH% on air microbial population ecology confirmed by (Al-Dagal and Daniel,1990). The positive correlations between indoor gases and microbial population wer recognized partially as their metabolites and partially birds exhaled air (Gustafasson and Martensson , 1990) , On comparing the mean differences of indoor climate between closed and open environments as shown in (table 7) showed significant mean differences were in indoor Ta .°C , AVm/sec, CO_2 and NH_3 ppm where increased in closed Vs open (p= 0.001, 0.036 ,0.001 and 0.001 respectively) while RH% increased in open Vs closed (p=0.001), the effect of season on indoor gases accumulation (mainly ammonia) especially in closed Vs open houses was previously confirmed by (Seedorf and Hartung , 1999) . The nature of environment affected some of indoor microbial loads as revealed in (table 8) where indoor air f & b cfu were significantly increased in open Vs closed (p=0.033 and 0.008 respectively) , while in closed environment the litter b.cfu were significantly increased Vs open(p=0.018) . From the aforementioned results it could be concluded that closed system had high indoor gases levels that might annoying birds and their keeper. Litter had higher microbial load Vs air and the higher loads were at 35 days old for all except air f.cfu was at 28 days old , the association of increased ammonia levels on 21-28 days old with the increased fungal count in air confirmed inadequate ventilation rates that enclosed the indoor gases not exhaled .The indoor Ta. °C was positively correlated with air microbial loads(f & b cfu counts) but negatively with that of litter. Indoor RH% and AV were positively correlated with air f.cfu, CO_2 gas had no significant effects or correlations with indoor air loads but found with litter f cfu . Meanwhile, NH_3 showed positive correlations with indoor air f & b and so with litter b cfu. Open system had lowered indoor air parameters than closed . Indoor air f. cfu mean was less than in litter .These differences should be considered regarding the effect of both indoor air and litter microclimate on microbial ecology. Indoor Ta .°C showed positive correlation with litter f. cfu , RH%, CO_2 and NH_3 were positively correlated with air f & b cfu as well as with litter f. cfu with CO_2 . Significant mean differences were noticed between environments , indoor Ta, AV, CO_2 and NH_3 were increased in closed Vs open, while RH% increased in open Vs closed . Conclusively, the effect of season on indoor gases accumulation (mainly ammonia) was noticeable in closed Vs open house .The nature of environment affected the indoor microbial ecology, where indoor air f & b. cfu were significantly increased in open Vs closed in closed environment the litter b.cfu were significantly increased Vs open. The severity of cool and highly fluctuated weather on housing broiler in open ecosystem during winter should be considered as health risk for brooded chicks and the effect of incomplete thermal insulation on dissipation of indoor air gases to outdoor air.

Table 1: Mean values (X±SD) of indoor air parameters in closed ecosystem during winter.

Air parameters	V (1)		V (2)		V (3)		V (4)		V (5)		V (6)		Visits (total)	
	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD
Ta. .C⁰	26.2750	.1500	30.2200	1.7297	29.0800	1.0918	28.5400	.5771	28.2800	1.3027	25.0400	1.1480	27.9621	2.0545
RH. %	47.1250	1.4175	60.0800	8.6439	57.1600	4.4948	67.2000	2.6306	61.7800	3.1586	48.0800	3.3071	57.2414	8.3778
A.V. (m/sec)	.25000	.17321	.19400	012280	.48000	.68702	.68000	.77910	.18000	.08367	.21000	.08944	.33517	.44534
CO2. ppm	324.7500	16.500	490.000	74.1620	800.0000	187.0829	1720.000	311.4482	1340.000	89.4427	860.0000	245.9675	943.0690	511.4117
NH3. ppm	.1300	.01414	.2800	.1903	4.4000	1.5166	16.2000	6.3008	27.6000	8.1425	13.0000	4.4721	10.6179	10.8679

Ta ., RH and AV = ambient temperature .C° & relative humidity % and air velocity in meter/second(m/sec).
CO_2 and NH_3 .= carbon dioxide and ammonia in part/million(ppm).
V= visit number.

(Table-2):Mean values(X±SD) of microbial loads of indoor air and litter in closed ecosystem during winter.

Air & litter	V (1)		V (2)		V (3)		V (4)		V (5)		V (6)		Visits (total)	
	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD
air –f	5.50	5.43	50.74	28.1	46.32	47.02	52.93	41.8	95.84	21.2	12.78	5.85	45.35	40.48
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air –b	3.18	3.28	50.34	31.79	12.42	0.26	92.14	62.30	146.01	93.42	523.01	284.01	142.50	217.00
litter –f	0.03	0.002	59.22	48.29	32.92	40.26	177.82	370.45	81.84	71.92	309.74	502.33	6114.06	5261.29
litter –b	2.67	2.04	285.74	329.24	97.20	52.11	73.24	64.03	859.60	597.52	1196.45	650.71	9743.35	581.47

V= visit number F= fungal load B= bacterial load

V visit number F fungal load B bacterial load

(Table 3);Effect of indoor air parameters on air and litter microbial loads in closed ecosystem during winter.

Air parameters	Air - F	Air – B	Litter-F	Litter-B
Ta.C°	.380**	-.555***	-.304*	-.346*
	.042	.002	.109	.066
RH%	.627***	-.254	-.037	-.187
	.001	.185	.851	.332
A.V (m/sec)	.447***	-.128	.113	-.168
	.015	.507	.560	.383
CO2ppm	.286	.135	.304*	.134
	.133	.486	.108	.490
NH3ppm	.485***	.324*	.209	.493***
	.008	.086	.277	.007

. (Table-4);Mean values(X±SD) of indoor air parameters in open ecosystem during winter.

Air parameters	V (1)		V (2)		V (3)		V (4)		V (5)		Visits (total)	
	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD
Ta. C°	17.7667	.3055	18.5400	.4037	21.2200	.1643	17.7600	1.7925	16.7800	2.9778	18.4696	2.1887
RH.%	56.6667	.4933	67.9600	.2702	74.8000	2.1679	73.1600	2.1373	68.9200	.7596	69.3130	5.8559
A.V. (m/sec)	.26667	.15275	.16000	.08944	.12000	.04472	.11000	.05477	.14000	.005477	.15000	.08660
CO2.ppm	353.3333	47.2582	350.0000	50.0000	470.0000	44.7214	500.0000	122.4745	528.0000	98.3362	447.8261	105.3115
NH3. ppm	.1167	.01528	.3000	.1871	1.6000	.5477	5.8400	1.7111	7.1600	2.8902	3.2543	3.3236

Ta . , RH and AV = r ambient temperature .C° & relative humidity % and air velocity in meter/second(m/sec).
CO_2 and NH_3 .= carbon dioxide and ammonia in part/million(ppm).
V= visit number

(Table 5):Mean values (X±SD) of indoor air and litter microbial loads in open ecosystem during winter

Air & litter	V (1)		V (2)		V (3)		V (4)		V (5)		Visits (total)	
	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD	X	±SD
air –f	1.57	0.40	30.30	24.68	54.74	14.15	184.04	9360.61	135.68	95.91	88.20	84.42
air –b	3.87	1.30	5.90	6.67	357.10	134.83	555.36	217.72	568.16	174.40	335.21	270.60
litter -f	0.03	0.002	3.56	1.60	7.33	6.14	86.99	32.65	449.20	407.19	118.94	251.30
litter -b	0.18	0.13	3.60	1.69	29.32	5.51	281.72	181.38	365.00	212.70	147.77	199.75

f and b = fungal and bacterial colony forming units count.

(Table 6): Effect of indooor air parameters on air and litter microbial load in open ecosystem duringg

Air parameters	Air - F	Air – B	Litter-F	.Litter-B
Ta. C⁰	-.193	-.045	-.492***	-.158
	.377	.837	.017	.470
RH%	.433**	.513***	.007	.196
	.039	.012	.975	.369
A.V (m/sec)	-.291	-.256	.052	.009
	.178	.238	.813	.966
CO2ppm	.536***	.419**	.465**	.192
	.008	.046	.025	.381
NH3ppm	.759***	.822***	.607***	.854***
	.001	.001	.002	.001

Values in columns are correlation (r) and significance , * at P≤ 0.1 . ** at P ≤ and *** at P ≤ 0.001

(Table 7: Mean differences of indoor air parameters between closed and open ecosystems in winter.

Air parameters	Winter					
	Closed		Open		T	Sig
	X	±SD	X	±SD		
Ta –C	27.9621	2.0545	18.4696	2.1887	15.96	0.001***
RH.%	57.2414	8.3778	69.3130	5.8559	6.10	0.001***
A.V. m/sec	.33517	.44534	.15000	.08660	2.19	0.036**
CO2.ppm	943.0690	511.4117	447.8261	105.3115	5.08	0.001***
NH3 ppm	10.6179	10.8679	3.2543	3.3236	3.45	0.001***

Values in column are T test mean significant differences between both indoor parameters during winter.

Significance , * at P≤ 0.1 . ** at P ≤ and *** at P ≤. 0.001.

(Table): Mean differences of indoor air and litter microbial load between closed and open ecosystems in winter.

Air & litter	Winter					
	Closed		Open		T	Sig
	Mean	+SD	Mean	+SD		
air –f	45.35	40.48	88.20	84.42	2.24	0.033**
air –b	142.49	217.00	335.21	270.60	2.78	0.008***
litter -f	6114.06	5261.30	118.94	251.30	0.07	0.946
litter -b	9743.35	58.15	147.77	199.75	2.47	0.018***

f and b = fungal and bacterial colony forming units count.
Values in columns are correlation (r) and significance , * at P≤ 0.1 . ** at P ≤ and *** at P ≤. 0.001.

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