Journal of Advanced Veterinary and Animal Research
ISSN 2311-7710 (Electronic)
http://doi.org/10.5455/javar.2018.e258
A periodical of the Network for the Veterinarians of Bangladesh (BDvetNET)

June 2018
Vol 5 No 2, Pages 146-154.

Original Article

Growth performance, microbial and hemato-biochemical profile, and organs histology of broiler chickens fed diets supplemented with a seasoning named *Jumbo Cube* as source of monosodium glutamate

Pascaline Ciza Azine[1], Jean Raphaël Kana[2,#], Tadjong Ruben Ngouana[2], Audrey Kenfack[2], Nzako Aurelie Sonkeng[2], Kemajou Quentin Bunto[2], Tchantchou Chamberlain Djemen[2], Simo Philippe Lyale[2], Kenhagho Arielle Kemmo[2], Nia Tatiana Ngnouamen[2], Dongmo Kissel Ngeupi[2] and Alexis Teguia[2]

• **Received:** March 26, 2018 • **Revised:** April 20, 2018 • **Accepted:** April 23, 2017 • **Published Online:** May 3, 2018

AFFILIATIONS

[1]*Department of Animal Production, Faculty of Agronomy and Environmental Science, Université Evangélique en Afrique, Democratic Republic of Congo.*

[2]*Animal Production and Nutrition Research Unit, Faculty of Agronomy and Agricultural Sciences, University of Dschang. POBox:70 Dschang, Cameroon.*

CORRESPONDENCE:

[#] Jean Raphaël Kana,
Animal Production and Nutrition Research Unit, Faculty of Agronomy and Agricultural Sciences, University of Dschang. POBox:70 Dschang, Cameroon.
E-mail: kanajean@yahoo.fr

ABSTRACT

Objective: this study was conducted in order to assess the effects of dietary *Jumbo Cube* as source of Monosodium Glutamate (MSG) on production performances of broiler chickens.

Materials and methods: 320 day-old Ross 308 broiler chicks were randomly divided into five groups of 64 chicks each. Negative and positive control groups were fed on basal diet with no supplement (R0-) and 1 gm of antibiotic (R0+) respectively and the 3 others groups were fed on diets supplemented with the quantities of *Jumbo cube* containing 1 mg, 2 mg and 4 mg of MSG/Kg of feed. Feed intake (FI), feed conversion ratio (FCR), weight gain (WG), blood parameters and intestinal microbial counts were evaluated.

Results: Results revealed that feeding broilers with *Jumbo Cube* as MSG source significantly ($P<0.05$) decreased FI at the starter phase with no significant effect at the finisher phase. Diet supplemented with 2 mg of MSG/Kg significantly ($P<0.05$) increased LBW and WG, and decreased FCR. Dietary MSG significantly ($P<0.05$) has no significant effect on bacteria counts during starter phase. At the finisher phase, GMS induced a significant increase in lactic bacteria and E. coli counts as compared to the control ration without any supplement. White blood cells (WBC) significantly decreased with inclusion of 1mg and 2 mg of MSG/Kg. Dietary MSG markedly decreased albumin/globulin ratio, LDL-cholesterol and creatinine.

Conclusion: It was concluded that *Jumbo Cube* can be used as source of MSG (2 mg/Kg) to improve growth performance in broiler chickens.

KEYWORDS

Broiler; Feed additive; Growth promoter; Monosodium glutamate; Seasoning

How to cite: Azine PC, Kana JR, Ngouana TR, Kenfack A, Sonkeng NA, Bunto KQ, Djemen TC, Lyale SP, Kemmo KA, Ngnouamen NT, Ngeupi DK, Teguia A. Growth performance, microbial and hemato-biochemical profile, and organs histology of broiler chickens fed diets supplemented with a seasoning named *Jumbo Cube* as source of Monosodium Glutamate. Journal of Advanced Veterinary and Animal Research. 2018; 5(2):146-154.

INTRODUCTION

In order to mitigate the public risk about drug residues and others side effects of antibiotics feed additives in livestock products and to reduce dependence of farmers on antibiotics growth factors, many natural and synthetic substances have been investigated. Amongst those substances, essential oils (Ngouana et al., 2017) and amino acid salt such as monosodium glutamate (Khadiga et al., 2009; Gbore etal., 2016) has been widely studied.

Monosodium glutamate (MSG) is the sodium salt of glutamic acid which is found in many proteins (Tawfik and Al-Badr, 2012). Glutamate plays multiple roles in animal physiology. It is a neurotransmitter stimulator, an activator of taste receptors in the digestive tract (Kirchgessner, 2001) and small intestine cells use it as a major energy substrate (Burrin and Stoll, 2009). MSG has been widely used in human diets as flavor enhancer to promote consumption rates of a particular food (Parshad and Natt, 2007).

Although, MSG could influence on the appetite center and improve the palatability of foods, it positively impact on body weight gains (Egbuonu et al., 2010). However, some authors incriminated MSG as cause of some negatives responses, which could be attributed to ingestion of large doses by individuals hypersensitive to MSG (Collison et al., 2009; Husarova and Ostatnikova, 2013). Despite evidence of negative consumer response, the Food and Drug Administration of the United States concluded that MSG is harmless and should be listed as foods additives (Tawfik and Al-Badr, 2012; Shi et al., 2012).

MSG is the basic chemical element of commercial seasonings such as *Jumbo Cube* which contain other compounds such as plant extracts, disodium inosinate, oligo-elements which could have beneficial effects on animal production. These commercial seasonings are the most popular condiments in food industry; they are used to increase flavor and the appetite of consumer (Dossou-Yovo et al., 2016). However, the inclusion of MSG associated with other flavor enhancers like disodium inosinate found in common seasonings like *Jumbo Cube* has not been tested on animal nutrition. The general objective of the present research is to evaluate the effect of dietary graded levels of *Jumbo Cube* as source of flavor enhancer containing MSG on growth performances, intestinal microbial counts, and hemato-biochemical parameters of broilers chickens.

MATERIALS AND METHODS

Ethical statement: The ethical standards from the 1964 Helsinki Declaration and latterly amendment were applied. All co-authors have actively participated to the manuscript development and gave their consent prior to submission

Site of study: The trial was carried out at the experimental farm of the University of Dschang, located at 1420 m above sea level, between 5°26' North and 10°26' East. It has moderate temperature ranged from 10°C to 25°C with average annual rainfall from 1500 to 2000 mm over a 9 months rainy season.

Animals: A total of 320 days-old Ross 308 broiler chicks were acquired from a local hatchery and divided into 5 experimental groups of 64 chicks each. Each group was subdivided into four sub groups of 8 males and 8 females. Chicks were litter-brooded to 21 days old at a density of 20 chicks/m² and 10 chicks/m² to 49 days of age. Vaccination, health rules and poultry management practices were maintained. At the beginning of the trial, animals were weighed and on weekly basis thereafter.

Dietary treatment and experimental design: Experimental diets were formulated by supplementing control diet (R0-) (**Table 1**) with 1 gm of antibiotic (Doxycyclin®)/Kg of feed as positive control (R0+), and quantities of *Jumbo Cube* which provided 1mg, 2 mg and 4 mg of MSG /Kg of diet respectively. *Jumbo Cube* is a common commercial flavor enhancer in Cameroon. It contains 46, 3% of MSG and others compounds such as vitamin A, onion extracts, sodium Inosinate and Guanylate, but only MSG was taking into consideration in diet formulation. Each experimental ration including the control was fed to 16 chicks replicated 4 times in a completely randomized design.

Growth, hematological, serum biochemistry and histological structure of liver and Kidney: In the present study, Feed intakes (FI), weight gain (WG) and feed conversion ratio (FCR) were evaluated on a weekly basis. At 49 days old, 5 males and 5 females were selected from each group and slaughtered for carcass evaluation as proceeded by Kana et al. (2017). Blood for hematological analysis was collected in a test tube with anticoagulant. Hematological parameters including White blood cell (WBC), Red blood cell (RBC), Haemoglobin (Hb), Haematocrit (HCT) and Platelets (PLT) were analyzed using Genius electronic hematocymeter (Model KT-6180 S/N 701106101557). Meanwhile, blood for biochemical

analysis collected in tube free from anticoagulant, was stored at room temperature for 24 h. The serum was collected for the evaluation of serum content in Aspartate aminotransferase (AST), Alamine aminotransferase (ALT), urea, creatinine, total proteins, albumin, globulin, triglyceride, total cholesterol, HDL and LDL-cholesterol using Chronolab® commercial kits. Fragment of liver and kidney were randomly sliced from each treatment and immersed in 10% formol solution for 1 week. Selected tissues were dehydrated respectively in eight graded level of ethanol and xylene, and embedded in paraffin for cooling. Using a microtome, sections of 5µm were cut up and stained in haematoxyline and eosine. The observation was done at 40X magnification

Microbial count: At the end of the starter and finisher phases, faeces were collected in the cloaca using an antiseptic scovel from 4 birds per treatment. The number of colony of lactic acid bacteria, *Escherichia coli* and *Salmonella sp.* were counted in an appropriate specific culture medium (MRS Agar for lactic acid bacteria, Mac Conkey Agar for *E. coli* and SS Agar for *Salmonella* respectively), as proceeded by Pineda et al.(2012).

Statistical analysis: Data were subjected to one way analysis of variance using Statistical Package for Social Science (SPSS 20.0). Duncan's Multiple Range test (at 5% level) was used to compare treatment means whenever there was significant difference (Vilain, 2012).

RESUTS

The effect of *Jumbo cube* as source of MSG on feed intake (FI), live body weight (LBW), weight gain (WG) and feed conversion ratio (FCR) are summarized in **Table 2**. At the starter phase (1-21 days), feeding chickens with MSG decreased significantly ($P<0.05$) FI as compared to the control diet without additive (R0-). Meanwhile, at the finisher phase (22-49 days) and throughout the entire period of the study (1-49 days), FI was not markedly ($P>0.05$) affected whatever the quantity of MSG in the ration. Feeding broilers with antibiotic and 2 mg of MSG/Kg of diet significantly ($P<0.05$) increased LBW and WG, and decreased the FCR whatever the study period.

The effects of various treatments on carcass yield and relative weight of organs are summarized in **Table 3**. Apart for the carcass yield which significantly($P<0.05$) increase with the ration supplemented with 2mg of GMS compared to other level of MSG, treatments failed to induce any markedly ($P>0.05$) effect on carcass characteristics and digestive organs.

Table 1: Composition of experimental diets

Ingredients (gm/Kg)	Starter	Finisher
Maize	54	64
Wheat bran	5	1
Soybean meal	22	16
Cotton seed meal	5	5
Fish meal	5	5
Bones meal	1	1
Oeister Shell	1	1
Palm oil	2	2
Premix 5%*	5	5
Calculated chemical composition		
Metabolizable Energy (Kcal/Kg)	2928.86	3042.76
Crude Proteins (gm/Kg)	23.00	20.40
Lysine (gm/Kg)	1.43	1.19
Methionine (gm/Kg)	0.48	0.44
Calcium(gm/Kg)	1.17	1.35
Phosphorus	0.53	0.56

**Premix 5%: crude proteins 400 mg, Lysin 33 mg, Methionin 24 mg, Calcium 80 mg, Phosphorous 20.5 mg, metabolizable energy 2078kcal/Kg, Vitamins: Retinol 10 000 000 IU, Cholecalciferol 3 000 000 UI, Tocopherol 2500 IU, Phylloquinon 4000 mg, Thiamin 5000 mg, Riboflavin 500 mg, Pyridoxin 2500mg, Cyanocobalamin 5 mg, Folic acid 10 000 mg and Niacin 2000 mg.*

The dietary effects of MSG on the intestinal microbial load are presented in **Table** 4. At the starter phase, the treatment did not affect ($P>0.05$) the bacteria count. Meanwhile, at the finisher phase, MSG supplemented diets induced the highest bacterial counts whatever the bacterial species compared to the control diet without any additives.

Serum biochemical parameters of broiler chickens as affected by GMS levels in the ration are summarized in **Table 5**. Supplementing broilers with 1 mg (RJ_1) and 4 mg (RJ_4) of MSG/Kg lead to a significant ($P<0.05$) increase in serum content in proteins and globulin. Increasing doses of MSG decrease significantly ($P<0.05$) the albumin/globulin ratio and the creatinine content. The LDL-cholesterol content significantly decreased with the inclusion of MSG whatever the doses in the ration.The serum content in urea, AST and ALT were not markedly ($P>0.05$) affected by the rations.

As shown in **Table 6**, a part for the white blood cell count which significantly decreased with 2mg and 4mg of MSG in the ration, the treatments failed to affect hematological parameters of broilers chickens. The histological sections of organs revealed that MSG has no toxic effects on both the kidney (**Figure 1**) and the liver (**Figure 2**). Kidney of broilers fed on increasing doses of MSG and on control ration without MSG have dense and rounded glomerulars(G). The liver has well delineated hepatic lobules by connective tissue bands (C) and distinct portal spaces (P) between lobules.

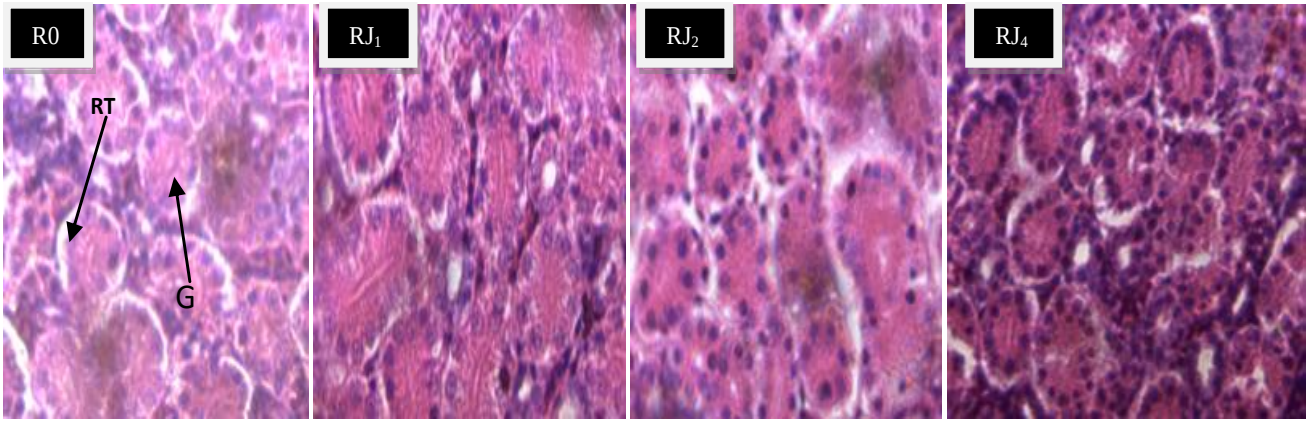

Figure 1. Histological structure of the kidney of broiler chikens as affected by *Jumbo Cube* as source of MSG (40X). RT: Renal tubule; G: Glomerular

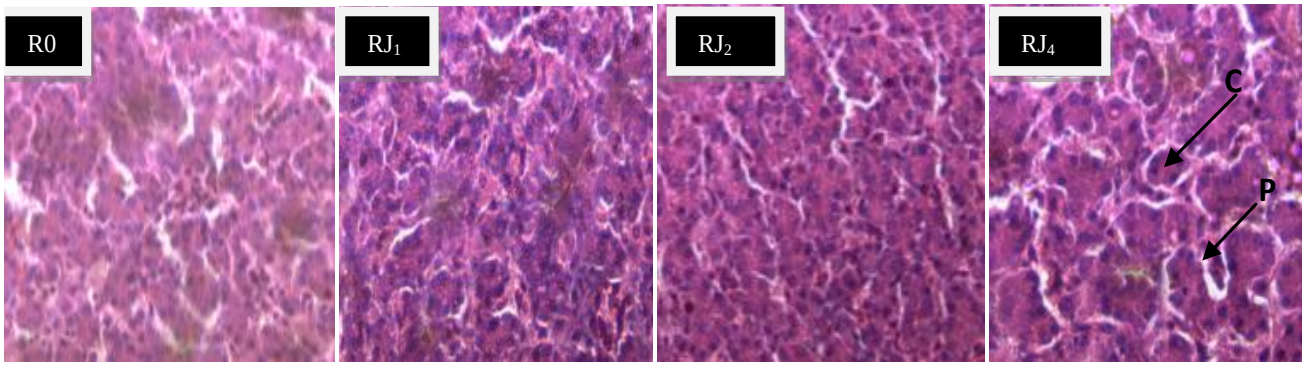

Figure 2. Histological structure of the liver of broiler chikens as affected by *Jumbo Cube* as source of MSG (40X). C=Conjonctive tissues , P=Portal spaces

Table 2: Growth performances as affected by level of *Jumbo Cube* as source of MSG from 1 to 49 days

Study period (days)	Treatments					
	R0-	R0+	RJ_1	RJ_2	RJ_4	P
Feed Intake (gm)						
01-21	1201.72± 33.12^{a}	1125.48±27.23^{bc}	1101.63±32.06^{c}	1129.33±22.19^{bc}	1159.15±19.01^{b}	0.001
22-49	4383.46±211.55	4395.70±147.40	4470.78±179.39	4383.11±206.22	4632.23±81.01	0.242
01-49	5585.17±243.71	5521.18±123.31	5572.40±164.01	5512.44±288.42	5791.37±86.40	0.227
Live body weight (gm)						
01-21	615.54±46.48^{b}	695.60±42.11^{a}	633.35±16.12^{b}	694.90±23.47^{a}	621.52±20.41^{b}	0.004
01-49	2117.45±13.55^{c}	2548.93±63.96^{a}	2195.20±57.69^{bc}	2524.29±39.19^{a}	2209.50±64.91^{b}	0.000
Weight gain (gm)						
01-21	575.80±46.48^{b}	655.86±42.11^{a}	593.61±16.12^{b}	655.16±23.47^{a}	581.78±20.41^{b}	0.004
22-49	1501.91±36.80^{b}	1853.33±36.43^{a}	1561.85±61.59^{b}	1829.40±62.63^{a}	1587.97±67.90^{b}	0.000
01-49	2077.71±13.55^{c}	2509.19±63.96^{a}	2155.46±57.69^{bc}	2484.55±39.19^{a}	2169.76±64.91^{b}	0.000
Feed conversion ratio						
01-21	2.10±0.21^{a}	1.73±0.15^{c}	1.86±0.04^{bc}	1.73±0.08^{c}	1.99±0.04^{ab}	0.003
22-49	2.92±0.07^{a}	2.37±0.08^{b}	2.86±0.11^{a}	2.40±0.09^{b}	2.92±0.10^{a}	0.000
01-49	2.69±0.13^{a}	2.20±0.04^{b}	2.59±0.08^{a}	2.22±0.07^{b}	2.67±0.05^{a}	0.000

a, b, c: in the same line values affected with different letter differ significantly (P<0.05)

R0- = negative control ration.R0^{+}: R0- + 1 gm/Kg Doxycyclin®; RJ_1 : R0-+ 1 mg of MSG ; RJ_2 : R0-+ 2 mg of MSG ; RJ_4: R0-+ 4 mg de of MSG; P : probability

Table 3. Carcass yield (%) and the relative weight of digestive organs as affected by *Jumbo Cube* as source of MSG

	Treatements					
	R0-	**R0+**	**RJ_1**	**RJ_2**	**RJ_4**	**P**
Carcass traits						
Carcass yield (%)	72.20±1.50^{ab}	72.22±3.54^{ab}	70.81±2.49^{b}	73.95±2.28^{a}	70.94±2.00^{b}	0.055
Liver (% BW)	1.91±0.22	2.12±0.35	1.97±0.19	1.83±0.22	2.12±0.22	0.101
Heart (% BW)	0.47±0.09	0.46±0.10	0.45±0.11	0.48±0.08	0.53±0.05	0.446
Abdominal fat (% BW)	1.54±0.77	1.12±0.45	1.32±0.50	1.37±0.57	1.08±0.60	0.474
Digestives organs traits						
Gizzard (% BW)	1.52±0.20	1.46±0.20	1.39±0.18	1.48±0.15	1.53±0.21	0.530
Pancreas (% BW)	0.21±0.04	0.23±0.04	0.23±0.05	0.24±0.02	0.23±0.04	0.825
Intestine weight (gm)	97.67±13.60	94.89±9.40	100.00±18.58	95.40±14.08	102.44±18.48	0.808
Intestine lenght(cm)	232.44±27.87	217.67±30.87	231.22±24.82	213.90±13.37	237.11±19.39	1.175
Intestine density(gm/cm)	0.42±0.03	0.44±0.03	0.43±0.06	0.45±0.05	0.43±0.04	0.841

a, b: in the same line values affected with different letter differ significantly (P<0.05)
R0- = negative control ration.R0⁺: R0- + 1 gm/Kg Doxycyclin®; RJ_1 : R0-+ 1mg of MSG ; RJ_2 : R0-+ 2m g of MSG ; RJ_4: R0-+ 4mg de of MSG ; P : probability

Table 4. Intestinal microbial load of broiler chickens as affected by level of *Jumbo Cube* as source of MSG

Bacterial count (Log_{10}CFU)	Treatments					
	R0-	**R0+**	**RJ_1**	**RJ_2**	**RJ_4**	**P**
Starter phase						
Lactic acid bacteria	9.58±0.25	9.33±0.21	9.48±0.00	9.26±0.29	9.59±0.24	0.205
Escherichia coli	10.14±0.40	10.00±0.12	10.35±0.34	10.25±0.35	10.48±0.35	0.302
Salmonella	10.49±0.29	10.45±0.34	10.70±0.00	9.79±0.98	10.69±0.01	0.099
Finisher phase						
Lactic acid bacteria	9.79±0.16^{c}	10.36±0.39^{b}	11.11±0.13^{a}	10.73±0.21^{b}	10.49±0.16^{b}	0.000
Escherichia coli	9.56±0.25^{c}	9.98±0.34^{b}	10.41±0.05^{a}	10.36±0.32^{ab}	10.16±0.12^{ab}	0.001
Salmonella sp.	7.26±0.36	7.51±0.36	7.60±0.24	7.93±0.24	7.78±0.25	0.058

a, b,c : in the same line values affected with different letter differ significantly (P<0.05)
R0- = negative control ration.R0⁺: R0- + 1 gm/Kg Doxycyclin®; RJ_1 : R0-+ 1mg of MSG ; RJ_2 : R0-+ 2m g of MSG ; RJ_4: R0-+ 4mg de of MSG; P : probability

Table 5. Biochemical parameters of Broilers chickens as affected by level of *Jumbo Cube* as source of MSG

Serum biochemical parameters	Treatments					
	R0-	**R0+**	**RJ_1**	**RJ_2**	**RJ_4**	**P**
Total protein (gm/dL)	2.04±0.25^{ab}	1.75±0.35^{b}	2.12±0.25^{a}	1.76±0.15^{b}	2.36±0.27^{a}	0.001
Albumin (gm/dL)	1.65±0.32^{a}	1.32±0.18^{abc}	1.54±0.37^{ab}	0.96±0.10^{c}	1.16±0.22^{bc}	0.008
Globulin (gm/dL)	1.61±0.26^{bc}	1.32±0.26^{c}	1.86±0.43^{ab}	1.57±0.19^{bc}	2.08±0.23^{a}	0.002
Albumin/Globulin	1.16±0.27^{a}	1.04±0.20^{a}	0.62±0.22^{b}	0.68±0.17^{b}	0.52±0.08^{b}	0.000
Triglyceride (mg/dL)	45.89±8.43^{ab}	32.79±4.69^{c}	38.29±2.35^{bc}	51.98±7.62^{a}	43.53±9.27^{ab}	0.003
Total Cholesterol (mg/dL)	60.45±21.72	82.67±0.53	64.55±14.66	77.01±5.98	71.19±21.10	0.200
HDL-Cholesterol (mg/dL)	39.84±1.40^{bc}	49.50±4.27^{a}	36.69±7.93^{c}	38.73±4.73^{bc}	44.37±3.45^{ab}	0.010
LDL-Cholesterol (mg/dL)	48.87±5.79^{a}	46.79±2.29^{a}	26.68±3.84^{b}	30.07±1.82^{b}	30.36±1.34^{b}	0.000
Creatinine (mg/dL)	0.50±0.14^{a}	0.43±0.08^{ab}	0.56±0.37^{a}	0.21±0.06^{bc}	0.18±0.07^{c}	0.011
Urea (mg/dL)	38.06±6.47^{ab}	29.97±2.65^{b}	27.55±6.63	31.29±7.94	31.88±9.09	0.287
AST (IU/l)	143.94±34.87	129.50±17.13	152.54±26.40	198.91±15.28	156.62±38.02	0.077
ALT (IU/l)	38.35±16.70^{b}	35.43±2.31^{bc}	59.50±11.37	39.37±9.46	32.38±10.14	0.068

a, b, c: in the same line values affected with different letter differ significantly (P<0.05)
R0- = negative control ration.R0⁺: R0- + 1 gm/Kg Doxycyclin®; RJ_1 : R0-+ 1 mg of MSG ; RJ_2 : R0-+ 2 mg of MSG ; RJ_4: R0-+ 4 mg de of MSG ; P : probability

Table 6. Hematological parameters of broiler chickens as affected by the level of *Jumbo Cube* as source of MSG

Blood parameters	Treatments					
	R0-	**R0+**	**RJ_1**	**RJ_2**	**RJ_4**	**P**
WBC (10^3/µL)	86.00±4.02^{a}	81.50±3.54^{ab}	79.48±3.98^{b}	78.34±3.16^{b}	81.94±4.78^{ab}	0.034
RBC (10^6/µL)	2.32±0.26	2.26±0.44	2.34±0.20	2.35±0.15	2.37±0.14	0.953
Hb (gm/dL)	13.62±1.16	13.25±2.26	13.55±1.29	13.46±1.20	13.40±0.94	0.993
HCT (%)	32.52±3.20	31.92±5.52	34.37±6.79	32.96±2.73	32.26±2.26	0.889
MPV (fL)	141.07±8.98	142.25±5.25	146.30±20.95	140.12±4.30	136.33±4.86	0.594
MCH (pg)	59.15±6.30	58.98±3.52	57.78±2.00	57.08±1.41	56.54±3.41	0.676
PLT (10^3/µL)	149.67±78.05	120.33±25.28	147.50±19.57	109.60±12.54	122.57±21.16	0.355

a, b: in the same line values affected with different letter differ significantly (P<0.05)
R0-=negative control ration.R0⁺: R0- + 1 gm/Kg Doxycyclin®; RJ_1 : R0-+ 1 mg of MSG ; RJ_2 : R0-+ 2m g of MSG ; RJ_4: R0-+ 4 mg de of MSG; P : probability.
WBC=White blood cell; RBC=red blood cell; Hb=Hemoglobin; HCT=Hematocrit; MCH=Mean corpuscular hemoglobin; PLT=Platelets; MPV: Mean platelet volume

DISCUSSION

The present study revealed that supplementing broilers diets at the starter phase with*Jumbo Cube* as MSG sourcedecreased FI. Similar results were reported by Khadiga et al. (2009) who supplemented broilers diets with 0.25 and 0.50% MSG. The decrease in FI with MSG can be the consequence of low digestive enzymes secretion in young chicks, which increases substantially from 21 days. At the finisher period and over all the study period, the FI was not significantly affected by the experimental diet. The present result corroborates the results of An et al. (2015) who reported no significant effect on FI with inclusion of onion extracts in broilers diet.

Feeding broilers with antibiotic and 2 mg of MSG/Kg of diet significantly (P<0.05) increased LBW and WG, and decreased the FCR whatever the study period. This result agrees with the result of Gbore et al. (2016) who reported a significant improvement in growth performance of rabbits supplemented with 4 mg MSG/Kg of body weight (bwt). Similarly, an increase in LBW was reported in rats treated with 15 and 30 mg MSG/Kg bwt (Falalieieva et al., 2010). In this study, the MSG induced an increase in live bwt for about 16.11 and 4.16% respectively with 2 mg and 4 mg of MSG/Kg of diet compared to the negative control diet without any supplement. The improvement in LBW and WG in the present study could be attributed to the multiple effects of MSG on the digestive tract which resulted in an increase in gastric and pancreatic secretions, better digestion and absorption of nutrients with improved growth performances as consequence (Burrin and Janeczko, 2008). This could be also attributed to the beneficial effects of other substances such as onions extracts and vitamin A containing in the *Jumbo Cube*. Indeed, onion extracts have anti-bacterial and anti-oxidant properties (Srinivasan et al., 2004; Melvin et al., 2009) which could lead to improvement of growth performance (An et al., 2015). Vitamin A plays an important role in vision cell multiplication, energy metabolism and immune regulation (Saeed et al., 2017). Increased weight and weight gain has been reported in chickens supplemented with vitamin A (Villar et al., 2002). Moreover, the inclusion of 2 mg of MSG decreased FCR for about 21.17% compared to control diet without feed additives.This improvement of the FCR could be explained by the increased in WGof chicken fed on diet supplemented with 2 mg MSG/Kg suggesting that digestibility of feed and absorption of the resulted nutrients were better with diets supplemented with this dose of MSG. This result is in agreement with Rahimian et al. (2016) who reported a significant drop in FCR with 0.2% of black pepper. This result contradicted the findings of Gbore et al. (2016) who reported a significant increase in FCR in rabbits fed with 2 mg and 4 mg MSG/Kg bwt. This difference could be explained by the mode of administration used by these authors.

Feeding broilers with diet supplemented with 2 mg GMS lead to a significantly higher carcass yield compared to the rations supplemented with 1 mg and 4 mg of GMS. This is explained by the higher WG recorded in this group of chickens. The same trend was recorded by Rahimian et al. (2016) who reported a significant increase in carcass yield with diet supplemented with black pepper and protexin. It contradicts the result of Aji et al. (2011) and An et al. (2015) who reported no significant difference in the carcass yield of chickens fed with ration supplemented with garlic and onion extracts respectively.

At the finisher phase, inclusion of MSG in the ration induced a significantly higher bacterial count irrespective to the bacterial species compared to control diet without additives. This result suggests that dietary inclusion of MSG promote the multiplication of bacteria and balance the intestinal flora. This result contradicts the findings of Rahimian et al. (2016) who recorded a decrease in *E. coli* count with the inclusion of black pepper in chicken's diet.

Supplementing broilers with 1 mg and 4 mg of MSG/Kg lead to a significant increase in serum content in proteins and globulin. This result is in agreement with the findings of Obochi et al. (2009) who reported a significant increase in serum content in protein in rats fed by 100 mg MSG/Kg bwt. The increase in serum protein content could be attributed to the activation by MSG of transcriptional promoter which enhances the ability of RNA polymerase to recognize the nucleotide at the initiation phase, thereby increased protein synthesis (Bernard et al., 2002). This result contradicted the findings of Reza et al. (2012), Okediran et al. (2014) and Gbore et al. (2016) who respectively recorded a decrease in serum protein content in pig, rat and rabbit treated with MSG.

Increasing doses of MSG decrease significantly the albumin/globulin ratio suggesting the enhancement of immune system of chickens fed on MSG. This result suggests that at low doses MSG could improve the immune system of broilers. This result disagree the findings of Gbore et al. (2016) who recorded no effect of MSG on the immune system of rabbit.

Serum content in triglycerides increased significantly with 2 mg and 4 mg of MSG/Kg of feed. This result supported the findings of Egbuonu and Onyinye (2011) who reported a significant increase in serum triglyceride in rats fed with 15 mg of MSG in drinking water. The increase in serum triglycerides could indicate breakdown in triglycerides metabolism that could be resulted in a high mobilization of free fatty acids from the peripheral fat depots (Bopanna et al., 1997).

As the regulation of triglycerides is driven by the availability of free fatty acids (Schummer et al., 2008), an enhanced lipolysis could, as a consequence, increase the biosynthesis of plasma triglyceride. This may overwhelm the ability of the low density lipoprotein (LDL) to transport the accumulating triglycerides back to the adipose tissue, leading to the increased serum triglyceride concentration observed in the present research. This statement is sustained by the decreased of LDL-cholesterol which could indicate that MSG induces reduction of LDL receptors for cholesterol, reducing the transport of cholesterol to cells and the risk of atherosclerosis (Law, 1999). This result contradicted the result of Inuwa et al. (2011), Kuldip et al. (2011) and Okediran et al. (2014) who observed an increase in serum LDL-cholesterol levels with oral ingestion of MSG to rats.

The dietary inclusion of MSG did not significantly affect the serum content in AST and ALT. This result is supported by the exploration of histological sections of the liver of chickens fed on MSG which revealed no mark of injury. Moreover, serum content in creatinine significantly decreased with inclusion of 2 mg and 4 mg of MSG/Kg of diet. The decreased in creatinine content indicated that the MSG did not affect the renal function as shown by the histological section of kidneys.This result disagree the findings of Tawfik and Al-Badr (2012) who reported a significant increase in creatinine in adult rats treated with GMS. Similarly, Sharma et al. (2013) observed cases of lithiasic kidneys (hydronephrosis) and urinary tract obstruction and increase in creatinine content in rats with treated with MSG.

Supplemented broilers diet with 1 mg and 2 mg of MSG lead to decrease of number of WBC. This result contradicts the findings of Gbore et al. (2016) who reported a significant increase of number of WBC in rabbits orally fed on increasing dose of MSG. This decrease in the number WBC reported in this study indicates that the inclusion of MSG in the feed at low doses would strengthen the immune system of animals.

CONCLUSION

The present results shown that feeding broiler chickens with *Jumbo Cube* as MSG source enhanced growth performance with no detrimental effect on the histological structure of the liver and kidney, and hemato-biochemical parameters. Considering the growing restrictions of antibiotics growth promoters, 2 mg of MSG/Kg could be use as feed additive to mitigate the public concern about bacteria resistance issues as well as antibiotics residues in broiler chickens meat.

ACKNOWLEDGEMENT

The authors would like to extend their sincere appreciation to the research facility at the University of Dschang, Cameroon. Mrs Pascaline C Azine acknowledges the fellowship received from the Organization for Women for Science for Developing World (OWSD) and the "Université Evangélique en Afrique, Democratic Republic of Congo" (UEA-DRC).

CONFLICT OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and publication of this article.

AUTHORS' CONTRIBUTION

CAP, NTR, KA, SNA, BKQ, DTC, LSP, KKA, NNT and NDK went to the field to carry out the trial and collect the samples. KJR supervised the overall research work, wrote with CAP the first draft before being revised by TA and approved by all the authors.

REFERENCES

1. Aji SB, Ignatius K, Ado Y, Nuhu J, Abdulkarim A, Aliyu V, Gumbo M, Ibrahim MA, Abubakar H, Buakar M, Imam M, Numan P. Effect of feeding anion (*Allium cepa)* and garlic (*Allium Sativum*) on some performances characteristics of broiler chickens. Research Journal of Poultry Science. 2011; 4:22–27. https://doi.org/10.3923/rjpscience.2011.22.27
2. An BK, Kim JY, Oh SI, Kang CW, Cho S, Kim SK. Effects of onion extracts on growth performances, carcass characteristics and blood profile of white mini broilers. Asian Australian Journal of Animal Sciences. 2015; 28(2):247–251. https://dx.doi.org/105713/ajas14.0492

3. Bernard NO, Scialli AR, Bobela S. The current use of estrogens for growth suppressant therapy in adolescent girls. Journal of Pediatric Adolescent Gynecology. 2002; 15:23–26. https://dx.doi.org/10.101016/S1083-3188(01)00135-8
4. Bopanna KN, Kanna J, Sushma G, Balaraman R, Rathod SP. Antidiabetic and antihyperlipidemic effects of neem seed kernel poweder on alloan diabetic rabbits. Indian Journal of Phamacology. 1997; 29:162–167.
5. Burrin DG, Janeczko MJ. Emerging aspects of dietary glutamate metabolism in the developing gut. Asian Pakistan Journal of Clinical Nutrition. 2008; 17(1):368–371.
6. Burrin DG, Stoll B. Metabolic fate and function of dietary glutamate in the gut. American Journal of Clinical Nutrition. 2009; 90:850–856. https://dx.doi.org/10.3945/ajcn.2009.27462y
7. Collison KS, Maqbool Z, Saleh SM, Inglis A, Makhoul NJ, Bakheet R, Al-Johi M, Al-Rabiah R, Zaidi MZ, Al-Mohanna FA. Effect of dietary monosodium glutamate on*trans*fat-induced nonalcoholic fatty liver disease. Journal of LipidResearch. 2009; 50:1521–1537. https://dx/doi.org/10.1194/jlr.M800418-JLR200
8. Dossou-Yovo P, Tossou LTC, Sezan A, Yelouassi RAC. Evaluation of the nutritional quality of the most consumed seasonings named «cube» in South of Benin. International Journal of Innovation and Applied Studies. 2016; 17(1):94–99.
9. Egbuonu AC, Onyinye SN. Effects of high monosodium glutamate on some serum markers of lipid status in male Wistar rats.Journal of Medicine and Medical Sciences. 2011; 2(1):653–656.
10. Egbuonu, ACC, Obidoa O, Ezeokonkwo CA, Ejikeme PM, Ezeanyika L. Some biochemical effects of sub-acute oral administration of L-arginine on monosodium glutamate-fed Wistar albino rats: Body weight changes, serum cholesterol, creatinine, and sodium ion concentrations. Toxicology and Environmental Chemistry. 2010; 92(7):1331–1337. https://doi.org/10.1080/02772240903450645
11. Falalieieva TM, Kukhars'kyĭ VM, Berehova TV. Effect of long-term monosodium glutamate administration on structure and functional state of the stomach and body weight in rats. Fiziola Zhotechnia. 2010; 56(4):102–110.
12. Gbore FA, Olubu RO, Irewole MA, Ruth AO, Ajobiewe G. Oral administration of monosodium glutamate alters growth and blood parameters in female rabbits. European Journal of Biological Research. 2016; 6(3):218–225. https://dx.doi.org/10.5281/zenodo.150297
13. Husarova V, Ostatnikova D. Monosodium glutamate toxic effects and their implications for human intake: A review. Journal of Medical Research. 2013; 608765. https://doi.org/10.5171/2013.608765
14. Inuwa HM, Aina VO, Baba G, Aim I0 and Ja'afaru L. Determination of nephrotoxicity and hepatoxicity of monosodium glutamate (MSG) consumption. British Journal of Pharmacology and Toxicology. 2011; 2(3):148–153.
15. Kana JR, Mube KH, Ngouana TR, Tsafong F, Komguep R, Yangoue A, Teguia A. Effects of dietary mimosa small bell (Dischostachy glomerata) fruit supplement as alternative to antibiotics growth promoter for broiler chicken. Journal of World's Poultry Research. 2017; 7(1):27–34.
16. Khadiga A, Ati AA, Mohammed S, Saad A M, Mohamed HE. Response of broiler chicks to dietary monosodium glutamate. Pakistan Veterinary Journal. 2009; 29(4):165–168.
17. Kirchgessner AL. Glutamate in the enteric nervous system. Current Opinion Pharmacology. 2001; 1:591–596. https://doi.org/10.1016/S1471-4892(01)00101-1
18. Kuldip S, Jyoti S, Arvindpreet K, Pushpa A. Alteration upon Oral Ingestion of Monosodium Glutamate in Various Lipid and Lipoprotein Fractions in Serum of Adult Male Rat. Journal of Life Sciences. 2011; 3(1):17–21. https://doi.org/10.1080/09751270.2011.11885164
19. Law MR. Lowering heart disease risk with cholesterol reduction: evidence from observational studies and clinical trials. European Heart Journal Supplements. 1999; 1(2):S3–S8.
20. Melvin J, Joyochitra J, Vijayapriaya M. Antimicrobial activity of some cammon spices against certain human pathogens. Journal of Medicinal Plants Research. 2009; 3:1134–1136.
21. Ngouana TR, Kana JR, Necdem TB, Doriane YMD, Mube KH, Kuiede S, Teguia A, Meimandipour A. Performances of broiler chickens fed on diet supplemented with thyme and oregano essential oils stabilized in a plant charcoal matrix. Journal of World's Poultry Research. 2017; 7(2):79–87.
22. Obochi GO, Malu SP, Obi-Abang M, Alozie Y, Iyam MA. Effect of garlic extracts on monosodium glutamate (MSG) induced fibroid in wistar rats. Pakistan Journal of Nutrition. 2009; 8(7):970–976. https://doi.org/10.3923/pjn.2009.970.976
23. Okediran BS, Olurotimi AE, Rahman SA, Michael OG, Olukunle JO. Alterations in the lipid profile and

liver enzymes of rats treated with monosodium glutamate. Sokoto Journal of Veterinary Sciences. 2014; 12(3):42–46. https://doi.org/10.4314/sokjvs.v12i3.8
24. Parshad RK, Natt JK. Effects of monosodium glutamate on food acceptance and toxicity of selenium in rats. Indian journal of Experimental Biology. 2007; 45:802–806.
25. Pineda L, Chwalibog A, Sawosz E, Lauridsen C, Engberg R, Elnif J, Hotowy A, Sawosz F, Gao Y, Ali A, Sepehri H. Effect of silver nanoparticles on growth performance, metabolism and microbial profile of broiler chickens. Archives of Animal Nutrition. 2012; 66(5):416–429. http://dx.doi.org//10.1080/1745039X.2012.710081
26. Rahimian Y, Faghani M, Masoud SD, Ali R, Abbas D, Mohammad HG. Potential use of protexin probiotic and black pepper powder on Cobb 500 broiler chicks.Azarian Journal of Agriculture. 2016; 3(6)129–134.
27. Reza RA, Knabe CD, Tekwe SD, Ficken MD, Fielder S, Eide SJ, Lovering SL, Guoyao W. Dietary supplementation with monosodium glutamate is safe and improves growth performance in post weaning pigs. Amino Acids. 2012; 44:911–923. https://doi.org/10.1007/s00726-012-1420-x
28. Saeed A, Dullaart RPF, Schreuder TCMA, Blokzijl H, Faber KN. Disturbed vitamin A metabolism in non-alcoholic fatty liver disease (NAFLD): A review. Nutrients. 2017; 10(29):1001–1029. https://doi.org/10.3390/nu10010029
29. Schummer CM, Werner U, Tennagels N, Schmol D, Haschke G, Juretschke H, Patel MS, Gerl M, Kramer W, Herling AW. Dysregulated pyruvate dehydrogenase complex in Zucker diabetic fatty rats. American Journal of Physiology, Endocrinology and Metabolism. 2008; 294:E88–E96. http://dx.doi.org/10.1152ajpendo.00178.2007
30. Sharma A, Prasongwattana V, Cha'on U, Selmi C, Hipkaeo W, Boonnate P, PethlertS, Titipungul S,Intarawichian P, Waraasawapati S, Puapiroj A, Sitprija V, Reungju S. Monosodium glutamate (MSG) consumption is associated with urolithiasis and urinary tract obstruction in rats. PLoS ONE. 2013; 8(9):e75546. https://doi.org/10.1371/journal.pone.0075546
31. Shi Z, Yuan B, Wittert GA, Pan X, Dai Y, Adams R,Taylor AW. Monosodium glutamate intake, dietary patterns and asthma in chinese adults. PLoS One. 2012; 7(12):e51567. http://dx.doi.org/10.1371/journal.pone.0051567
32. Srinivasan K, Sambaiah K, Chandrasekhara N. Spices as beneficial hypolipidemic food adjuncts: A review. Food Reviews International. 2004; 20:187–220. http://dx.doi.org/10.1081/FRi-120037160
33. Tawfik MS, Al-Badr N. Adverse effects of monosodium glutamate on liver and kidney functions in adult rats and potential protective effect of vitamins C and E. Food and Nutrition Sciences. 2012; 3:651–659. https://dx.doi.org/10.4236/fns.201235089
34. Vilain M. Méthodes expérimentales en Agronomie. Pratique et analyse. 2nd Edn., Technique et Documentation. Paris. 2012; p. 424.
35. Villar PG, Diaz CA, Avila GE, Guinzberg R, Pablos JL, Pina E. Effects of dietary Supplementation with vitamin A or vitamin E on growth performance in broilers. American Journal of Veterinary Research. 2002; 63(5):573–576.

****