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Assessing the efficacy of monosodium glutamate as a growth enhancer in broiler chicken production

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Abstract—The purpose of this research was to assess the efficiency of monosodium glutamate (MSG) as growth promoter in broiler chicken production. The study evaluated the effect of varying concentrations of MSG in the drinking water of broiler chickens on their growth, carcass and caecal Escherichia coli population. Ninety (90) chicks at 21 days of age were randomly selected and assigned to 5 treatment groups (0g/L, 2g/L, 3g/L, 4g/L and 5g/L) of MSG concentrations in a Completely Randomized Design (CRD) with 18 chicks per treatment and 6 chicks per replicate. MSG was administered via drinking water. Feed and water were given ad-libitum. The parameters measured were feed intake, weight gain, feed conversion efficiency, carcass dress weight, digestive organ traits and caecal Escherichia coli concentrations. Data collected were analysed using one-way ANOVA in GenStat. The results of the study showed an improvement ($P<0.05$) in feed intake and daily weight gain at 5g/L concentration and the highest ($P<0.05$) feed conversion efficiency was achieved at concentrations of 2 and 3g/L respectively. Carcass dress weight, liver and intestinal weights increased ($P<0.05$) at a concentration of 5g/L. However, those group of birds on 2g/L MSG concentration had the highest ($P<0.05$) heart weight and those of birds in the control had the highest ($P<0.05$) intestinal length. Escherichia coli concentration in the caeca reduced ($P<0.05$) as the concentration of MSG increased. In conclusion, MSG supplementation in broiler chickens' production could improve growth and reduce pathogenic microbe especially E. coli

***Keywords*—monosodium glutamate, broiler chickens, growth performance, caecal microbes**

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INTRODUCTION

Broiler meat is one of the major sources of proteins and other essential nutrients such as vitamins and minerals which are needed by the body for growth and maintenance. Broiler meat industry is one of the fasters growing industry in the world (Bahri et al., 2019). Broilers are fast growers and could convert feed into meat within a relatively shorter period. But they also have weaknesses and tend to be vulnerable to disease attacks which makes them inefficient, and this affect their growth performance (Ensminger et al., 2004).

Supplementation of extra feed is one of the solutions to prevent diseases attacks thereby boosting their immunity and promote growth. Growth enhancers or promoters are agents that are added to broiler feed to enhance feed conversion efficiency and body growth and their immunity (Miles et al., 2006, Madhupriya et al., 2018, Maslami et al., 2019). Growth promoters are feed supplements that are added to nutritionally balanced diet which induce full utilization of maximum genetic potential of the host, in terms of growth and feed conversion efficiency (Walker and Duffy, 1998, Allen, 1999, Angelakis et al., 2013, Dhama et al., 2014).

Due to health concern, the use of growth promoters like Antibiotics, Arsenical and antimicrobial have been under critic because of their residues in meat and these residues can reduce human resistance to especially antibiotics and other hazards. As results of these residual effects on public health, many natural and synthetic substances have been studied (Ruegg, 2013, Singh et al., 2014, Azine et al., 2018). Among this substance are essential oil, probiotics, prebiotics, synbiotic, herbal preparation and amino acid salt such Monosodium glutamate (MSG) (Khadiga et al., 2009, Gbore et al., 2016, Ngouana et al., 2017).

This health concerns about the residual effects of growth promoters such antibiotics, arsenicals and antimicrobial has resulted in the formation of World Health Organization (WHO) regulation concerning the disallowing of these substance as animal feed supplements. Exponential population growth of the world especially Africa has necessitated high demand of quality animal protein source and broiler is not an exception. Hence the need to exploit other feed supplement that are less expensive, locally available and can be used as growth enhancers with no residual effects on broiler meat.

Monosodium glutamate is a sodium salt of glutamic acid which is found in both animals and plant protein sources (Tawfik and Al-Badr, 2012). Glutamate is a feed supplement that can enhance growth of broilers and their immune system, glutamate functions as a component of proteins, a medium for synthesis of amino acids, a precursor for many non-essential amino acids and aid in metabolism (Young and Ajami, 2000, Blachier et al., 2009, Maslami et al., 2019).

Shakeri et al., (2014) also reported that inclusion of glutamate in the diet of broilers can improve small bowel development, length of the intestinal villi and nutrient absorption. Addition, glutamate in the diet of broilers enhances the growth of connective tissue which leads to body weight gain (Ajinamoto, 2007, Maslami et al., 2018). Glutamate supplementation in broilers diet has increase digestive enzyme activities particularly amylase (Devi-Priya et al., 2010, Olubodun et al., 2015).

Notwithstanding reports of negative effects of glutamate to consumers, the Food and Drugs Administration of the Unites States has certified MSG as harmless and should be permitted to be used as feed supplements for livestock production (Tawfik and Al-Badr, 2012, Shi et al., 2012).

Monosodium glutamate regulates Inductible Nitric Oxide Sythase in some tissues and this basic mechanism has helped in protection of parasite, fungi, bacteria, harmful cells, intracellular protozoa and viruses in broilers (Li et al., 2007). There is little information on how varying concentrations of monosodium glutamate in the drinking water of broiler chickens could influence their growth performance and intestinal microbial loads.

Therefore, this study aims at determining the effects of monosodium glutamate on; growth performance, carcass characteristics and gut microbial population of broiler chickens.

MATERIALS AND METHODS

The study was conducted at the University for Development Studies (UDS), Tamale, Nyankpala, northern Ghana. Nyankpala is located in the Guinea Savanna Zone on latitude 09° 25″ N and longitude 00° 58″ N at altitude 183m above sea level. The temperature fluctuates between 19°C (minimum) and 42°C (maximum) with a mean annual temperature of 28.3°C. Rainfall is mono-modal and occurs from April to October with a mean annual rainfall of 1200mm and a mean annual day - time humidity of 54% (Kasei, 1988). The poultry house was open sided to allow for natural ventilation. Light was provided 24 h daily, as is common practice in northern Ghana to stimulate feed intake during cooler night temperatures (Dei et al., 2011).

A total of 200-day-old Cobb 500 broilers chicks were obtained from a hatchery at Dormaa in the Bono Region of Ghana. The chicks were brooded for 21 days, and starter diet formulated to meet their nutritional requirement [CP (21.4%) and ME (2850 kcal/kg)] (Table 1). The experimental material (MSG) (454g/sachet containing 99+% of MSG) was purchased from a local market in Tamale and administered in drinking water at a concentration of 0g/L (Control group), 2g/L, 3g/L, 4g/L and 5g/L for a period of 14 days (from 21 – 35 days of age).

Ninety (90) chicks at 21 days of age were randomly selected and assigned to 5 treatment groups (0g/L, 2g/L, 3g/L, 4g/L and 5g/L) of Monosodium glutamate (MSG) in a Completely Randomized Design (CRD) with 18 chicks per treatment and 6 chicks per replicate. The birds were weighed using electronic weighing scale (JADEVER JPS-1050) and this was done to establish a uniform initial weight (0.97kg) throughout the replicates. Each group were further subdivided in to three replicates with 6 chicks per replicate. The birds were then placed in fifteen deep litter pens with a floor space of 0.16m2/bird.

Feed intake was obtained by subtracting the left-over feed in the feed trough at the end of the week from the total feed supplied for the week. This was measured weekly by using digital scale (JADEVER JPS-1050) to weigh the feed. Mean feed intake per bird per day was calculated by dividing the feed consumed by the number of birds in the replicate and the number of days in a week. Live-weight of birds in each replicate was measured weekly by weighing them in batches using a digital electronic scale (JADEVER JPS-1050), and weekly live weight gains calculated by dividing total weekly live-weight gain by the number of birds in the replicate and by the number of days in a week. Feed conversion efficiency was defined as live weight gain per unit feed consumed. This parameter was calculated by dividing daily live-weight gain by the amount of feed consumed per day by each replicate bird. Mortality was recorded as and when they occur. All dead broilers were autopsied by a Veterinary officer of the Department of Veterinary Science.

At the end of the feeding trial, birds were starved for 8 hours and two birds per replicate were randomly selected and slaughtered by jugular venipuncture. Carcasses were then scalded in hot water (about 800C), de-feathered and eviscerated to get carcass dress weight. Carcass dressing percentage was calculated by dividing carcass dress weight by the bird's live weight, multiplied by 100. After evisceration, the internal organs were separated and weighed individually. The internal organs weighed included empty gizzard, heart and liver and expressed as a percentage of dress weight to a relative organ weight. The intestines were emptied, and the weight and length taken.

The caeca of three birds from each treatment were extracted and stored at -200C for total E. coli count at the Spanish laboratory, UDS, Nyankpala Campus.

Statistical analyses

All variables measured were subjected to one-way Analysis of Variance (ANOVA) and *post-hoc* Tukey's honest significant difference (HSD) test with 95% family-wise confidence level.

RESULTS AND DISCUSSIONS

The results of the effect of varying levels of monosodium glutamate concentration in the drinking water of broiler chickens on growth performance as shown in table 3 below revealed a significant improvement ($P<0.05$) in feed intake and daily weight gain as the concentration of MSG increased up to 5g/L in their drinking water. However, MSG concentrations of 2g/L and 3g/L produced similar ($P>0.05$) feed intake and daily weight gain respectively, and the control group recording the least ($P<0.05$) feed intake and daily weight gain respectively. Feed utilization was at its best at concentrations of 2g/L and 3g/L respectively and those birds on the 5g/l concentration showed least ($P<0.05$) feed utilization. Figure 1 shows the mean cumulative growth rates of the various treatment groups which indicated clearly the enhanced growth performances of the MSG-based groups over their control counterpart.

The supplementation of MSG in the drinking water of broiler chickens at varying concentrations could improve feed intake of birds. This phenomenon could be attributed to the ability of MSG to trigger taste receptors in the gastro-intestinal tract (Kirchgessner, 2001) and also employ encouraging sway on the taste center (Burrin and Stoll, 2009). The significant increase in feed intake of birds given MSG at different concentrations indicated that MSG was palatable and acceptable to the birds. This result is in line with the reports of Tanaka et al. (1983) and Reddy et al. (1986).

Table 1: Ingredient and nutrient composition of concentrate-based starter diet

INGREDIENTS	AMOUNT (KG)
Maize	56
Wheat bran	7
Concentrate (42%CP)*	37
CALCULATED NUTRIENT COMPOSITION	
Energy (ME, Kcal/Kg)	2850
Crude protein (%)	21.4
Calcium (%)	10.5
Phosphorus (%)	6.7
Lysine (%)	13.3
Methionine (%)	6.4

Concentrate* calculated analysis: ME (kal/kg): 2250, Crude protein: 42.00%, Crude fat: 4.40%, Crude fibre: 5.00%, Lysine: 3.20%, Methionine: 1.40%, Meth+Cyst: 2.00%, Calcium: 2.50%, Sodium: 0.45%, Phosphorus: 1.16%, Anti-oxidant: E321, Enzymes: (4*1640), Mould inhibitor added, Vitamins added and Salinomycin added.

Table 2: Ingredient and nutrient composition of concentrate-based grower diet

INGREDIENTS	AMOUNT (KG)
Maize	60
Wheat bran	7
Concentrate (42%CP)*	33
NUTRIENT COMPOSITION	
Energy (ME, Kcal/Kg)	2896
Crude protein (%)	20.1
Calcium (%)	0.95
Phosphorus (%)	0.63
Lysine (%)	1.2
Methionine (%)	5.9

Concentrate* calculated analysis: ME (kal/kg): 2250, Crude protein: 42.00%, Crude fat: 4.40%, Crude fibre: 5.00%, Lysine: 3.20%, Methionine: 1.40%, Meth+Cyst: 2.00%, Calcium: 2.50%, Sodium: 0.45%, Phosphorus: 1.16%, Anti-oxidant: E321, Enzymes: (4*1640), Mould inhibitor added, Vitamins added and Salinomycin added.

Table 3: Effect of varying levels of monosodium glutamate supplementation on growth performance of broiler chickens (21-56 days).

Variables	**Control**	**2g/L**	**3g/L**	**4g/L**	**5g/L**	**L.S.D.**	**P**
Feed intake (g/b/d)	98.90^{d}	108.54^{c}	108.20^{c}	113.98^{b}	132.37^{a}	0.744	<0.001
Weight gain (g/b/d)	41.36^{d}	46.85^{c}	46.51^{c}	47.80^{b}	52.02^{a}	0.277	<0.001
FCE	0.42^{b}	0.43^{a}	0.43^{a}	0.42^{b}	0.39^{c}	0.005	<0.001
Mortality	1.33	1.00	1.67	1.33	1.67	2.349	0.963

L.S.D. =least significant difference, P= probability, means in a row with similar superscripts are not significantly different.

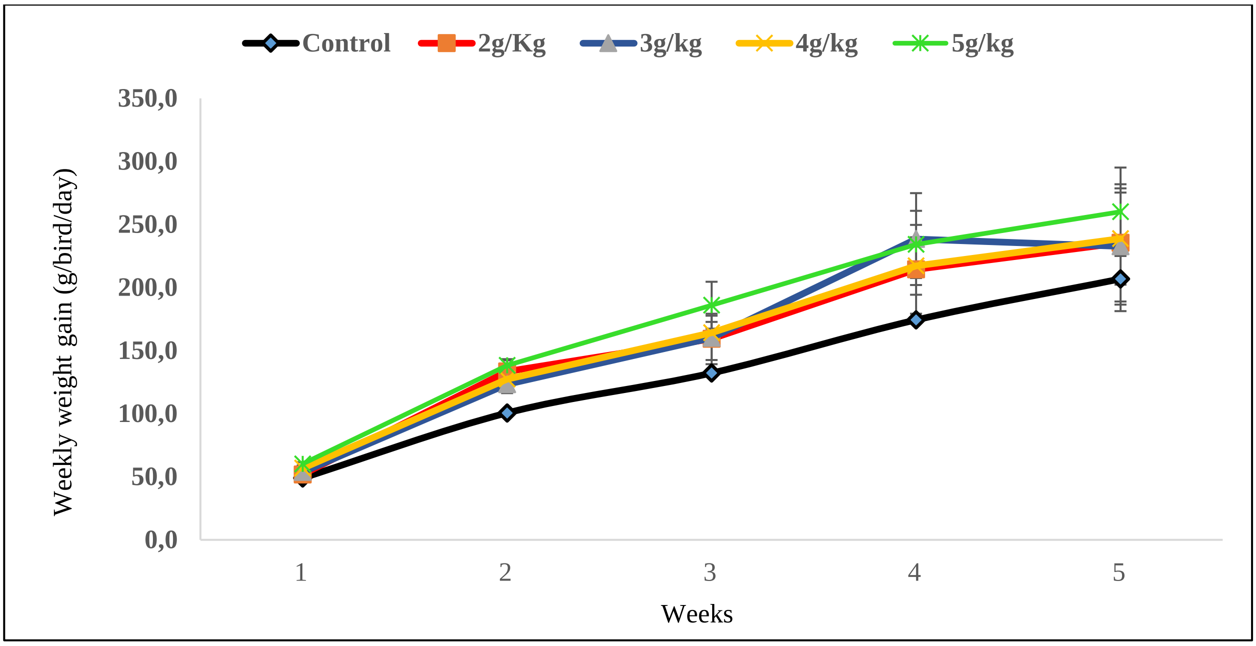

Figure 1: Cumulative growth rate of broiler chickens administered varying concentration of MSG in their drinking water. Where visible, error bars represent standard error of mean growth rate (n= 3 per data point).

Table 4: Effect of varying levels of monosodium glutamate (MSG) supplementation on carcass yield and relative weight of digestive organs of broiler chickens (21-56 days).

Variables	Control	2g/L	3g/L	4g/L	5g/L	L.S.D.	P
Dress weight (Kg)	2.32[d]	2.43[c]	2.47[b]	2.48[b]	2.80[a]	0.013	<0.001
Carcass yield (%)	79.95	81.18	80.19	79.12	79.98	2.405	0.483
Liver (% BW)	1.75[b]	1.54[d]	1.59[c]	1.60[c]	1.93[a]	0.016	<0.001
Heart (% BW)	0.28[d]	0.43[a]	0.39[c]	0.42[ab]	0.39[bc]	0.017	<0.001
Digestive organ traits							
Gizzard (% BW)	1.55	1.55	1.73	1.82	1.56	0.494	0.623
Pancreas (% BW)	0.13	0.11	0.12	0.12	0.12	0.051	0.945
Intestinal weight (g)	34.70[e]	39.73[b]	38.73[c]	36.27[d]	47.30[a]	0.431	<0.001
Intestinal length (cm)	229.3[a]	205.7[b]	206.7[b]	205.7[b]	208.0[b]	2.486	<0.001

L.S.D. =least significant difference, P= probability, means in a row with similar superscripts are not significantly different, BW= body weight.

Table 5: Effect of monosodium glutamate (MSG) supplementation on caecal Escherichia coli count of broiler chickens (21-56 days).

Bacterial count (Log_{10} CFU)	Control	2g/L	3g/L	4g/L	5g/L	L.S.D	P
Escherichia coli	5.62[a]	4.19[b]	3.13[c]	2.04[d]	0.94[e]	0.667	<0.001

L.S.D. =least significant difference, P= probability, means in a row with similar superscripts are not significantly different.

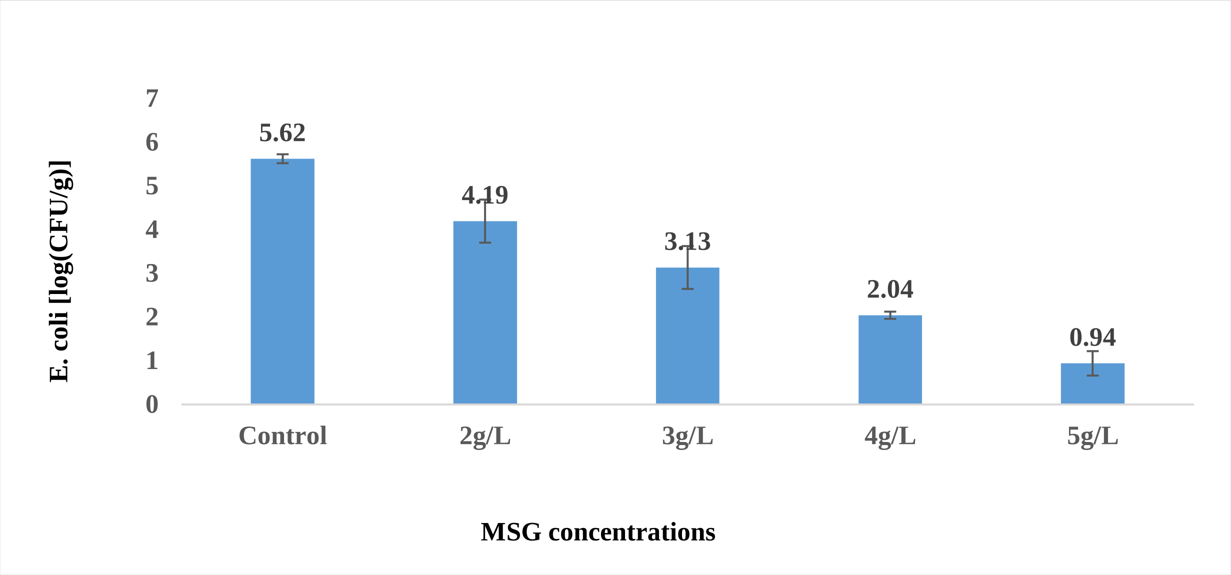

Figure 2: Trend of reduction in E. coli concentration as MSG was increased. Where visible, error bars represent standard error of mean E. coli count (n= 3 per data point).

Addition of MSG up to 5g/L of drinking water resulted in significant body weight gain over their control counterparts. The improvement in body weight gain in the current study could be ascribed to the numerous effects of MSG on the digestive tract which could result in a surge in gastric and pancreatic discharges, improved digestion, and absorption of nutrients with enhanced growth performances (Burrin and Janeczko, 2008). Shakeri et al., (2014) also reported that addition of glutamate in the diet of broilers can advance small bowel development, length of the intestinal villi and nutrient absorption. Ebadiasl (2011) also reported that MSG administration could aid the formation and elongation of intestinal mucous villi in the small intestine. Glutamate is a feed extra that can boost growth of broilers and their immune system, glutamate functions as a element of proteins, a medium of amino acid synthesis, an originator of numerous non-essential amino acids and also support in metabolism (Young and Ajami, 2000, Blachier et al., 2009, Maslami et al., 2019).

The inclusion of 5g/L of MSG decreased FCR by about 7.7% compared to control group, 2g/L and 3g/L of MSG inclusion improved FCR by about 10.3% over their 5g/L of MSG counterparts. Zuidhof et al., (2014) stated that feed conversion efficiency can be influenced by feed intake and weight gain. This improvement of the FCR could suggest efficient feed utilization at a dose lower than 5g/L of MSG in the drinking water of broiler chickens.

Birds on 5g/L concentration of MSG treatment recorded a lower feed conversion efficiency as compared to 2g/L, 3g/L, 4g/L treatment of MSG and the control group. Despite 5g/L concentration of MSG recording low feed conversion efficiency, there was a positive correlation between feed intake and weight gain within this same treatment. Usman (2009) and Zuidhof et al., (2014) stated that feed conversion efficiency can be influenced by feed intake and weight gain. Low feed conversion efficiency could have occurred as results of high feed utilization by the birds since their digestive tract were well developed as compared to the control group. Razak et al., (2016) reported that low feed conversion efficiency is an indication of feed efficiency. Andriyanto et al., (2015) reported that nutritional quality could aid broilers feed conversion. Low feed conversion efficiency as a result of MSG supplementation have been reported by Shakeri et al., (2014), Zulkfli et al., (2016), Olubodun et al., (2015) and Maslami et al., (2019) but this finding does not agree with Gbore et al., (2016) who reported an increase in feed conversion efficiency in rabbits fed with 2mg and 4mg MSG/Kg. These differences could be attributed to species differences and also mode and period of administration.

Carcass dress weight was higher ($P<0.05$) at a concentration of 5g/L and the control group showed the least ($P>0.05$) carcass dress weight. However, birds fed concentrations of 3g/L and 4g/L showed comparable carcass dress weight. The liver weight and the intestinal weight both showed improvement ($P<0.05$) at a concentration of 5g/L (Table 4).

The heart weight of those birds fed 2g/L and 4g/L concentrations respectively were comparable ($P>0.05$) but higher ($P<0.05$) than those of 3g/L and the control group. Similar ($P>0.05$) heart weights were also observed between those birds fed concentrations of 4g/L and 5g/L and those of 3g/L and 5g/L respectively (Table 4).

The weights of gizzard, pancreas and the carcass yield were not affected ($P>0.05$) by the use of MSG in the drinking water of broilers at the studied concentrations (Table 4).

Carcass yields of the experimental population were not influenced by the administration of MSG. However, carcass yields generally were high for this study but carcass yield finding in this study is contrary to the findings of Azine et al., (2018) who reported a significant higher carcass yield (73.95%) in 2mg of MSG in broilers diet.

Generally, carcass dress weight was higher for MSG-treated groups than for those without MSG treatment. This is an indication that MSG has the potential to improve carcass dress weight. This improvement in carcass dress weight could be associated with the role and concentration of MSG, in the development of the digestive organs which play a major role in digestion and absorption of nutrients. Rahimian et al., (2016) reported an increased dress weight when broilers were fed with black pepper and protexin which also has a stimulatory effect on the development of the digestive organs of birds. The increasing effect of MSG on carcass dress weight is suggestive of the fact that the effect of MSG on the broiler carcass performance is dose dependent.

Glutamate which is a building block for protein synthesis in the muscle might have affected the carcass dress weight of broilers on 4g/L and 5g/L (higher concentration) as a result of the concentration as compared to those on 2g/L and 3g/L (lower concentration) and this in line with Maslami et al., (2019), who stated that formation of protein in the muscle will affect its carcass dress weight.

Generally, MSG-treated broilers had lower fat deposition as compared to the non-MSG group. This phenomenon could be attributed to the fact that glutamate is a precursor for other non-essential amino acids such as arginine and proline. Arginine inclusion in broilers diet has the potential to reduce fat deposition in broilers (Fouad et al., 2012). Glutamate been a precursor for arginine could have triggered the reduction in abdominal fat since glutamate is a building block for proteins for muscle development and this is confirmed in this study where MSG-treated groups did significantly better than those treated without MSG.

Relative weights of gizzard and pancreas of the experimental population were not influenced by the administration of MSG but had an influence on the intestinal weight and length respectively. The experimental population treated with MSG generally had higher intestinal weight than those without MSG treatment. The highest intestinal weight gain was observed in birds treated with MSG at 5g/L. Development of the intestines could improve the accumulation of large quantity of feed and efficient absorption of nutrients respectively which resulted in higher feed consumption. According to Ibrahim (2008), the development of the intestines can increase the capacity of the digestive tract to accommodate more feed, aids in digestion and absorption and consequently growth rate. Ebadiasl (2011) reported that MSG administration could aid the formation and elongation of intestinal mucous villi in the small intestine. Glutamate inclusion in broiler feed was reported to improve intestinal development which could result in a relative increase in weight of the duodenum and jejunum (Bartell and Batal, 2007). The development of the intestinal mucous villi could have accounted for the weight increase of the intestines. Ebadiasl (2011) reported that, MSG has the potential to improve the intestinal mucous villi cells.

However, intestinal length tends to reduce with MSG administration as observed in this study. Motasem et al., (2018), reported that supplementation of garlic powder in broiler diet increased their intestinal length.

Caecal Escherichia coli counts indicated a decreasing ($P<0.05$) trend as the level of MSG concentration was increased (Table 5) (figure 2).

The decreasing trend of pathogenic microorganisms particularly Escherichia coli count in the gastrointestinal tract of the broiler chicken could be due to monosodium glutamate used as growth enhancer in the drinking water of the birds. This decreasing trend was observed as the concentration of monosodium glutamate was increased in the drinking water and this finding is in line with Rahimian et al. (2016), who also recorded a decrease in Escherichia coli count when another growth promoter (black pepper) was included in the diet of broilers. However, the findings of this research contradict the findings of Azine et al. (2018), who reported an increasing trend of Escherichia coli count when the concentration of monosodium glutamate was increased in broilers diet.

CONCLUSIONS

The supplementation of commercially produced Monosodium glutamate (MSG) as growth enhancer can improve growth performance of broiler chicken and reducing pathogenic microorganism population in the gastrointestinal tract, particularly E. coli when administered in their drinking water for the period of 14 days (21-56 days of age). MSG can serve as alternative growth promoters in broilers chicken production as it can easily be obtained and cheap as compared to antibiotics which is expensive and capable of causing antibiotic resistance in birds, which is of public health concern.

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