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Effect of Different Levels of Aqueous Suspension of Bentonite Nanoparticles on Performance and Carcass Characteristics of Broiler Chickens

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ABSTRACT

The study aimed to investigate the impact of different concentrations of aqueous suspension of bentonite nanoparticles (ASBN) on the productive performance of broiler chickens. The research was conducted at the University of Jordan poultry farm in Almuwaqar research station. A total of 240 Ross 308 broiler chickens were distributed among four treatments, with three replicates per treatment. Treatment T1 was the control, while T2, T3, and T4 received 1%, 2%, and 3% of ASBN, respectively. The study found that the use of ASBN at levels of 1%, 2%, and 3% significantly ($p>0.05$) improved the growth performance of broiler chickens. The lowest feed conversion ratio (FCR) was observed in T2 (1% ASBN) on day 28, indicating better feed efficiency. However, carcass characteristics parameters, such as dressing and cut percentages, were not significantly influenced by ASBN treatment. Interestingly, T4 (3% ASBN) resulted in a higher weight of the breast compared to the other treatments. The study concluded that using ASBN at levels of 1%, 2%, and 3% can enhance the growth performance of broiler chickens without negative impacts on their carcass characteristics.

Keywords: Bentonite nanoparticles, Broiler chickens, Carcass characteristics, Performance.

INTRODUCTION

The poultry industry is one of the most important pillars of food security in Jordan. This sector provides achievable and affordable animal protein and it is considered the main source of protein all over the world. Nanotechnology is an advanced tool to solve uncertain facts or unsolved scientific problems related to chemistry, physics, biology, and medicine. Scientists have defined nanotechnology based on the fact that related to the measurements of nanometers (Ramirez and Hernandez, 2010; Buzea *et al.*, 2007 & Scott, 2005). The nanotechnology in these previous fields is still very limited. Recently, nanotechnology has the potential to solve mysteries objectives in animal production and health (Patil, *et al.*, 2009). In the poultry industry, nanotechnology can be applied to enhance feed efficiency, reduce disease transmission, and improve the quality and safety of poultry products. Overall, nanotechnology has great potential to enhance the productivity, sustainability, and profitability of the poultry industry (Sadr *et al.*, 2023).

Bentonite is a natural safe clay material, abundant in Jordan with low cost, and convenient for use in animal feed. The antibacterial properties of bentonite have been confirmed (Martsouka *et al.*, 2021). Due to their healing and antimicrobial properties, bentonites are widely used

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in the pharma, cosmetics, and agriculture industries (Srasra *et al.,* 2020). Their antibacterial activity came from their very high cation exchange capacity, high surface area, high swelling capacity, high water dispersibility, high absorption capacity, and non-toxic properties (Martsouka *et al.,* 2021). There are several biological mechanisms by which clay minerals are used in broiler chicken nutrition for numerous reasons, improve birds' performance, and intestinal health, improve the enzymatic activity in the digestive tract, ammonia emission control, and comprising toxin binding (Swain *et al*., 2016; Bailey *et al.,* 2006; Xia *et al.,* 2004, and Lee *et al.,* 2003).

Nanoclay minerals have been a unique additive possessing sizeable surface area, higher porosity, strong cation exchange activities, and more active sites (Al-Beitawi *et al.,* 2017a). In addition, nano clay minerals at particular levels would improve the growth performance of broiler chickens (Elshuraydeh *et al.,* 2014).

Nanotechnology is a promising new tool for improving broiler production; however, additional studies are needed in this field (Elshuraydeh *et al.,* 2014). Nanoclay minerals are used for the enhancement of intestinal nutrient digestion and absorption (Martsouka *et al.,* 2021). Improved performance could be attributed to enhanced nutrient digestibility and retention (Al-Beitawi *et al.,* 2017b). Overall, the use of nanotechnology in broiler production has great potential to improve the productivity, efficiency, and sustainability of the industry. Therefore, the objective of this study was to investigate the effect of using different levels of aqueous suspension of bentonite nanoparticles (ASBN) on the productive performance and carcass characteristics of broiler chickens.

Materials and Methods

Study location, animals, and experimental design

This study was conducted at the University of Jordan poultry farm in Almuwaqar research station. Two hundred and forty, one-day-old (Ross 308) broiler chickens were distributed to four treatments (T), each treatment had three replicates with 20 birds/replicate. Birds were reared on floor pens at the poultry house. Feed and water were provided ad libitum. The rearing period was divided into 2 phases: starter diet (1-14 days) and grower diet (15-28 days). Regular commercial broiler diets were provided for all treatments. Diet composition is shown in Table 1.

Table (1). Basal diet composition and nutrient content.

Ingredients	unit	Starter (1-14 d)	Grower (15- 28d)
Corn	kg	579.4	616.7
Soy Bean Meal	kg	370	335
Soy oil	kg	14	15
Limestone	kg	14	14
Lysine Sulphate	kg	3.1	2.3
Mono calcium phosphate	kg	7	5.5
Salt	kg	2	2
Sodium Bicarbonate	kg	1.5	1.5
Threonine	kg	1.3	1
Methionine	kg	3.5	3
L- Valine	kg	0.1	0
Broiler Mineral Premix	kg	1	1
Choline Chloride 70%	kg	0.4	0.4
Betaine HCl	kg	0.3	0.3
Broiler Vitamins Premix	kg	1.1	1
Mycotoxin binder	kg	1	1
Avizyme 1505	kg	0.2	0.2
Axtraphy 10000	kg	0.1	0.1
Total kg		1000.000	1000.000
Calculated Analysis			
Metabolizable Energy	Kcal/ Kg	3,100.00	3,150.00

Crude Protein	%	23	21.5
Crude Fat	%	4.5	4.7
Crude Fiber	%	2.3	2.3
Calcium	%	1	0.95
Avi.Phosphorus	%	0.48	0.435
Dig.Lysine	%	1.28	1.15
Dig.Methionin	%	0.51	0.59
Dig.Methionin +Cysteine	%	0.95	0.87
Dig.Threionin	%	0.86	0.77
Dig. Valine	%	0.96	0.87
Sodium	%	0.16	0.16
Chloride	%	0.19	0.19

Aqueous suspension of bentonite nanoparticles was provided in drinking water once per week for 4 hours in the intended treatments (T2, T3, T4), while T1 was left as control. The different bentonite nanoparticle levels (1%, 2%, and 3%) were added to the tap water, while T1 (control) was provided with blank water at the same time of treatment. The bell drinkers were pulled out in front of all treatments (including the control) for 2 hours before offering the aqueous suspension of bentonite nanoparticles (ASBN) or the tap water for the control. The required amounts of ASBN were offered to chick drinkers for 4 hours, while the amount of drinking water was adjusted according to the bird's age. The ASBN was provided in the chick drinkers (not in the bell drinkers), once per week, for 4 hours, and this practice was repeated every week till the end of the experiment. The ASBN was given for the first time at 5 days of age, then repeated on days 12, 19, and 26 of age. Mortality was registered weekly and used to calculate the corrected feed conversion ratio. Bird weight and feed intake were measured weekly for each replicate and corrected FCR was calculated as well. On day 28, two birds from each replicate were randomly selected and slaughtered. Live weight, hot carcass weight, weight of breast, spleen, liver, gizzard, and heart were taken for each bird and cuts were weighed for each bird, and each cut percentage was calculated relative to body weight. Statistical analysis was conducted by using the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 2004). LSD test was used to compare means of significant effects at $p < 0.05$.

Aqueous suspension of bentonite nanoparticles preparation

Bentonite was obtained from the Al-Azraq area in Jordan through (Al-Bustami Corporation, Amman/Jordan). The chemical composition of bentonite used in this study is shown in Table 2.

Table (2). Chemical composition* of bentonite

Content	**(%)**
Fe_2O_3	5.86
MnO	0.035
TiO_2	1.01
CaO	3.54
K_2O	2.66
P_2O_5	0.085
SiO_2	54.85
AL_2O_3	11.70
MgO	3.85
Na_2O	1.23
CL	0.093
SO_3	0.177
L.O.I	14.60

* Provided by the Natural Resources Authority/ Laboratories Directorate, Amman-Jordan

Bentonite was converted to nanoscale at the Jordan University of Science and Technology – nanoinstitute. The production of nanoparticles was achieved through a ball milling machine and a ball milling producer. The jar was filled with a powdered sample, and then balls of suitable size and number comparable to the powder (comparable to hardness) were added. The program of

milling was set at 800 rpm, 20 cycles, 3 minutes for each cycle. Bentonite nanoparticles were reduced to 100 nm. The particle size of bentonite was confirmed using a scanning electron microscope (SE image 600.000X- 200 nm) as shown in Figure 1.

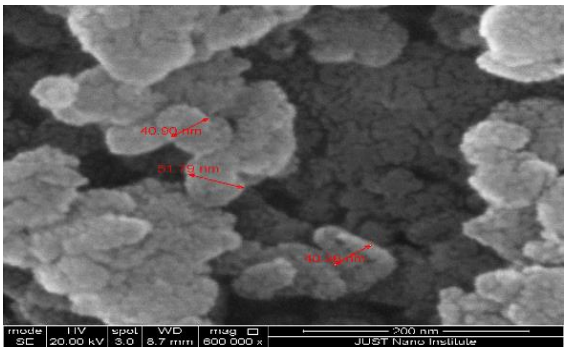

Figure (1): Image of bentonite nano at Scanning Electron Microscope (SEM).

In this experiment, the bentonite nanoparticles were mixed with drinking water to create solutions with different concentrations. The concentrations used were 1%, 2%, and 3%, which correspond to 10g, 20g, and 30g of bentonite nanoparticles per 1000 ml of water, respectively. nano-silica

Result and Discussion

Body weight and weight gain

The results showed a significant difference at ($P< 0.05$) in bird body weight gain (BWG) between the treatments at day 28 of the rearing periods. On day 28 the highest significant weight gain was for T3 (2% ASBN) which was (1207.33g) as shown in Table 3.

Table (3): The effect of feeding different levels of ASBN on the production performance of broiler chickens.

Parameter	T1	T2	T3	T4
Body Weight Day 7 g	171.567	175.600	168.900	169.667
Body Weight Day 14 g	518.07	510.90	506.60	496.03
Body Weight Day 28 g	1632.37 ^{b}	1676.83 ^{a}	1713.90 ^{a}	1652.67 ^{a}
Body Weight gain Day 14 g	476.67	472.70	467.60	458.73
Body Weight gain Day 28 g	1114.23 ^{b}	1165.93 ^{ab}	1207.33 ^{a}	1156.70 ^{a}
Total Body Weight gain g	1590.97	1638.63	1674.90	1615.37
Average feed intake day 14 g	475.87	474.33	487.33	469.20
Average feed intake day 28 g	1557.00	1484.57	1572.37	1515.53
Total Average feed intake g	2032.87	1958.87	2059.70	1984.70
FCR Day 14	0.998	1.003	1.042	1.023
FCR Day 28	1.397 ^{b}	1.274 ^{a}	1.303 ^{a}	1.310 ^{a}
Total FCR	1.277 ^{b}	1.196 ^{a}	1.230 ^{a}	1.228 ^{a}
Mortality Rate % Overall (D1 – D28)	6.6 ^{a}	3.3 ^{b}	5 ^{b}	0 ^{b}

a,b- means with different letters in the same raw are significantly different at $p\leq0.05$

T1: control. T2: % ASBN. T3: 2% ASBN. T4:3% ASBN.

This result was similar to Al-Beitawi *et al.*, (2017b) found that the use of 2% nano clay minerals as fed significantly improved broilers' performance in terms of live body weight, and body weight gain compared to control groups. However, the use of a 2% concentration of the Aqueous Nanosuspension of clay minerals

significantly improved the growth performance of broiler chickens in terms of the live body weight LBW and BWG (Al-Beitawi *et al.*, 2017a and Elshuraydeh *et al.*, 2014). The results are consistent with Ghazalah *et al.*,. (2021) reported that the use of nano-silica at 0.20% and bentonite at 0.50% improved growth performance in broiler chickens.

Feed Intake and Feed Conversation Ratio

There were no significant differences between 1%, 2%, and 3% of ASBN on feed intake in the control groups as shown in Table 3. There were significant differences between the treatment in feed conversation ratio (FCR) between control and ASBN treated chichen, for the overall rearing period 1.277, 1.196,1.230, and 1.228, for the T1, T2, T3, and T4, respectively. The role of ASBN in improving the gut health and mucosal structure. This would be also attributed to the ability of nanoparticles to bind with the pathogenic microbes that may be established in the gut of broiler chickens. This result was in agreement with Al-Beitawi *et al.*, (2017a) who reported that the use of the aqueous nanosuspension of clay minerals significantly improved the FCR of broiler chickens. Also, Al-Beitawi *et al.*, (2017b) observed an improvement in FCR when broilers were fed 2% nano clay minerals compared to control groups. Ghazalah *et al.*, (2021) showed that the best FCR value was recorded with treatment supplemented with commercial nano clay (bentonite 0.50%) followed by those having 0.05% and 0.10% of NS, compared with the control group at the period of 29–35 days of age. These results may be attributed to the beneficial properties of nano bentonite: high absorption capacity, improvement in the enzymatic activity of the digestive tract, increased pH, and lowering the viscosity of fluids.

There were no significant differences between 1%, 2%, and 3% of ASBN on feed intake in the control groups. On the other hand, Ghazalah *et al.*, (2021) showed that there was significantly increased feed intake with the addition of bentonite 0.50% during 29–35 days compared to all the treatments. Karomy and Maged. (2021) reported that the Sodium Bentonite (SB) at 1, 2 % alone, and 1 % SB + 1 % aluminum silicate can be used in pelleted-making diets to improve growth performance, decrease feed intake, and enhance feed efficiency ratio. Increased protein digestibility, mean protein efficiency ratio and viscosity, production index, and serum protein were observed in broiler chickens.

Carcass characteristics

Results for carcass characteristics parameters (dressing and cuts percentages) are presented in Table 4.

Table (4): The effect of feeding different levels of ASBN on carcass cuts percentage to carcass weight.

Parameter	T1	T2	T3	T4
Dressing percentage	68.083	68.183	68.983	69.716
Breast percentage	37.050 ^{ab}	36.383 ^{b}	38.750 ^{ab}	39.417 ^{a}
Liver percentage	22.950	21.783	21.600	22.950
Heart percentage	4.650	4.667	4.967	5.200
Spleen percentage	1.167	1.150	0.933	1.033
Gazzird percentage	16.467	16.667	16.333	15.133

Means with the same letter in the same raw are not significantly different at $p \leq 0.05$

T1: control. T2: % ASBN. T3: 2% ASBN. T4:3% ASBN.

The values of the dressing, lever, heart, spleen, and gizzard did not significantly increase in birds. Also, the use of the T4 (3% ASBN) increased the weight of the breast compared to other treatments. The results are consistent Ghazalah et al. (2021) observed that the supplementation of nanosilica and bentonite had no significant effects of dietary treatments on carcasses, abdominal fat, bursa, thymus, and relative organ weight (liver, heart, gizzard, and spleen). Al-Beitawi *et al.,* (2017b) reported that the use of 1.5% of nano clay minerals (T3) in broiler chickens' diet at day 28 of age offered once a week increased liver, gizzard, heart, and pancreas percentage compared to C1, C2, C3, and other dietary treatments. However, 2% of nano clay minerals offered once a week only increased spleen percentage compared to other dietary treatments. Al-Beitawi *et al.,* (2017a) found that the values of the dressing, breasts, thighs, and drumsticks significantly increased in birds receiving the nanosuspensions of clay minerals (2%). The dressing and cuts percentages were 73.45, 28.25, 12.88, and 10.71 for the dressing, breast, thigh, and drumstick, respectively.

Mortality rate

Daily mortalities were recorded for each replicate within treatment. Then the weekly mortality rate was calculated as the number of dead chicks subtracted from the number of live chicks at the beginning of that week shown in Table 3. The mortality rate was significantly lowered in all ASBN-treated groups compared with the control group.

Conclusion

In conclusion, the addition of ASBN in drinking water for 1 time per week to broiler enhances the feed conversion ratio, increases body weight gains, and reduces the mortality rate. This would be due to the significance of nano bentonite's beneficial properties such as the high capacity for absorption, the ability of nanoparticles to bind with pathogens, a large surface area for layers, improvement in the enzymatic activity of the digestive tract, and increasing the pH and lowering the viscosity of fluids. However, these activities were beyond the scope of this study and it is highly recommended to be measured in future studies.

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تأثير مستويات مختلفة من المعلق المائي لجزيئات البنتونايت النانوية على الأداء وخصائص الذبيحة للدجاج اللاحم

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ملخص

هدفت هذه الدراسة الى تحديد تأثير استخدام تركيزات مختلفة من المعلق المائي لجسيمات البنتونايت النانوية ASBN على الأداء الإنتاجي للدجاج اللاحم. تم اجراء البحث في مزرعة دواجن الجامعة الأردنية بمحطة أبحاث الموقر. تم توزيع مئتان واربعون صوصا عمر يوم نوع (روس 308) على أربعة معاملات لكل معاملة ثلاثة مكررات. كانت المعاملة الاولى ((T1معاملة الشاهد، اما المعاملة الثانية والثالثة والرابعة T2 وT3 وT4 اخذت مادة البنتونايت النانوية التي تم اضافتها مع مياه الشرب بتراكيز (1% و2% و3%) على التوالي، حيث تم تربية القطيع لمدة ثمانية وعشرون يوم، كان يتم تسجيل مؤشرات اداء الطيور اسبوعيا طوال فترة التجربة. أظهرت النتائج أن استخدام مادة البنتونايت النانوية بمستويات 1٪ و 2٪ و 3٪ في مياه الشرب أدى إلى تحسين معنوي في أداء نمو الدجاج اللاحم، حيث لوحظ ان اقل نسبة تحويل علفي كانت في المعاملة الثانية T2 اشارة الى كفاءة علفية افضل وهي (1.196) عند اليوم 28, ومع ذلك فان مؤشرات خصائص الذبيحة مثل نسب الجلد واللحم لم تتاثر في معاملات ال ASBN.ومن المثير للاهتمام, تبين انه هنالك زيادة في وزن صدر الدجاج في المعاملة T4 مقارنة بالمعاملات الاخرى. وتخلص الدراسة الى أن استخدام ASBN بمستويات 1% و2% و3% يمكن أن يعزز أداء نمو دجاج التسمين دون آثار سلبية على خصائص الذبيحة.

الكلمات الدالة: جزيئات البنتونايت النانوية، دجاج التسمين، الأداء، خصائص الذبيحة.

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