Comparing the Effects of Supplementary Antibiotic, Probiotic, and Prebiotic on Carcass Composition, *Salmonella* Counts and Serotypes in Droppings and Intestine of Broiler Chickens

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**Abstract**

The effects of antibiotic, probiotic, and prebiotic as dietary feed additives on carcass composition as well as *Salmonella* counts and its serotypes in droppings and intestine of broiler chickens on days 1, 28, and 56 of experiment were investigated. Dietary treatments were control diet (basal diet without additives), OXYT diet (basal diet with 600 ppm of the antibiotic oxytetracycline), GRO-UP diet (basal diet with 500 ppm probiotic), and MOS-500 or MOS-1000 diets (basal diet with 500 or 1000 ppm mannan oligosaccharide prebiotic, respectively). From an initial total of 190 day-old Arbor acres broiler chicks, two birds were randomly selected from each treatment and sampled for *Salmonella*. The remaining 180 birds were randomly allotted to the five dietary treatments with three replicates of 12 birds each. Feed and water were supplied ad libitum. The results indicated that breast, neck, drumsticks and liver yields significantly affected by the inclusion of feed additives (*P* < 0.05). Significant differences were observed in average *Salmonella* counts in both the intestines and droppings of broiler chickens at different days of experiment (*P* < 0.05). *Salmonella* Gallinarum and *Salmonella* Typhi were serotypes identified in the droppings and intestine of broiler chickens. Our findings reveal that the inclusion of prebiotic oligomannno or probiotic GRO-UP as antibiotic substitutes in diets of broiler chickens can rapidly reduce some *Salmonella* serotypes and aid to the control *Salmonella* organisms.

**Keywords**

Carcass  
Probiotic  
*Salmonella*  
Broiler chicken  
Mannan oligosaccharide

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**Introduction**

The benefits of broiler production cannot be over emphasized in the face of rising demand for animal protein in many developing countries. To maximize production, broilers must be free from diseases and fed appropriate diets that meet their nutritional requirements for optimal production (Tannock, 1998). Antibiotics are widely used in animal feed to boost animal performance and productivity. Tetracyclines (oxytetracycline and chlortetracycline) are arguably the most commonly used therapeutic antibiotics in food animal production (Fairchild *et al*., 2005).


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Oxytetracycline (OTC) is a broad spectrum antibiotic known as tetracyclines which were developed to enhance the control of bacterial infections (Alam, 2000). Stutz and Lawton (1984) showed that using 55 ppm OTC improved growth performance and reduced the ileum weight of chicks. Zulkifli et al. (2000) demonstrated that chicks given diets supplemented with 50 mg/kg OTC during 21-42 days of age increased body weight gain (BWG) but the antibody produced against Newcastle disease virus (NDV) was not affected. Talabi et al. (2013) also documented the use of OTC powder in feed of broiler chicks at 0.05 g/kg as a growth promoter. However, at low levels of antibiotic administration, resistant microbial cells survive and develop resistance (Huygebaert et al., 2011; Toghyani et al., 2011).

As a result, other feed additives such as prebiotics and probiotics have been suggested for animal feeding. They are increasingly adopted as antibiotic substitutes to improve performance and gut health in poultry and pigs (Higgins et al., 2008; Marković et al., 2009). Probiotics are live microbial feed supplements that enhance intestinal health (Fuller, 1989). Prebiotics are indigestible food ingredients that selectively induce growth of one or more bacterial population in the colon (Gibson and Roberfroid, 1995). Mohammad Gheisar et al. (2016) concluded that the inclusion of prebiotic (e.g. lactulose) improves growth performance and alters excreta microbial populations with no adverse effect on broiler chickens. Nonetheless, more work is needed to establish useful relationships in prebiotic and probiotic supplementation and poultry performance. The objective of the current study is to compare the effects of prebiotic, probiotic, and antibiotic supplementation on carcass composition, and Salmonella counts and their serotypes in droppings and intestine of broiler chickens.

Materials and Methods

Experimental location

The experiments were conducted at the Poultry Unit of the Directorate of University Farms (DUFARMS) of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The area lies within the rainforest zone of South-Western Nigeria (7°10′37″N, 3°26′58″E) at an altitude of 173 m above sea level. The climate is humid with a mean annual rainfall of 1037 mm. The mean annual temperature and humidity are 34.7°C and 82%, respectively (Google Earth, 2013).

Animal management and experimental diets

All procedures used in this study were approved by the Animal Management Committee of the Federal University of Agriculture, Abeokuta and in accordance with the guidelines for care and use of animals in research (FASS, 2010). A total of 190 day-old broiler chicks (Arbor acres strain) were sourced from a reputable hatchery in Abeokuta, Ogun state, Nigeria. The birds were weighed and randomly allotted to five dietary treatments including control diet (basal diet without additives), OXYT diet (basal diet with 600 ppm of the antibiotic oxytetracycline), GRO-UP diet (basal diet with 500 ppm probiotic), and MOS-500 or MOS-1000 diets (basal diet with 500 or 1000 ppm mannan oligosaccharide prebiotic, respectively, with three replicates of 12 broiler chickens. Two birds were randomly selected from each treatment group and sampled for Salmonella. The chicks were subjected to standard brooding in a deep litter system. At the starter phase (0-4 weeks), birds were fed with formulated broiler starter diet (23.01% CP and 2856 ME Kcal/kg) while at finisher phase (5-8 weeks), they were fed with broiler finisher diet (20.71% CP and 2911 ME Kcal/kg). Fresh water and feed were supplied ad libitum. Routine vaccination and medications were administered to the birds accordingly.

Probiotic GRO-UP™ was supplied by Bio Ingredients Ltd., Lagos, Nigeria with the composition of Saccharomyces cerevisiae: 1.5 × 10^{11} cfu/kg, Lactobacillus sporogenes: 3 × 10^{9} cfu/kg and fortified with phytase phosphorus, proteins, calcium and carbohydrates. Prebiotic oligomannno® (Mannan oligosaccharide) was supplied by Yonichi Chemical Institute Co., Ltd. Machikita 9-25, Moriyama-Ku, Nagoya, Japan and composed of hydrolyzed Guar gum fiber. The composition of the experimental basal diet is presented in the Table 1.
Table 1. Ingredients and chemical composition of basal diet (as - fed basis)

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>Starter (Weeks 0-4)</th>
<th>Finisher (Weeks 4-8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>50.66</td>
<td>55.00</td>
</tr>
<tr>
<td>Wheat offal</td>
<td>5.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Fish meal (72% CP)</td>
<td>3.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>24.24</td>
<td>18.00</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>10.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Palm kernel cake</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>Bone meal</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Oyster shell</td>
<td>1.00</td>
<td>2.75</td>
</tr>
<tr>
<td>Lysolecithin</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Methionine + Cystine</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>Available phosphorus</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>1.20</td>
<td>1.80</td>
</tr>
</tbody>
</table>

Calculated analysis

- Metabolizable energy (Kcal/kg): 2856
- Crude protein (%): 23.01
- Lysine (%): 1.30
- Methionine (%): 0.60
- Methionine + Cystine (%): 1.00
- Available phosphorus (%): 0.50
- Calcium (%): 1.20


Sample collection

Bird droppings were collected from two birds per replicate three times (on days 1, 28 and 56 of experiment) by collecting from the cloaca using a sterile glass rod. Intestines scrapings were also collected from two birds per replicate after slaughter. Both droppings and intestinal scrapings were analyzed for Salmonella isolation/screening and population studies.

Salmonella count

2 g of each sample was homogenized in 20 mL of Selenite F broth and 1 mL of the homogenate was added to 9 mL of Selenite F broth. 9 mL of Selenite F broth was then placed in six sterile tubes and serial diluted to 10⁻⁶-fold. 1 mL of the final diluent was spread on a dried Xylose Lysine Desoxycholate (XLD) Agar and incubated at 37 ± 1°C for 24 hrs. Colonies identified as Salmonella were counted and estimated as follows:

Let X be total number of colonies counted.

Weight of sample ~ 2 g; Volume used for culture ~ 2/20 = 1/10; Dilution used for culture ~ 10⁻⁶

Total colony forming unit (cfu) = X × 10⁻⁶× X = X × 10⁻⁶/cfu/mL

Since, 2g of sample was put into 20 mL of peptone water = 2/20 = 0.1g/mL.

Then, 0.1 g = X × 10⁶ cfu of isolates

1 g = X × 10⁶× 1 = X × 10⁶

0.1

Pre-enrichment, Salmonella isolation and screening

Salmonella isolation and screening were carried out at the Veterinary Microbiology Laboratory of the College of Veterinary Medicine, Federal University of Agriculture, Abeokuta, Nigeria. The representative samples (droppings and intestine) were transferred separately into a non-selective medium (Buffered Peptone Water, BPW agar) for pre-enrichment, then incubated at 37°C ± 1°C for 16-20 hours (Hendriksen, 2003).

Selective enrichment

0.1 mL of the pre-enriched sample was transferred into 10 mL of Rappaport-Vassiliadis R10 Broth with soya peptone (RVS) medium and incubated at 41.5 ± 1°C for 24 ± 3 hrs. The sample was then inoculated with a sterile loop onto plates containing Xylose Lysine Desoxycholate (XLD) Agar and Brilliant Green Agar (BGA) so that colonies were well isolated. The inoculated petri dishes were inverted and transferred to an incubator at 37 ± 1°C for 24 ± 3 hrs. Typical colonies of Salmonella grown on XLDA had a black centre and a lightly transparent zone of...
reddish colour due to the colour change of the indicator. Typical colonies of Salmonella on BGA appeared pink measuring 1 mm to 2 mm in diameter and caused the colour to change to red. Suspected colonies were streaked onto pre-dried nutrient agar plates and incubated at 37 ± 1°C for 24 ± 3 hrs and the cultures were further used for confirmatory tests (Rappaport et al., 1956; Vassiliadis et al., 1978; Peterz et al., 1989).

Identification of Salmonella serotypes

Motility test
Motility test was carried out to determine the motility of the Salmonella organisms (i.e. motile or non-motile).

Biochemical test
Serotypes were biochemically identified using a kit (Oxoid microbat 24E). The Oxoid microbat 24E kit contains the following reagents: H2S (hydrogen sulphide gas), to determine the ability of the Salmonella organisms to produce H2S; glucose, to determine the ability of the Salmonella organisms to ferment glucose and consequently producing acid and gas; mannitol, to determine the ability of the Salmonella organisms to ferment mannitol; O-Nitrophenyl-β-D-galactopyranosidase, to determine the presence of enzyme β-galactosidase by utilizing O-Nitrophenyl-β-D-galactopyranosidase to differentiate late lactose fermenting Salmonella organisms from non-lactose fermenting organisms; xylose, to determine the ability of the Salmonella organisms to ferment xylene sugar; indole test, to determine the ability of Salmonella organisms to split indole from tryptophan present in peptone water; and urease test, to determine the ability of Salmonella organisms to produce enzyme urease as this will split urea to form ammonia and CO2 (Hendriksen, 2003; Collins et al., 2004; Park et al., 2009; Nataro et al., 2011; PHE, 2015).

Carcass yield evaluation
At week eight of the experiment, 30 birds (2 birds per replicate) were randomly selected, weighed, and slaughtered. Scalding was done at 60°C following standard commercial procedures (Jensen, 1984), then evisceration. Dressed weight was determined. Parts such as head, neck, shank, thigh, drumstick, back, breast weight and visceral organs (gizzard, intestines, liver, heart and kidney) were weighed. The weights of the various parts were expressed as percentage of the live weights.

Statistical analysis
Data obtained were subjected to Analysis of Variance (ANOVA) in a Completely Randomized Design (CRD) using SAS (2003). Significant means among variables were separated using Duncan’s Multiple Range Test.

Results
The effects of dietary feed additives on carcass composition of broiler chickens are presented in Table 2. There were significant (P < 0.05) differences in the weights of breast, neck, drumsticks, and liver. Breast and drumstick weights were similar between the control, OXYT, and GRO-UP treatments. Birds in both MOS-500 and MOS-1000 groups had the lowest (P < 0.05) breast weight and drumsticks. Birds fed OXYT and GRO-UP diets had the greatest neck weights while the lowest weight was found in birds fed MOS (500 ppm) diets. Birds fed OXYT diets had the highest (P < 0.05) liver weight while birds fed the control diet had the lowest. However, there was an insignificant difference between dressing percentage of treatments.

Salmonella counts in droppings of broiler chickens were significantly different between dietary treatments at different intervals (P < 0.05; Table 3). The initial count in all droppings ranged from 5.50 to 6.50 cfu × 106/g though there was a reduction in colony counts in all treatments over time. The total colony counts of Salmonella in the droppings of birds fed the control diet were higher (P < 0.05) than other treatments. Salmonella counts in droppings of birds fed OXYT, GRO-UP and MOS (1000 ppm) diets were lower than other treatments during the first four weeks of rearing. The highest (P < 0.05) count in droppings and the lowest percentage reduction (15.38%) was recorded in birds fed control diet. During the second four weeks, the lowest (P < 0.05) count in droppings and highest percentage reduction (95.45%) was recorded for birds fed MOS (1000 ppm) diets while the lowest percentage reduction (18.18%) was recorded for birds fed control diet. Overall, birds fed diets with MOS (1000 ppm) had the highest percentage reduction in average Salmonella counts (98.18%), followed by MOS (500 ppm) (92.31%), while birds fed the control diet had the lowest percentage reduction in Salmonella counts (30.77%).
while present at weeks 0 and 8 but absent at week 8 while Salmonella Typhi was present throughout the experiment. In the droppings of birds fed OXYT diets, Salmonella Gallinarum was present throughout the experiment while Salmonella Typhi was absent throughout the experiment. In the droppings of birds fed MOS-500 and MOS-1000 diets, Salmonella Gallinarum was present throughout the experiment while Salmonella Typhi was present at week 0 but absent at weeks 4 and 8 of the experiment. There were significant (P<0.05) differences in average Salmonella counts between dietary treatments in the intestine of broiler chickens at different intervals (Table 5). The initial count across all treatments ranged from 6.65 to 7.80 cfu × 10^6/g. However, there was a reduction in colony counts in all treatments by weeks 4 and 8. The total colony counts of Salmonella in the intestine of birds fed OXYT diets was higher (P<0.05) than other treatments. By the end of week 4, the Salmonella counts in the intestine of birds fed OXYT and MOS (500 ppm) diets were lower than other treatments (P<0.05). The highest (P<

### Table 2. Effects of dietary feed additives on carcass composition of broiler chickens (% live body weight)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>OXYT</th>
<th>GRO-UP</th>
<th>MOS (500 ppm)</th>
<th>MOS (1000 ppm)</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>2234.67</td>
<td>2107.00</td>
<td>2184.93</td>
<td>2114.8</td>
<td>2079.87</td>
<td>27.16</td>
<td>0.11</td>
</tr>
<tr>
<td>Dressing</td>
<td>68.03</td>
<td>62.90</td>
<td>64.45</td>
<td>66.73</td>
<td>64.51</td>
<td>0.84</td>
<td>0.24</td>
</tr>
<tr>
<td>Head</td>
<td>2.49</td>
<td>2.47</td>
<td>2.49</td>
<td>2.70</td>
<td>2.44</td>
<td>0.04</td>
<td>0.71</td>
</tr>
<tr>
<td>Shank</td>
<td>4.97</td>
<td>4.24</td>
<td>4.85</td>
<td>4.64</td>
<td>4.71</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>Thigh</td>
<td>10.74</td>
<td>11.09</td>
<td>11.54</td>
<td>10.62</td>
<td>10.06</td>
<td>0.22</td>
<td>0.45</td>
</tr>
<tr>
<td>Breast</td>
<td>18.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.41</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Back</td>
<td>17.35</td>
<td>16.20</td>
<td>15.99</td>
<td>17.05</td>
<td>17.12</td>
<td>0.31</td>
<td>0.72</td>
</tr>
<tr>
<td>Wings</td>
<td>8.83</td>
<td>9.18</td>
<td>8.98</td>
<td>8.46</td>
<td>8.87</td>
<td>0.12</td>
<td>0.33</td>
</tr>
<tr>
<td>Neck</td>
<td>3.16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.74&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.86&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.52&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.24</td>
<td>0.01</td>
</tr>
<tr>
<td>Drumsticks</td>
<td>10.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.21</td>
<td>0.03</td>
</tr>
<tr>
<td>Heart</td>
<td>0.44</td>
<td>0.53</td>
<td>0.44</td>
<td>0.54</td>
<td>0.48</td>
<td>0.02</td>
<td>0.58</td>
</tr>
<tr>
<td>Liver</td>
<td>1.97&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.09</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gizzard</td>
<td>1.76</td>
<td>2.24</td>
<td>2.01</td>
<td>2.08</td>
<td>1.75</td>
<td>0.08</td>
<td>0.75</td>
</tr>
<tr>
<td>Spleen</td>
<td>0.15</td>
<td>0.15</td>
<td>0.11</td>
<td>0.14</td>
<td>0.16</td>
<td>0.01</td>
<td>0.41</td>
</tr>
<tr>
<td>Lungs</td>
<td>0.54</td>
<td>0.63</td>
<td>0.56</td>
<td>0.58</td>
<td>0.52</td>
<td>0.24</td>
<td>0.23</td>
</tr>
<tr>
<td>Kidney</td>
<td>0.35</td>
<td>0.58</td>
<td>0.46</td>
<td>0.48</td>
<td>0.39</td>
<td>0.36</td>
<td>0.22</td>
</tr>
</tbody>
</table>

<sup>a</sup>Means on the same row having different superscripts are significantly different (P< 0.05).

<sup>b</sup>Control (No additive); OXYT: Oxytetracycline (antibiotics); GRO-UP (probiotics); MOS: Mannan oligosaccharide (prebiotics).

### Table 3. Effects of dietary feed additives on average Salmonella counts (cfu/g × 10<sup>6</sup>) in droppings of broiler chickens at different intervals

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control</th>
<th>OXYT</th>
<th>GRO-UP</th>
<th>MOS (500 ppm)</th>
<th>MOS (1000 ppm)</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 0</td>
<td>6.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.85&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.50&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Weeks 0-4</td>
<td>5.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.25&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.20&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Weeks 4-8</td>
<td>(5.58)</td>
<td>(64)</td>
<td>(58.93)</td>
<td>(57.26)</td>
<td>(60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in colonization (%) (Weeks 0-8)</td>
<td>30.77</td>
<td>88.89</td>
<td>80.35</td>
<td>92.31</td>
<td>98.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Means on the same row having different superscripts are significantly different (P<0.05).

Values in brackets indicate percentage reduction.

Control (No additive); OXYT: Oxytetracycline (antibiotic); GRO-UP (probiotic); MOS: Mannan oligosaccharide (prebiotic).

Table 4 shows the effects of dietary feed additives on Salmonella serotypes present in the droppings of broiler chickens at different time intervals. The results revealed that Salmonella Gallinarum and Salmonella Typhi were identified across all treatments. In the droppings of birds fed the control diet, Salmonella Gallinarum was present at weeks 0 and 4 but absent at week 8 while Salmonella Typhi was present throughout the experiment. In the droppings of birds fed OXYT diets, Salmonella Gallinarum was present throughout the experiment while Salmonella Typhi was absent throughout the experiment. In the droppings of birds fed GRO-UP supplemented diet, Salmonella Gallinarum was present at weeks 0 and 8 but absent at week 4 while Salmonella Typhi was present at weeks 0 and 4 but absent at week 8 of the experiment. In the droppings of birds fed MOS-500 and MOS-1000 diets, Salmonella Gallinarum was present throughout the experiment while Salmonella Typhi was present at week 0 but absent at weeks 4 and 8 of the experiment. There were significant (P<0.05) differences in average Salmonella counts between dietary treatments in the intestine of broiler chickens at different intervals (Table 5). The initial count across all treatments ranged from 6.65 to 7.80 cfu × 10^6/g. However, there was a reduction in colony counts in all treatments by weeks 4 and 8. The total colony counts of Salmonella in the intestine of birds fed OXYT diets was higher (P<0.05) than other treatments. By the end of week 4, the Salmonella counts in the intestine of birds fed OXYT and MOS (500 ppm) diets were lower than other treatments (P<0.05). The highest (P<
0.05) count in the intestine and the lowest percentage reduction (17.29%) was observed in birds fed control diet. By the end of week 8, Salmonella counts in the intestine of birds fed diets with feed additives were statistically similar and significantly lower than the control (P < 0.05). The highest percentage reduction was recorded for birds fed MOS (1000 ppm) diets (60%) followed by MOS (500 ppm) (50%), while the lowest percentage reduction was recorded for birds fed control diet (14.55%). Overall, birds fed diets with MOS (1000 ppm) had the highest percentage reduction in the Salmonella counts (86.11%), followed by MOS (500 ppm) (83.01%), while the control diet had the lowest percentage reduction in salmonella count (29.32%).

### Table 4. Effects of dietary feed additives on Salmonella serotypes present in the droppings of broiler chickens at different intervals

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Week 0</th>
<th>Week 4</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S. Gallinarum</td>
<td>S. Typhi</td>
<td>S. Gallinarum</td>
</tr>
<tr>
<td>Control</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>OXYT</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>GRO-UP</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MOS (500 ppm)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>MOS (1000 ppm)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*: present; -: absent;
Control (No additive); OXYT: Oxytetracycline (antibiotics); GRO-UP (probiotics; MOS: Mannan oligosaccharide (prebiotics).

### Table 5. Effects of dietary feed additives on average Salmonella counts (cfu/g × 10^6) in the intestine of broiler chickens at different intervals

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control</th>
<th>OXYT</th>
<th>GRO-UP</th>
<th>MOS (500 ppm)</th>
<th>MOS (1000 ppm)</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 0</td>
<td>6.65^d</td>
<td>7.80^a</td>
<td>7.65^b</td>
<td>6.80^a</td>
<td>7.20^b</td>
<td>0.13</td>
<td>0.04</td>
</tr>
<tr>
<td>Weeks 0-4</td>
<td>5.50^-</td>
<td>2.25^c</td>
<td>2.80^c</td>
<td>2.30^c</td>
<td>2.50^-</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Weeks 4-8</td>
<td>4.70^c</td>
<td>1.35^b</td>
<td>1.60^b</td>
<td>1.15^b(50%)</td>
<td>1.00^b(60%)</td>
<td>0.38</td>
<td>0.01</td>
</tr>
</tbody>
</table>

% Reduction in colonization (Weeks 0-8) 29.32 82.69 79.08 83.09 86.11

^a-bMeans on the same row having different superscripts are significantly different (P < 0.05).
Values in brackets indicate percentage reduction.
Control (No additive); OXYT: Oxytetracycline (antibiotics); GRO-UP (probiotics); MOS: Mannan oligosaccharide (prebiotics).

### Table 6. Effects of dietary feed additives on Salmonella serotypes present in the intestine of broiler chickens at different intervals

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Week 0</th>
<th>Week 4</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S. Gallinarum</td>
<td>S. Typhi</td>
<td>S. Gallinarum</td>
</tr>
<tr>
<td>Control</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>OXYT</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>GRO-UP</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>MOS (500 ppm)</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>MOS (1000 ppm)</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

*: present; -: absent;
Control (No additive); OXYT: Oxytetracycline (antibiotics); GRO-UP (probiotics; MOS: Mannan oligosaccharide (prebiotics).

Table 6 shows the effects of dietary feed additives on Salmonella serotypes present in the intestine of broiler chickens at different time intervals. Salmonella Gallinarum and Salmonella Typhi were identified across all treatments. In the intestine of birds fed control diet, Salmonella Gallinarum was present at week 0 and 4 but absent at week 8 of the experiment, while Salmonella Typhi was present throughout the experiment. In the intestine of birds fed OXYT diets, Salmonella Gallinarum was present at week 0 but absent at weeks 4 and 8 of the experiment, while Salmonella Typhi was present throughout the experiment. In the intestine of birds fed GRO-UP diets, Salmonella Gallinarum was present at week 0 but absent at weeks 4 and 8 of the experiment.
the experiment, while Salmonella Typhi was present throughout the experiment. In the intestine of birds fed MOS (500 ppm) and MOS (1000 ppm) diets, Salmonella Gallinarum was present at weeks 0 and 4 but absent at week 8 of the experiment, while Salmonella Typhi was absent throughout the experiment.

Discussion
The relative weights of breast, neck, drumsticks and liver (but not dressing) were significantly affected by dietary supplementation of feed additives. The addition of MOS had no effect on body weight at any age. Mathis (2000) found that the combination of certain antibiotics with MOS could lead to additive or synergistic benefits on broiler performance, compared to using antibiotics alone. The lowest drumsticks and breast meat yield recorded were in birds fed MOS at 500 ppm and 1000 ppm contrasts the report of Clementino Dos Santos et al. (2002) who stated that dietary MOS (0.1%) significantly increased breast yield as a percentage of dressed carcass. Mohammed et al. (2008) did not observe any significant effects of prebiotic and probiotic supplements on the relative weights of dressing, liver, heart, and gizzard. Similarly, Midilli et al. (2008) did not observe any impact of MOS on carcass traits and relative weights of internal organs in broiler chickens. Dosage, method of preparation, and animal condition may be responsible for such inconsistencies. Growth stimulants as feed additives are added to poultry diet to enhance growth rate and economic meat production (Bunyan et al., 1997). The observed effects of feed additives on some of the carcass traits could point to the growth-promoting effects of these dietary additives in relation to improved gut environment and a stable intestinal flora (Eltazi, 2014).

Previous studies demonstrated that prebiotics can moderate the gut environment by increasing the number of beneficial microbes and hindering rapid multiplication of intestinal pathogens (Patterson and Burkholder, 2003; Higgins et al., 2008). Dietary prebiotics reduced Salmonella population in the intestine of chickens (Bailey et al., 1991; Pascual et al., 1999; Stern et al., 2001) and supported competitive exclusion and immune modulation (Jin et al., 1997; Simon et al., 2001). The observation that feeding broiler chickens diets supplemented with Mannan oligosaccharide (MOS at 500 ppm and 1000 ppm) reduced Salmonella counts in the droppings and intestine support the argument of the active prebiotic function that mannan oligosaccharide (MOS) performs in the gut of broiler chickens. A similar trend was observed by Mohammadi Gheisar et al. (2016) with the prebiotic lactulose. Spring et al. (2000) noted a significant reduction in caecal Salmonella counts in chickens that received 4000 ppm of dietary MOS. Oyoto et al. (1989) found that dietary inclusion of 2.5% mannose reduced Salmonella colonization and 0.1% mannose decreased shedding, and colonization of caecal and liver after infection with $2 \times 10^7$ cfu of Salmonella enteritidis in 2-week old chickens (Fernandez et al., 2000; Agunos et al., 2007).

The beneficial activity of GRO-UP and MOS against Salmonella spp observed in the present study was supported by Courtin et al. (2008) who found that feed additives increase the number of bifidobacteria in the caecum of chickens. Salmonella Gallinarium and Salmonella Typhi were identified in the droppings and intestine of broiler chickens at different time intervals. This result agrees with Davies and Wray (1993) who reported that Salmonella bacteria are more closely associated with poultry than their ubiquitous distribution deserves. Salmonella bacteria may not exist as single entities but in a huge range of serotypes, including poultry-specific pathogens like Salmonella Gallinarium and Salmonella Typhi. The serotype distribution at different time intervals in droppings and intestine of broiler chickens is of high economic interest.

Conclusion
Carcass composition was not adversely affected by the inclusion of feed additives in broiler diets. There was a higher percentage reduction in Salmonella colonization in birds fed diets with prebiotics and probiotics. At the end of week eight, broiler chickens fed diets with mannan oligosaccharide (1000 ppm MOS) had the highest percentage reduction in overall Salmonella count, followed by birds fed 500 ppm MOS. Birds fed the control diet had the lowest percentage reduction in Salmonella counts in the droppings and intestine. The inclusion of MOS (both 500 or 1000 ppm) or GRO-UP as antibiotic substitutes in diets of broiler chickens can control and eradicate some Salmonella serotypes.
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