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FIRST STUDY OF THE IMPACT OF THE SYRIAN NATURAL ZEOLITE ON AIR BIOLOGICAL CONTAMINATION CONCENTRATIONS IN BROILER FARMS DURING SPRING AND AUTUMN

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ABSTRACT

The aim of this study was to investigate the effect of three different levels of Syrian natural zeolite on the bacterial load concentrations in the air of broilers farms for five weeks. This study was conducted in private commercial broiler farm in the Lattakia Governorate, Syria. During the period of 2021 in spring (from March to April), and in autumn (from October to November) seasons. In the experiment, commercial broiler hybrid (Roos 308), with a total number of three thousand one day old were randomly assigned to four groups. Each group (750 birds) has three replicates with 250 birds in each replicates (in addition to the control section), this experiment was designed using complete randomized. The results showed that the average concentrations value for *Staphylococcus* spp. during spring, at the fifth week of the fattening period, in the treatment Tz_3 (75%) was recorded 4.1×10^5 CFU/m^3, while in autumn; the value was 4.3×10^5 CFU/m^3. And for *Escherichia coli* in spring, was 3.8×10^3 CFU/m^3 and in the autumn 7.5×10^3 CFU/m^3. The results concluded that the addition of Syrian natural zeolite to the broiler litter resulted in significantly ($p<0.05$) decrease of airborne bacteria at the end of experiment with superior effect to Tz_3 treatment in the internal air, and the the lowest concentration was noted in spring compared to autumn. This result provides a guide to the optimal use of the different ratios of the Syrian natural zeolite, and development of new way to reduce the airborne microorganism in the broiler farms.

Keywords: Airborne bacteria; broiler; *Escherichia coli*; natural zeolite; *Staphylococcus*.

1. INTRODUCTION

The broiler farms are considered as a reservoir of pathogenic microorganism, such as *Staphylococcus* spp. and *Escherichia coli*. The *Staphylococcus* spp. is considered a general indicator of total airborne bacteria content in the air of the broiler house, and accounted for up to 90% of the total content of the air microorganism. And contribute to about 5-34% of the total indoor air pollution. It is known that prolonged or repeated exposure to high concentrations of airborne microorganisms causing infections and the allergic effect such as emergence of respiratory system and intestinal diseases, which are considered a

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source of danger and are harmful to both birds and people working in these facilities, and have negative effects on health and production [1]. In addition, can lead to increased risk of upper respiratory symptoms and infections ranging from coughing to wheezing and shortness of breath, causing respiratory damage, allergic and poisoning effects, and immune toxicity, where a number of syndromes have been identified among workers in broiler farms [2]. The most common clinical signs of exacerbation of infectious, and chronic respiratory diseases include exacerbation of asthma and asthma-like syndrome, irritation of the mucous membranes, chronic bronchitis, and acute inflammatory processes [3,4]. The litter is one of the most important sources of bio pollution, and considered as the main container of birds' manure and wastes, as well as the quality of the litter used and its management, temperature, the acidity, all of these factors are responsible for increasing the concentration of the airborne bacteria in the air of the broiler farm during the fattening period [5-7]. And the bio pollution is influenced by many factors such, as environmental conditions (the temperature and humidity of the air, air velocity, season of the year), the composition of broiler diet, and the efficiency of its conversion to meat, which affect the quantity and physical and chemical properties of the manure, such as chemical composition, biodegradability, microbial and oxygen content [8]. In addition to efficiency of ventilation rates, bird density, age, activity, weight, and chickens emit to the environment considerable large amounts of dust produced by epithelial desquamation, as well as from skin, feed, and feces, which are spread throughout the barn combined with different microbes [9,10]. In total, this pollution negatively affects the health and production of birds When spread in the litter and in the atmosphere of the barn, which may lead to health risks when released to the outdoor environment [11,12].

The airborne bacteria increasing in closed places in cold areas, and in the inappropriate environmental conditions, there was a notable increasing in the level of air relative humidity, temperature, with daylight absence, and the moisture of the litter was increasing gradually whene the water spills from the drinkers, these encourage to survival the microorganism activity in the litter. Also the high temperature degrees of the litter and the pH all of these factors leads to emission highest amounts of bio aerosols. When the litter temperature rises, it creates a suitable environment to stimulate microbial activity in the litter, especially when the litter's pH tends to be alkaline, and at the last weeks of the fattening period accumulate a huge amount of feces, with the increase in the age of the birds. This would reduce the rate of development and decrease feed efficiency and performance of the birds. It may be associated with a high percentage of pathogens in the barn environment, which negatively affects the health and production of birds. Moreover, the proportion of germs and other pathogenic bacterial increases and spreads throughout and outside the barn.

Several studies have been performed for the assess the content of air bio pollution on broiler farms and studied of the potential risks on the broiler and human and its effects on the health and the productivity when the exposure to airborne pollutants for long period t in broiler facilities. And there are only few experimental data available on air bio pollution in broiler houses, and all of these studies that conducted without adding natural zeolite [1,2,13-22]. Over the last few years, several strategies have been suggested for the control of air and litter quality in broiler farms. Hence, it was concluded that the use of alternative management strategies necessitates the research on natural alternatives for safe use in broiler litter. And in recent years, there was a new interest in use of the natural zeolites as a means of reducing litter moisture and ammonia concentrations from broiler houses. The natural zeolite has received great attention in broiler industries, there is also evidence of intense research efforts towards adding the natural zeolite in broiler litter to reduce the pollutants released from broiler farms. Because, the zeolite have great potential for the mitigation and waste control processes produced by the broiler industries, and it is environmentally friendly and economical as litter additive, and it is have unique physical and chemical characteristics that may be used as litter additive, due to the moisture absorption characteristics of zeolites and acidifier, and thus will lead to the mitigation of the pollutant. Several researches had been conducted around the world to adding the natural zeolite in broiler litter to identify the ammonia gas concentrations, broiler litter bacteria concentrations and humidity of the broiler litter [23-29].

2. THE IMPORTANCE AND AIMS OF RESEARCH

The main aim of this study was to determine and detect the airborne bacteria, and reduce the potential of bio pollution in broiler farms, by finding new method to control high levels of airborne microorganisms by using environmentally safe alternative materials, that can absorb the humidity from the broiler litter and air, and minimizes the extensive use of antibiotics and disinfectants. and improves the overall health and productivity conditions. In view of absence studies concerned with the effect of the natural zeolite on the biological contamination in the air of broiler farms in the Syrian Arab Republic, locally, regionally and globally, the use of Syrian natural zeolite in broiler litter was conducted for the first time in this study. Hence, the objective here was to address the latter question by assessing the effect of the Syrian natural material on airborne bacteria in broilers farms.

3. MATERIALS AND METHODS

3.1 The Experiment Site

This study was conducted in private commercial broiler farm in the coastal region located on north of Lattakia Governorate, Syria as shown in Fig. 1(a) and shown in the satellite image Fig. 1(b). During the period of 2021 in spring (from March to April), and in autumn (from October to November) seasons. when the temperature of atmospheric air ranged between +20°C and + 25°C, and varied in the inside of broiler house from 20°C to 22°C. While the Indoor relative humidity was about 63 to 67%, and the outdoor relative humidity ranged between 56 to 62%.

3.2 Animal and Housing

The broiler house (25.00 x 8.00 m, height 3.40 m) was divided into four equal sections (treatments) completely separated from each other by wooden barriers (height 3.40 m), and the floors were spread with sawdust for litter before receiving the chicks. Upon arrival the chicks commercial broiler hybrid (Roos 308), with a total number of three thousand (3000) day old were used, and kept on (5-7) cm deep litter in each section (treatments). With density 10 bird/m^2 in spring and 12 bird/m^2 in autumn season. The broiler house follows a semi-enclosed care system, provided with the feeders and drinkers (automatic nipple watering system), and the diet and water were provided ad libitum.

3.3 Experimental Design

The Syrian natural zeolite was added to the litter (sawdust: zeolite) as shown in (Fig. 2) for the three treatments, with the following ratios: Tz_1 (25%) (75:25), Tz_2 (50%) (50:50), and Tz_3 (75%) (25:75), respectively, and in addition to the control section (treatment) Tz_0 (0%) without zeolite. Then, the birds with a total number of three thousand (3000) day old were randomly assigned to one of four groups. Each group housed (750) birds, and each section includes three sectors (divided into three replicates with 250 birds in each replicates). The measurements were performed in the indoor air in each section, to determine the concentrations of the overall airborne bacteria count at five different ages, during the (1, 2, 3, 4, 5) five weeks, respectively, once a week until the end of the fattening period. Airborne bacteria were precipitated on a Mannitol salt Agar (M S A) and MacConkey Agar (McC) in Petri dishes, for 5 minutes. The necessary information was recorded on the Petri dishes, then was sealed and temporarily stored in a portable thermos until they were transferred to the laboratory for the necessary analyses.

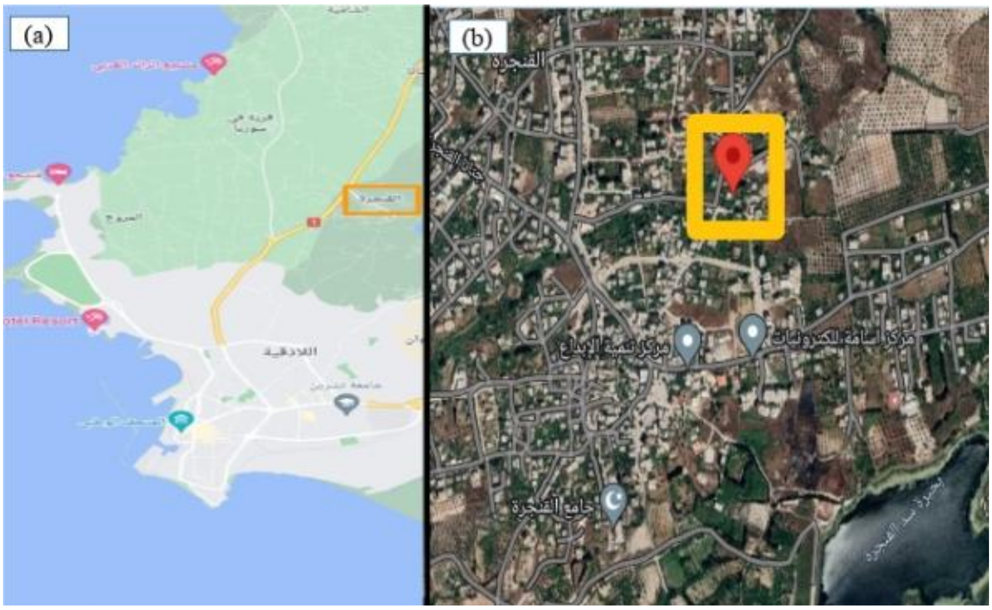

Fig. 1(a). The location of the broiler farm on the map, (b). Satellite image of the broiler farm in on north of Lattakia Syria

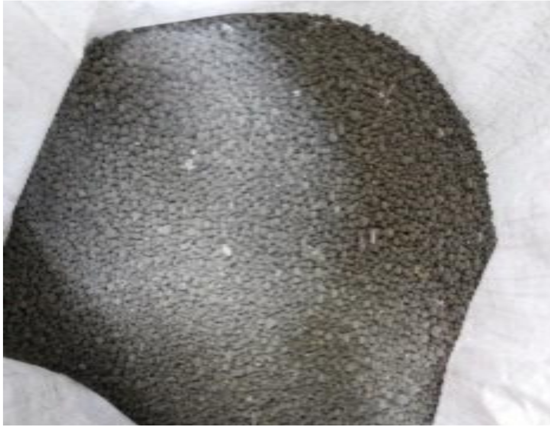

Fig. 2. The Syrian natural zeolite

Table 1. The general chemical composition of the Syrian natural zeolite ore, which was added in the broiler litter

Components	Si_2O	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	TiO	P_2O_5	Na_2O	K_2O	H_2O+CO_2
% wt	38.26	10.2	10.86	0.14	9.90	11.94	1.78	0.56	2.44	1.03	12.8

3.4 Syrian Natural Zeolite Ore

The definition of zeolite as a mineral was coined by Swedish mineralogist Axel Fredrik Cronstedt in 1756 [30]. The name Zeolite was derived from a Greek word meaning boiling stones, due to their ability to lose the water they contain in the form of vapors when heated, and this phenomenon appears as boiling. Zeolites are a group of hydrated aluminum silicates that follow the structural group of silica tectosilicate. This group has a composition similar to clay minerals with a three-dimensional structure, where aluminum and silicon are concentrated in structures made by oxygen atoms in a regular arrangement in the form of tetrahedra of (SiO_4) and (AlO_4). To make a shape, the mesh box is interspersed with gaps or channels. The symmetrical ionic substitution occurs between the tetravalent silicon and the trivalent aluminum, to replace it giving a net negative charge; this charge was modified through the unilateral and binary cations that settle in the gaps and channels. This gives the zeolite the chemical and physical properties that attracted the interest of researchers to use it in the field of agriculture and broiler production [31]. Natural zeolites have been characterized by being mostly impure, as they contain multiple types of zeolites. For this reason, the properties of natural zeolites vary according to the reservoirs in which they are found [32]. The zeolites of Clinoptilolite, Phillipsite, Chabazite and Analcime are among the most important zeolites scattered around the world [33]. Table 1. shows the general chemical composition of the Syrian (natural) zeolite ore (Al-Sis site) as a weight percentage [34]. The source of the zeolite dates back to the Al-Sis area of Tell Mkehelat, 170 km southeast of Damascus. It consists of quartz, calcite, olivine, and two types of zeolites, Phillipsites $(Ca, Na2, K2)_3Al_6Si_{10}O_{32}\cdot 12H_2O$ and Analcime $NaAlSi_2O_6\cdot H_2O$ [35].

3.5 Laboratory Work

We used two bacterial media, Mannitol salt Agar (M S A) and MacConkey Agar (McC) both of them were sterilized (autoclave device at 121 °C for 20 minutes). Then the Petri dishes were incubated at temperature 37°C for 24-48 hours and the grown bacterial colonies were calculated with a mechanical optic colony counter. The bacterial colonies were identified, and then, the gram staining was carried out to distinguish the bacteria into two groups, the first Gram-positive group, retains the violet color of crystal violet dye, and the second group, Gram-negative, does not preserve crystal violet dye and takes the red color of safranin or fuchsine. The overall number of the airborne bacteria was calculated using the Omeliansky equation to estimate the airborne bacterial count [36]. Sample collection was performed upon farm owner permission.

3.6 Statistical Analysis

The data of the experiment was designed using complete randomized (CRD), with two factors (zeolite and broiler age), and then subjected to analysis of variance (two ways ANOVA), using the GenStat (v.12) program. Using Duncan's test to show the significant differences between the averages of the concentrations of bacterial counts during the five weeks at a significant level of 5% ($P\leq 0.05$).

4. RESULTS AND DISCUSSION

4.1 Airborne Bacteria Concentrations of *Staphylococcus* spp. in the Broiler House during Spring and Autumn Seasons

Table 2. shows the average concentrations of airborne bacteria *Staphylococcus* spp. in the broiler house during spring and autumn, before and after adding Syrian natural zeolite to the litter of broiler for 5 weeks. The lowest concentration was noted in spring; while the highest was noted in autumn. In spring, in the first week of the fattening period, the concentration in the control treatment Tz_0 (0%) was 2.5×10^5 CFU/m^3, and in the three treatments the concentrations were Tz_1 (25%) 2.1×10^5, Tz_2 (50%) 1.8×10^5 and Tz_3 (75%) 1.5×10^5 CFU/m^3 respectively. While the concentrations at the fifth week in the treatment of the control amounted to Tz_0 5.4×10^5 CFU/m^3, and in the other three treatments, were Tz_1 4.9×10^5, Tz_2 4.4×10^5 and Tz_3 4.1×10^5 CFU/m^3 respectively. The results at the end of the fattening period in the fifth week, showed that there was an increase in the concentration, compared to the first week at the beginning of the period of fattening in the control treatment, which ranged from 2.5×10^5 CFU/m^3 to 5.4×10^5 CFU/m^3, while the values show a significant decrease ($p<0.05$) in the concentrations of the three treatments to which Syrian natural zeolite was added throughout fattening period, compared to the control. In autumn, the values of concentrations in the first week were as follows: Tz_0 2.7×10^5, Tz_1 2.2×10^5, Tz_2 1.8×10^5 and Tz_3 1.6×10^5 CFU/m^3 respectively; while the values in the fifth week were as follows: Tz_0 5.5×10^5, Tz_1 4.9×10^5, Tz_2 4.5×10^5 and Tz_3 4.3×10^5 CFU/m^3 respectively. It was noticed from the results that there was a significant increase in the fifth week compared to the first week in the treatment of the control, as the increase ranged from 2.7×10^5 CFU/m^3 to 5.5×10^5 CFU/m^3. On the other hand, a significant decrease ($p<0.05$) was noted in the values of the concentrations among the three treatments, compared to the control.

Concentrations of airborne pollutants increase in broiler farms with the increase in the age of the birds, and as the age and weight of the bird increases, this leads to an increase in the number of airborne bacterial loads [16]. The number of bacteria *Staphylococcus* spp. recorded in Spain $>10^5$ CFU/m^3 [13] and in other studies it varies significantly between 10^3 and 10^7 CFU/m^3 [37,38]. In addition, in Zagreb, Croatia, the concentrations of airborne microorganisms in broiler houses rise with the increase in the age of the birds. In the first week, they were 1.7×10^4 CFU/m^3, and in the fifth week 2.2×10^5 CFU/m^3 [16]. In the present study, the concentration of *Staphylococcus* spp. begins gradually to rise with broiler age. As shown in Table 2. in the control treatment in spring it ranged from 2.5×10^5 CFU/m^3 in the first week to 5.4×10^5 CFU/m^3 in the fifth week, and in autumn from 2.7×10^5 CFU/m^3 to 5.5×10^5 CFU/m^3 respectively. This is a logical result that the pollutant increasing in closed places in cold areas and in the last weeks of the fattening period accumulate a huge amount of feces. In inappropriate environmental conditions, leads to emission highest amounts of bio aerosols, that resulting from the decomposition and degradation of manure and feces when the physical and chemical properties were changed by the process of the biodegradability and fermentations of aerobic and anaerobic bacteria. In this case accelerates the formation of hazardous gases such as ammonia. All of these factors together contribute to accelerating the chemical reactions of uric acid present in bird feces, because of the action of some bacteria in the feces accumulated in the litter. When the litter temperature rises, it creates a suitable environment to stimulate microbial activity in the litter, especially when the litter's pH tends to be alkaline. As a result, the microbial and enzymatic decomposition of uric acid and proteins increases to ammonia gas because of

Table 2. Airborne concentrations (CFU/m^3) of *Staphylococcus* ssp. before and after adding Syrian natural zeolite to the broiler litter during spring and autumn seasons

Bacteria Staphylococcus ssp. concentrations Mannitol salt Agar (M S A)								
Seasons	**Spring**				**Autumn**			
Age (weeks)	**Tz_0 (0%)**	**Tz_1 (25%)**	**Tz_2 (50%)**	**Tz_3 (75%)**	**Tz_0 (0%)**	**Tz_1 (25%)**	**Tz_2 (50%)**	**Tz3 (75%)**
1	2.5×10^{5a}	2.1×10^{5b}	1.8×10^{5c}	1.5×10^{5d}	2.7×10^{5a}	2.2×10^{5b}	1.8×10^{5c}	1.6×10^{5d}
2	4.2×10^{5a}	3.9×10^{5b}	3.5×10^{5c}	3.1×10^{5d}	4.4×10^{5a}	4.0×10^{5b}	3.6×10^{5c}	3.3×10^{5d}
3	2.4×10^{5a}	1.9×10^{5b}	1.5×10^{5c}	1.0×10^{5d}	2.6×10^{5a}	2.1×10^{5b}	1.8×10^{5c}	1.5×10^{5d}
4	3.4×10^{5a}	2.6×10^{5b}	2.1×10^{5c}	1.9×10^{5d}	3.5×10^{5a}	2.9×10^{5b}	2.5×10^{5c}	2.1×10^{5d}
5	5.4×10^{5a}	4.9×10^{5b}	4.4×10^{5c}	4.1×10^{5d}	5.5×10^{5a}	4.9×10^{5b}	4.5×10^{5c}	4.3×10^{5d}

Treatment groups: Tz_0 (0%) Control = broiler litter (sawdust) without Syrian natural zeolite, $Tz_{1=}$ (25%), $Tz_{2=}$ (50%) and Tz_3 (75%) = broiler litter with Syrian natural zeolite in different ratio (sawdust: zeolite), [a,b,c,d] Means in the same row with significant differences among averages ($p<0.05$)

bacterial fermentation reactions. On the other hand, direct contact of birds with the litter and their stay for a long period on it accumulate a huge amount of the droppings. As well as breathing gases, in addition to the possibility of increasing exposure to pathological injuries and physiological changes proportional to the increase in the weight and size of the birds and thus the changes associated with this increase. Moreover, type of litter may contribute to body defects and bird mortality, proliferation of microorganisms related to moisture levels of the litter, and to an increase in the gas and dust levels in broiler houses. This may cause cerato-conjunctivitis of the eyes, reduce the rate and the depth of respiration and increase sensitivity due to irritation of mucus in the respiratory tract. This would reduce the rate of development and decrease feed efficiency and performance of the birds. It may be associated with a high percentage of pathogens in the barn environment, which negatively affects the health and production of birds. Moreover, the proportion of germs and other pathogenic bacterial increases and spreads throughout and outside the barn. Due to the natural zeolites moisture absorption characteristics Therefore, it is incorporated into litter to reduce moisture levels, through its ability to adsorb ions and water, that improve the physical, chemical and microbiological integrity of litter and therefore, can enhance ambience, performance and hygiene and when decreases of pH and water activity that directly affect microorganism survival. in the litter, and after incorporating the Syrian natural zeolite into the litter, the litter moisture levels decreases from 61.01% to 38.38% at the end of the fattening period [29]. Several researchers evaluated the content of air pollution on broiler farms and its effects on the health and the productivity. Moreover, of absence studies concerned with the effect of the natural zeolite on the biological contamination in the air of broiler farms, this research fills that gap, covered in this subject. And the *Staphylococcus* ssp. recorded the highest numbers during autumn, and the lowest number in spring. While, in Wroclaw, Poland in contrast the highest numbers of staphylococci in the air of poultry were recorded during spring [14]. The reason for the difference in results between our country and Europe, can be attributed to the geographical and microclimatic conditions, (climatic) difference, and to the differences in sampling methods, building capacity, density of birds rearing, age of birds, between the two continents.

4.2 Airborne Bacteria Concentrations of *Escherichia Coli* in the Broiler House during Spring and Autumn Seasons

Table 3. shows the average concentrations of airborne bacteria *Escherichia coli* in the broiler house during spring and autumn, before and after adding Syrian natural zeolite to the litter of broiler for 5 weeks. The lowest concentrations for *E. coli* in the broiler house was in spring, compared to the autumn, which recorded the highest concentrations. In both seasons, the differences statistically significant ($p<0.05$) were observed among the averages of the three treatments, compared to the control treatment. In spring, the first week, the concentration value was recorded in the control treatment Tz_0 6.9×10^2 CFU/m^3, while the three transactions were recorded as follows: Tz_1 6.4×10^2, Tz_2 6.1×10^2 and Tz_3 5.1×10^2 CFU/m^3 respectively. In the fifth week, at the end of the fattening period, the values were as follows: Tz_0 4.8×10^3, Tz_1 4.7×10^3, Tz_2 4.1×10^3, and Tz_3 3.8×10^3 CFU/m^3 respectively. The results show that there was a significant increase the control treatment in the fifth week, compared to the first week, and the concentration values ranged from 6.9×10^2 CFU/m^3 to 4.8×10^3 CFU/m^3**.** A significant decrease ($p<0.05$) in bacterial concentrations was observed in the three treatments, to which Syrian natural zeolite was added into the litter in all fattening periods; compared to the control group. In comparison to autumn, in the first week, the values were as follows: Tz_0 7.9×10^2, Tz_1 7.7×10^2, Tz_2 7.4×10^2 and Tz_3 7.1×10^2 CFU/m^3 respectively, whereas the values of the concentrations in the fifth week were as

Table 3. Airborne concentrations (CFU/m^3) of *Escherichia coli* before and after adding Syrian natural zeolite to the broiler litter during spring and autumn seasons

Bacteria *Escherichia coli* concentrations MacConkey Agar (McC)								
Seasons	**Spring**				**Autumn**			
Age (weeks)	**Tz_0 (0%)**	**Tz_1 (25%)**	**Tz_2 (50%)**	**Tz_3 (75%)**	**Tz_0 (0%)**	**Tz_1 (25%)**	**Tz_2 (50%)**	**Tz3 (75%)**
1	6.9×10^{2a}	6.4×10^{2b}	6.1×10^{2c}	5.1×10^{2d}	$7.9.10^{2a}$	7.7×10^{2b}	7.4×10^{2c}	7.1×10^{2d}
2	9.1×10^{2a}	8.8×10^{2b}	7.9×10^{2c}	7.3×10^{2d}	1.3×10^{3a}	1.1×10^{3b}	2.8×10^{2c}	2.4×10^{2d}
3	1.5×10^{3a}	1.4×10^{3b}	1.2×10^{3c}	1.1×10^{3d}	1.9×10^{3a}	1.6×10^{3b}	1.4×10^{3c}	1.2×10^{3d}
4	4.1×10^{3a}	3.6×10^{3b}	3.2×10^{3c}	1.9×10^{3d}	6.2×10^{3a}	6.0×10^{3b}	5.8×10^{3c}	5.1×10^{3d}
5	4.8×10^{3a}	4.7×10^{3b}	4.1×10^{3c}	3.8×10^{3d}	8.4×10^{3a}	8.1×10^{3b}	7.7×10^{3c}	7.5×10^{3d}

Treatment groups: Tz_0 (0%) Control = broiler litter (sawdust) without Syrian natural zeolite, $Tz_{1=}$ (25%), $Tz_{2=}$ (50%) and Tz_3 (75%) = broiler litter with Syrian natural zeolite in different ratio (sawdust: zeolite), ^{a,b,c,d} Means in the same row with significant differences among averages ($p<0.05$)

follows: Tz_0 8.4×10^3, Tz_1 8.1×10^3, Tz_2 7.7×10^3 and Tz_3 7.5×10^3 CFU/m^3 respectively. The results show that there was a significant increase in the control treatment in the fifth week, compared to the first week, and ranged between 7.9×10^2 CFU/m^3 to 8.4×10^3 CFU/m^3.

In this study, the concentrations of *Escherichia coli* in the air of the broiler house were relatively small numbers, compared to *Staphylococcus* ssp. As shown in Table 3. in spring, in the first week, the concentration values of the *E. coli*, were recorded in the control treatment 6.9×10^2 CFU/m^3, and in the fifth week were noted 4.8×10^3 CFU/m^3, while in autumn in the first week 7.9×10^2 CFU/m^3 and in the fifth week 8.4×10^3 CFU/m^3. And in Wroclaw, Poland, the greatest number of these bacteria occurred in spring ranged from 5.2×10^3 CFU/m^3 to 1.9×10^4 CFU/m^3 and the lowest number were noted in autumn 5.0×10^0 CFU/m^3 [14]. Similar results were observed by [16,39]. While, in the results of this study for emissions of the *E. coli*, the largest values were noted in autumn; and the lowest in spring. Many studies indicated that the bacterial content of the air of the broiler farms was mostly Gram-positive bacteria, high numbers of pathogenic *Staphylococcus* ssp. such as (*Monococcus, Diplococcus, Streptococcus, Staphylococcus*), and their number increases with the increase in the age of the birds [2,19,20,21,22]. The *Staphylococcus* spp. are considered as an indicator of the general bacterial content in the air, which can represent up to 90% of it [1,16,20,40,41]. These values are consistent with the following studies, Kaunas, Lithuania [42], Netherlands [43], Bulgarian [44], Hannover German [45] and Northern Europe [46]. In Wroclaw Poland, on the other hand, *Staphylococcus* spp. were the most numerous organisms in all seasons, and formed about 81% of the local microbial community [14], whereas *Escherichia coli*. Prevailed among the Gram-negative bacteria. Their rates were 1 to 4% of the general bacterial content in all of Poland [47], Zagreb, Croatia [16], Northern Europe and Denmark [48].

5. CONCLUSIONS

In general, *Staphylococcus* ssp. and *E.coli*. were present at all times during the fattening period and the lowest concentration was noted in spring compared to autumn. And the Syrian natural zeolite led to a significant decrease of airborne bacteria at the three treatment groups (Tz_1, Tz_2 and Tz_3), compared to the control group (Tz_0), in both season. Thus, treatment (Tz_3) outperformed the rest of the other treatments. This provides a guide to the optimal use of the different ratios, and development of new ways to reduce the airborne microorganism. For that reason, the Syrian natural zeolite had contributed to an effective management practice, capable of reducing biological pollution. Moreover, the results obtained in this study that can be used as a standard for the level of permissible concentrations of microorganisms in broiler farms to ensure healthy and productive conditions and less significant damages and losses caused by bio pollution in the broiler industry.

Therefore, we recommend further research in this field, adding different levels of Syrian natural zeolite to the broiler litter. It is of great importance to protect the broiler farms from bio pollution, to ensure the safe of the air from this pollution, that negatively affects on the health and production of birds and workers, when spread in the litter and in the atmosphere of the barn, which may lead to health risks when released to the outdoor environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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