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Asthma and histopathological changes associated with poultry dust exposure

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ABSTRACT

The study assessed the prevalence of symptoms of asthma among Nigerian poultry workers and the possible pathological changes in lung associated with dust exposure through an indirect experimental exposure of poultry dust to albino rats. Questionnaire was developed to elicit data on symptoms of asthma, and administered to 250 poultry workers as well as 100 control subjects. Forty albino rats were divided into 5 groups of 8 rats each, 4 groups were exposed to poultry dust in an exposure chamber, while the fifth group served as control. The histopathological features of lungs of the exposed rats include cells infiltration in alveoli, interstitial cells infiltration, alveolar wall thickening and granuloma formation. In most cases, necrosis and breaking of alveolar walls to form large zones were observed in the lungs of the exposed rats. Vasodilatation and fibrosis of the lungs were equally observed. The degree of lungs inflammation or degeneration was found to be positively correlated with duration of exposure to poultry dust ($r = +0.918$, $p < 0.05$). Significantly higher prevalence of sputum, cough, difficulty in breathing, tightness of chest and wheezing were obtained for poultry workers than the control populace. The result indicates that prolonged inhalation of poultry dust can result in extrinsic allergic alveolitis with prevalence of symptoms of asthma.

Key words: Asthma, Allergic alveolitis, Poultry dust.

INTRODUCTION

Asthma is a chronic respiratory disease characterised by lung inflammation, airway obstruction and bronchial hypereactiveness (bronchospasm). Symptoms of asthma include coughing, chest tightness, wheezing and shortness of breath [1]. In the year 2011, it was reported that 235 million people worldwide were affected by asthma [2], and approximately 250,000 people die per year from the disease [3]. Rates vary between countries with prevalence between 1 and 18% [3]. It is more common in developed than developing countries. It is the most common chronic disease among children [2]. Asthma resulting from workplace exposures is the world's most commonly reported occupational respiratory disease. Most occupational asthma cases are often not reported. Animal proteins, enzymes, flour, natural rubber latex and certain reactive chemicals are commonly associated with commonly associated with work related asthma.

Livestock and poultry buildings are rich in bioaerosols, which are particles that contain bacteria, fungi, viruses, endotoxins and β-D glucans [4,5,6]. Exposure to such bioaerosols may result in various infectious, allergenic and immunogenic conditions [4,5,6,7]. Prolonged inhalation of organic dust containing faecal materials and feather has been reported to cause hypersensitivity lung diseases (extrinsic allergic alveolitis) and symptoms such as coughing, wheezing and respiratory distress have been noted [6,7,8,9].

In Nigeria, it has been reported that poultry dust contain varieties of toxic chemicals, mycotoxins, toxigenic, microfungi and multidrug resistant bacteria [10,11]. Poultry workers were found to experience significantly higher frequency of symptoms of physical ill-health and anxiety than the control populace [12]. The study was carried out to assess the prevalence of symptoms of asthma among Nigerian poultry workers and the possible pathological changes in lungs of individuals exposed to poultry dust, through an indirect experimental exposure of poultry dust to albino rats.

MATERIALS AND METHODS

Exposure of albino rats to poultry dusts

The exposure of albino rats to poultry dust was carried out as described by Smith and co-workers [13] with some modifications. Forty adult male albino rats (mean weight 175.6 ± 12.6) were used for this study. All the rats were observed to be in good condition of health. The animals were grouped into 5 groups (A, B, C, D & E) of 8 rats each. Each group housed separately in stainless animal cages. Animals were fed with Growers mash of Livestock Feeds® (Adset, Benin City, Nigeria) throughout the course of the experiment.

The rats were exposed to sieved poultry dust in a fabricated exposure chamber (0.5m x 1.0m x 0.5m) with an inbuilt electric fan to aid dust dispersal and suspension in air. Group A rats were not exposed to poultry dust and served as control. Groups B, C, D and E rats were exposed for 3 hours/day for 3 days a week over a period of 2, 4, 6, and 8 weeks respectively.

The reactions of the rats to poultry dust during exposure in the chamber were observed and recorded. Twenty four hours after the last day of exposure, rats were weighed and anaesthetized by intraperitoneal injection of Phenobarbital (Lab. Renaudin, France) at a dosage of 100mg/kg body weight. The rats were exsanguinated via the abdominal aorta. Lungs from experimental albino rats were harvested into 10% formalin solution (V/V) for histopathological studies. Tissues were processed with the aid of Shandon automatic tissue processor, Shadon 2000® (Shandon Southern Instruments Ltd, Camberley Surrey, England) Tissue preparation into slides involved stages such as dehydration, clearing, vacuum impregnation, embedding and staining [14]. The degrees of lungs degeneration were scored according to Folgel-Mark and co-workers [15], as follows:

Description		*Score*
(i)	Normal lungs	1
(ii)	Cell infiltration in alveoli, no intestinal cell infiltration and no alveolar wall thickening	2
(iii)	Severe cell infiltration in alveoli, interstitial cell infiltration and alveolar wall thickening	3
(iv)	Cell aggregation in alveoli, Alveoli wall thickening and increased numbers of interstitial cell	4
(v)	Granuloma formation	5

Questionnaire for human dust exposure assessment

Questionnaire was developed to elicit data on symptoms of asthma, which include coughing, tightness of chest, difficulty in breathing, and wheezing. The questionnaire, which was adapted from the work of Thu and co-workers [16], was administered to 250 poultry workers and 100 control populace. The occurrence of each symptom of asthma was reported as follow: never =0, rarely =1, occasionally =2, often =3, very often=4

Data analysis

Data were analysed statistically using SPSS 16.0 window. A value of $p \leq 0.05$ was considered significant.

RESULTS AND DISCUSSION

The rats during exposure to poultry dust, expressed the following physical reactions inside the exposure chamber: rubbing of eyes and nostrils with the fore hands, closing of eyes and hiding of nostrils in between other rats as well as restlessness for the first 20-30 minutes, followed by calmness, while the eyes remained closed and nostrils hidden. This was an evidence that rats exposed to sieved poultry dust inhalation suffered severe occular and nasal irritation.

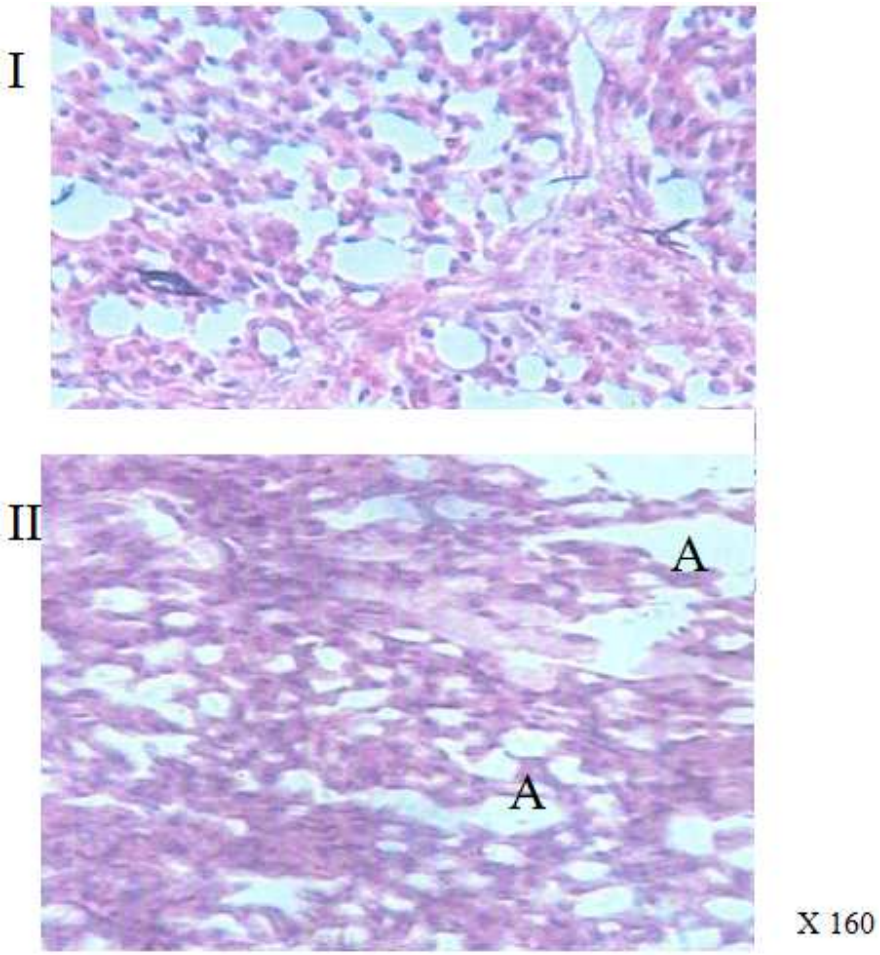

Figure 1. Photomicrograph of the lungs of albino rats exposed to poultry dust inhalation.
I – Normal lung of unexposed rat
II – Lung of exposed rat in early degeneration showing vacuolation (A)

The histopathological features of the lungs of rats exposed to poultry dust include cells infiltration in alveoli, interstitial cells infiltration, alveolar wall thickening and granuloma formation. In most cases necrosis and breaking of alveolar walls to form large zones were observed in the lungs of the exposed rats. Vasodilatation and fibrosis of the lungs were observed among rats exposed to poultry dust for a period of 8 weeks (Figures 1 & 2). The degree of lungs inflammation or degeneration was found to be positively correlated with duration of exposure to poultry dust ($r = +0.918$, $p < 0.05$; Figure 3).

Histopatological changes in lungs resembling hypersensitivity pneumonitis reported in this study were similar to what was reported by Fogel-Mark and co-workers [15] when guinea pigs were repeatedly exposed to inhalation of (1-3)-β-D glucan and endotoxin. The observed histopathological changes could have resulted from working in synergy of the various allergic, toxic and infectious agents present in poultry dust. According to Rylander [4] inhalation of organic dust causes immunological changes in the lungs resulting in allergic alveolitis, a chronic inflammation of the lungs, which are responsible for symptoms of respiratory diseases commonly reported by workers in such occupational settings.

Okiki and Ogbimi [17] earlier reported significant higher numbers of broncho-alveolar lavage (BAL) cells in albino rats exposed to poultry dust inhalation over a period of 3 weeks than unexposed rats, which is an indication that inhalation of poultry dust causes airway inflammation. High BAL cells have been observed by Smith and co-researchers [13] in rats exposed to fine outdoor dust, as well as by Fogel-Mark and co-workers [15] in guinea pigs exposed to (1-3) - β-D-glucan and endotoxins inhalation.

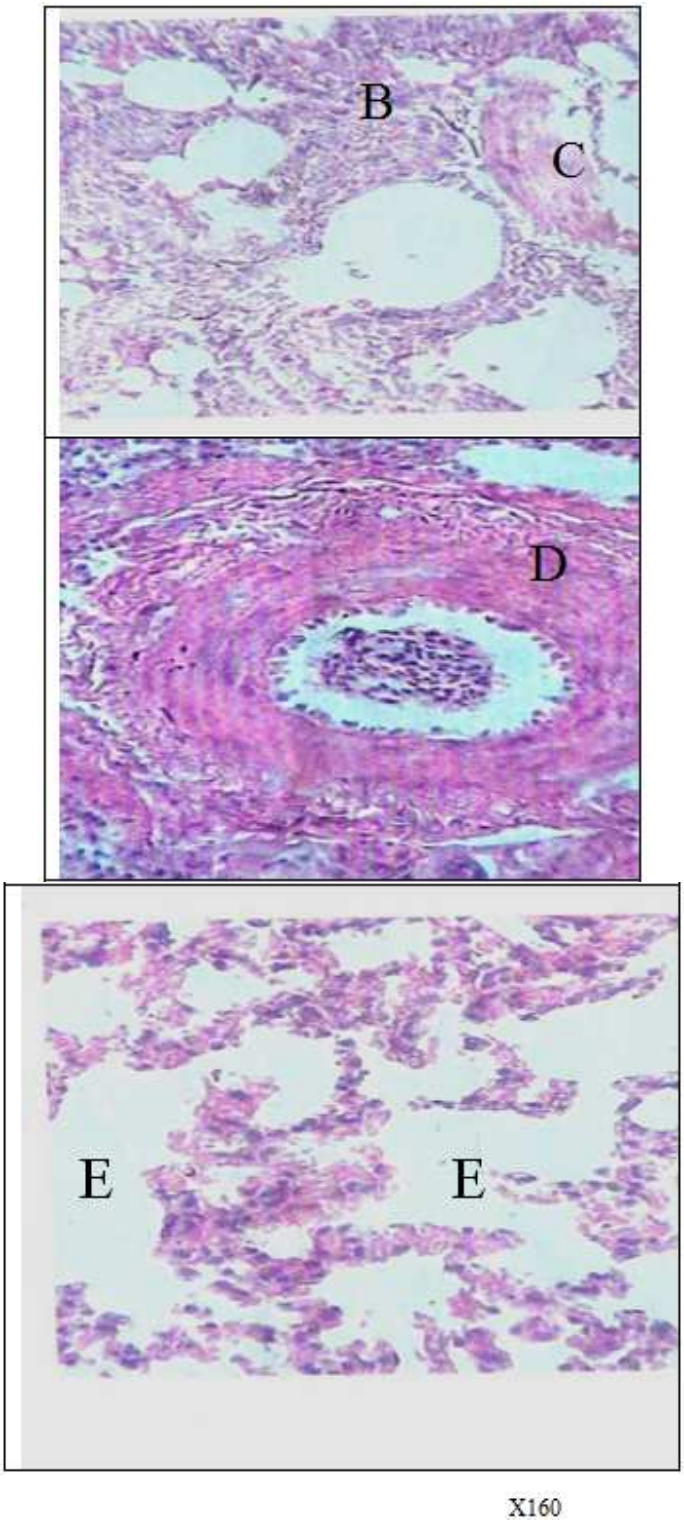

Figure 2: Photomicrograph of the lungs of albino rats exposed to poultry dust inhalation for a period of 8 weeks. Showing thickening of alveolar wall (B), fibrosis (C), dilation of blood vessel (D) and coalescent vacuolation (E)

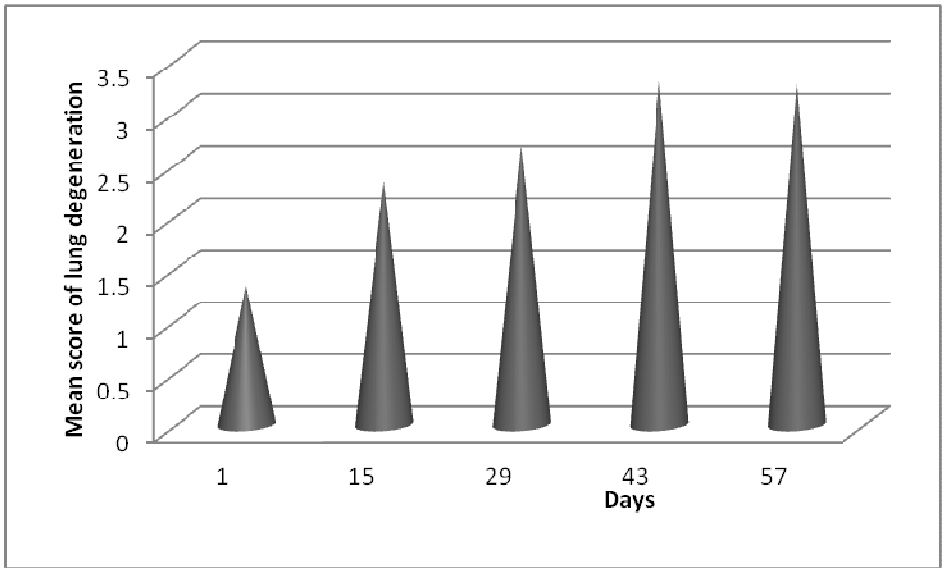

Figure 3: Variation of degree of degeneration of lungs of rats with duration of exposure to poultry dust (r = +0.918; P < 0.05)

Table 1: Comparing frequency of asthma symptoms between the poultry workers and control subjects

Symptoms	Poultry workers	Control
Cough	1.11[a]	1.00[b]
Sputum	1.13[a]	0.77[b]
Shortness of breath	0.67[a]	0.30[b]
Tightness in chest	0.90[a]	0.38[b]
Wheezing	0.22[a]	0.15[b]
Mean	0.81	0.52

[a-b] *Values with different superscript are significantly different at P < 0.05 (Paired t test)*

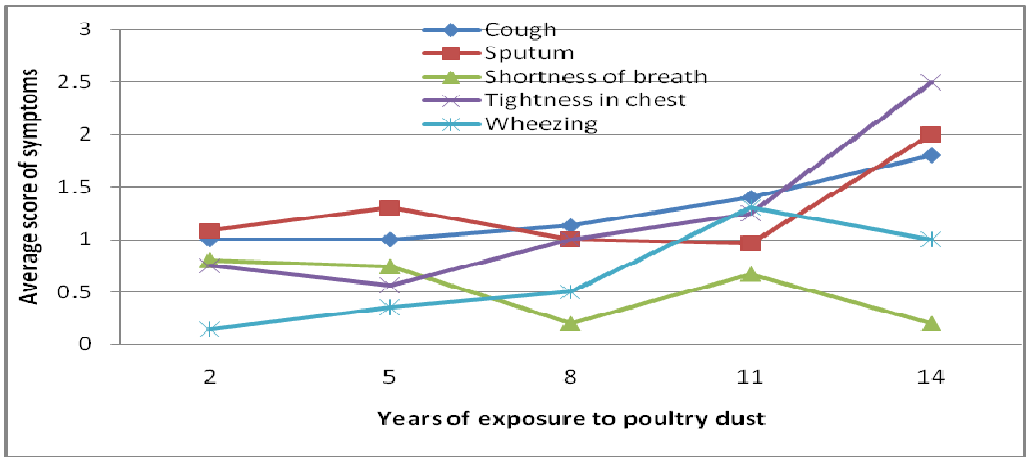

Figure 4: Variation of symptoms associated with bronchitis and hypereactive airways with years of exposure to poultry dust (Cough r = +0.929, P = 0.022; Sputum r = +0.600, P = 0.284; Shortness of breath r = -0.685, P = 0.202; Tightness in chest r = +0.893, P = 0.041; Wheezing r = +0.857, P = 0.064)

The human exposure assessment based on questionnaire showed that the prevalence of sputum, cough, difficulty in breathing, tightness of chest and wheezing were significantly higher for poultry workers than the control populace

(Table 1). Variation of symptoms associated with bronchitis and hypereactive airways with years of exposure to poultry dust are: Cough r = +0.929, P = 0.022; Sputum r = +0.600, P = 0.284; Shortness of breath r = -0.685, P = 0.202; Tightness in chest r = +0.893, P = 0.041; Wheezing r = +0.857, P = 0.064; Figure 4). The significant higher symptoms of asthma reported by poultry workers than control in this study could be attributed to airway irritation and inflammatory changes in lungs of the poultry workers as a result of occupational exposure to poultry dust.

CONCLUSION

Based on the report of this study, it can be inferred that occupational dust exposure in poultry confinements could result in hypersensitivity pneumonitis, which could manifest as asthma or respiratory distress. In the tropical countries, poultry are not reared in total enclosed confinements, as walls of poultry houses are made of wire-mesh. Workers in such poultry confinements are constantly exposed to poultry dust inhalation because they rarely use respiratory protectors. This is commonly observed among small and medium sized poultry farm workers in Nigeria. The use of respiratory protectors should be enforced so as to prevent cases of asthma and respiratory diseases among the poultry workers.

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