Annals of Animal and Biological Research, 2021; 1(1): 17-24

Original Article

Blood and reproductive indices of rabbit does gavaged different levels of monosodium glutamate

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Article Information
Keywords: Rabbit, haematology, serum biochemistry, monosodium glutamate

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Article History:
Received: December 10, 2020;
Accepted: March 20, 2021;
Published:: June 4, 2021

Article can be accessed at www.aabrjournalaaua.org.ng

Abstract

The study evaluated the haematological, serum biochemical and reproductive effects of different levels of monosodium glutamate (MSG) orally administered to female rabbits. Forty Dutch-belted female rabbits aged between 24 and 26 weeks were randomly distributed into four experimental groups after the initial weights were recorded. Group A was the control while rabbit does in groups B, C and D received 1, 2, and 4 ml MSG/kg body weight (BW), respectively. Each group was replicated twice with 5 rabbit does per replicate in a completely randomized design in an experiment which lasted for a period of 12 weeks. The results showed that MSG treatments significantly ($p<0.05$) influenced the total weight gain, feed intake and feed conversion ratio. The haemoglobin, mean corpuscular haemoglobin concentration, mean corpuscular volume and the leukocytes were significantly ($p<0.05$) reduced when the administration level was above 1 ml MSG/kg BW. The serum cholesterol, glucose, albumin: globulin ratio, creatinine and alanine aminotransferase concentrations were not significantly ($p>0.05$) influenced by MSG treatments when compared with the control group. However, administration of MSG at 4 ml MSG/kg BW significantly ($p<0.05$) increased the aspartate aminotransferase concentration of the treated rabbits. In conclusion, oral administration of MSG at 1 ml MSG/kg BW presented the best feed conversion ratio, total weight gain, reproductive and pre-weaning performance without any negative implications on the health status of the animals.

INTRODUCTION

The food crisis facing the developing countries, most especially those of African nations, has today resulted in malnourished population. This situation has significantly increased the demand for food especially those of animal origin. The level of animal protein consumption has direct influence on the general well being and health of the populace (Olarotimi, 2016). Poor nutrition in some countries is closely associated with lack of protein in the diet. It is evident that there is poor animal protein intake in the diet of average citizens of most developing countries. A lot of carbohydrates and fibres are taken on daily basis with little protein intake to balance the diet (Olarotimi, 2016). This, consequently, leads to several deficiency syndrome. Meeting the animal protein intake of the teeming population from the developing countries should be a continuous challenge to the animal scientists from the region. Rabbit meat has the potentials of meeting the protein requirements of the teeming populace of the developing nations, especially, the sub-Saharan Africa. This is occasioned by the high growth rate and gestation period potentials of rabbits (Olarotimi *et al.,* 2015). The awareness about the potentials of rabbit meat in bridging the shortfall in daily protein consumption of the developing countries is gaining rapid attention. This meat is relatively cheaper and comparatively lower in cholesterol than meats from other animals such as pork, beef, mutton and chevon which are also more expensive. Any management practice that may enhance local and adequate production of rabbit meat to meet the protein requirement is highly welcomed. One of such is using feed additives that may enhance both growth and reproductive potentials of the rabbits without any negative effect on the rabbit well being and consequently the consumer.

Flavouring agents, such as feed additives, are supplements used to enhance feed intake to improve both the palatability and acceptability of feeds (Jay *et al.,* 2010). Monosodium glutamate (MSG) is one of such feed additives that could be used in rabbit production to enhance both growth and reproductive potentials of the animal. It has been reported that MSG had significantly increased both the feed intake and weights gained

How to cite this article:
O. J. Olarotimi, O. T. Ewegbemi, D. Olorunfemi, O. A. Adu and F. A. Gbore. (2021). Blood and reproductive indices of rabbit does gavaged different levels of monosodium glutamate. *Ann. Anim. Bio. Res.* 1(1): 17-24

in rabbits (Gbore *et al.,* 2016) and mice (Gbore *et al.,* 2019) fed increased doses of MSG, while dietary MSG did not to confer negative effect on the reproductive potentials of domestic cocks (Olarotimi and Adu, 2020). In another development, the meat palatability from broilers fed diet containing up to 0.75 g MSG/kg diet was increased, and fat content was also significantly reduced at this inclusion level (Adetunji *et al.,* 2019).

However, there have been various conflicting reports about the safety of MSG as flavour enhancer by several authors. The testicular toxicity effect of MSG was reported by Lindemann *et al.* (2002) who observed a significant reduction in sperm production and increase in abnormal sperm morphology in a dose-dependent manner in male wistar rats. Igwebuike *et al.* (2011) also reported that MSG administration lowered serum testosterone levels and reduced caudal epididymal sperm reserves in male Sprague- Dawley rats, without any overt pathological lesions in testis. Though a general agreement had been reached scientifically on the safety of MSG, this was based on numerous biochemical, toxicological and medical studies (IFIC, 2009). Comprehensive studies on the effects of MSG on growth and reproductive potentials of female rabbits are still scarce. Therefore, this study was purposed to evaluate the influence of MSG on the growth performance, blood parameters as well as reproductive performance of adult female rabbits.

MATERIALS AND METHODS

The research was carried out at the Rabbit Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria. The farm is located in the rainforest vegetation belt of Nigeria. It is characterized by two rainfall peaks and high humidity during the raining season. It has an average rainfall of 1,524 mm annually and the rainy season lasts for 7 months (April - October). It is located at latitude 07°25°N and longitude 05°14°E with an average temperature of 27.5°C and a mean annual relative humidity of over 75% (Ajibefun, 2011).

Forty (40) female rabbits of six to seven months of age were sourced from a reputable farm for the experiment and were subjected to two weeks of physiological stabilization period. Each rabbit was housed individually in wire mesh rabbit hutches. The rabbits were fed commercially prepared rabbit mash containing 14.89% crude protein, 5% fat, 9% crude fiber, 1.0% calcium, 0.35% phosphorus and 2,497 Kcal/kg metabolizable energy *ad libitum*. The animals were randomly divided into four experimental groups with each group replicated twice and each replicate containing five animals in a completely randomized design. Monosodium glutamate (MSG) was procured from a reputable store and 40 g was dissolved in one (1) litre of distilled water. Group 1 was the control and received no MSG solution but was given 2 ml of distilled water only. Rabbits in Groups 2, 3 and 4 received 1, 2 and 4 ml MSG/kg BW orally, respectively every 72 hours using a rat gavage needle. The experiment lasted for a period of twelve weeks (84 days). The daily feed intake and weekly weight gains were recorded throughout the experimental period. On the 84th day of the study, five animals were randomly selected from each group.

Haematological and Serum Biochemical Analyses

Blood samples were collected from the ear vein of each rabbit into both heparinized bottles (for the haematological evaluation) and plain bottles (for the serum biochemistry analyses). The plain bottles were allowed to stand in the test tube rack in the laboratory in a slanting position for 15 minutes and then the tubes were centrifuged for 10 minutes at 3000 rpm to obtain clean supernatant serum. The serum samples collected were kept frozen at -20°C until the determination of serum parameters. Haematological parameters such as Packed cell volume (PCV), erythrocyte (RBC), haemoglobin (Hb) concentration, mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC) and leucocyte (WBC) were determined as previously described by Ewuola and Egbunike (2008). The serum total proteins were determined by the Biuret method using a commercial kit (Randox Laboratories Ltd, U.K) while albumin value was obtained by bromocresol green method (Doumas and Biggs, 1971). The globulin and albumin/globulin ratio were determined according to the method of Coles (1986). The serum creatinine and urea nitrogen were estimated by deproteinisation and Urease-Berthelot colorimetric method as described by Tietz (1995). Cholesterol was determined by standard enzymatic endpoint method (Roschlan *et al.,* 1974) using commercial test kits (Qimica Clnica Application, S.A), while the serum

enzymes Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) were obtained using auto analyzing test kits from Randox Laboratories, Crumlin, UK. The results were expressed as mg/dl.

Determination of fertility rate of does

Four sexually mature and disease free bucks were also acquired and semen was collected using an artificial vagina. Prior to semen collection, the artificial vagina, insemination syringes and other equipment were thoroughly sterilized using 70% alcohol solution. Ovulation was induced in the females through mechanical stimulation of the vagina 14 hours before insemination. The semen collection was achieved 2 hours before insemination. Within 5 minutes of collection, the semen was diluted with physiological saline to ratio 1:2 at 37°C in a pre-heated tube to avoid heat or cold shock. Among the does, two were carefully selected from each treatment group based on an obvious sign of ovulation with vulva becoming swollen and purple in colour. The selected females were gently laid on a flat, immovable surface and the hind legs were firmly fixed with the use of leather belts. The insemination syringe filled with the semen to 0.3 ml was gently inserted into the vagina and the content sharply discharged. After successful insemination of each animal, the syringe was gently removed and the females were placed in an individual cage. The date of inseminating each rabbit was recorded; palpation was carried out few days later to determine pregnancy. The following reproductive parameters were determined: gestation length, litter size, litter weight and foetal crown-rump length.

Determination of pre-weaning performance of the kittens

The kittens were maintained on the same level of MSG till 21 day *post-partum* and the following parameters were determined at the end of the experiment viz: litter weights, litter sizes and mortality of the rabbits at birth, days 7, 14 and 21 *post-partum*.

Statistical Analysis

All the data obtained were subjected to statistical analysis using Analysis of Variance (ANOVA) procedure of SAS (2008). The significant treatment means were compared using the Duncan Multiple Range Test option of the same software and p values of < 0.05 were considered significantly different.

RESULTS

Effect of monosodium glutamate on growth performance of the rabbits

The effects of different levels of MSG on the growth performance of female rabbits are shown in Table 1. The final live weight and total weight gain were significantly ($p<0.05$) increased among the rabbits treated with MSG solution with the group receiving 1 ml MSG/ kg BW recording the highest significant ($p<0.05$) means. However, there was a significant ($p<0.05$) reduction in these parameters at 2 and 4 ml MSG/kg BW when compared with the rabbits receiving 1 ml MSG/kg BW. Furthermore, the group that received 2 ml MSG/kg BW significantly ($p<0.05$) consumed more feed than those in groups A, B and D but the best feed conversion ratio was recorded among the rabbits in group B.

Table 1: Growth performance of female rabbits orally gavaged different levels of MSG

Parameters	Monosodium Glutamate Treatments				
	Control A	1 ml B	2 ml C	4 ml D	±SEM
Initial live weight (g)	1366.25	1369.63	1362.88	1367.50	37.54
Final live weight (g)	1738.75^{d}	1939.00^{a}	1886.38^{b}	1788.63^{c}	44.00
Total weight gain (g)	372.5^{d}	569.37^{a}	523.5^{b}	421.13^{c}	26.23
Total Feed Intake (g)	3529.25^{b}	3587.13^{b}	3909.13^{a}	3471.38^{c}	15.64
Feed conversion ratio	9.474497^{a}	6.226251^{c}	7.564838^{b}	8.243013^{ab}	0.40

abcd: Means on same row with different superscripts differ significantly ($P<0.05$).
SEM- Standard Error of Mean
MSG: Monosodium Glutamate

Haematological effect of monosodium glutamate on the rabbits

The haematological indices of the rabbits given monosodium glutamate (MSG) at varied levels are reported in Table 2. There were no significant ($p>0.05$) differences observed in the PCV, RBC and MCV of the MSG treated rabbits when compared with those in the control group. However, a progressive reduction was observed in the Hb, MCHC and MCH values as the levels

Table 2: Haematological variables of female rabbits orally gavaged different levels of MSG

Parameters	Monosodium Glutamate Treatments				
	Control A	1 ml B	2 ml C	4 ml D	±SEM
Packed Cell Volume (%)	33.30	31.08	29.65	27.23	2.73
Haemoglobin (g/L)	117.00^{a}	100.30^{ab}	98.60^{b}	90.70^{c}	1.22
Erythrocytes (10^6/mm^3)	6.10	6.08	5.05	4.48	1.10
Mean Corpuscular Volume	56.09	52.79	48.60	50.15	5.94
MCHC	34.80^{a}	33.68^{ab}	27.60^{b}	27.48^{b}	0.72
Mean Corpuscular Haemoglobin	19.68^{a}	17.86^{ab}	16.40^{b}	16.10^{b}	1.95
Leukocytes (10^3/mm^3)	6.70^{a}	4.78^{ab}	4.55^{ab}	3.95^{b}	1.45

abc: Means on same row with different superscripts differ significantly (P<0.05)
MCHC- Mean corpuscular haemoglobin concentration, SEM- Standard Error of Mean

of the MSG administered increased with significant (p<0.05) differences recorded among the animals in the groups that received 2 and 4 ml MSG/kg BW when compared with those in the control group. A significant (p<0.05) reduction in WBC was only observed among the rabbits in the group administered 4 ml MSG/kg BW when compared with those in the control group.

Effects of monosodium glutamate on the serum biochemistry of the rabbits

Table 3 shows the serum biochemistry of the rabbits administered varied levels of MSG. The varied levels of MSG administered in the present study did not significantly (p>0.05) influence the serum cholesterol, glucose, albumin: globulin ratio, creatinine and alanine aminotransferase concentrations when compared with the control group. The total protein, albumin and globulin concentrations were significantly (p<0.05) increased at 2 and 4 ml MSG/kg BW when compared with the control group. However, administration of MSG at 4 ml/ kg BW significantly (p<0.05) increased the aspartate aminotransferase and urea concentrations of the treated rabbits.

Effects of monosodium glutamate on reproductive performance of rabbit

The reproductive performance of the does gavaged with different levels of MSG is shown in Table 4. From the results, it was evident that administration of MSG above 1 ml/kg BW significantly (p<0.05) decreased the litter size and the total litter weight of the rabbit does when compared with the control group. Administration at 1 ml MSG/kg BW had no significant (p>0.05) influence on these parameters. Furthermore, the gestation periods of the does in the groups that received above 1 ml MSG/kg BW were significantly (p<0.05) prolonged.

Table 3: Serum biochemistry of female rabbits orally gavaged different levels of MSG

Parameter	Monosodium Glutamate Treatment				
	Control A	1 ml B	2 ml C	4 ml D	±SEM
Total protein (g/dl)	10.32^{b}	10.38^{b}	11.50^{a}	12.60^{a}	0.34
Albumin (g/dl)	4.10^{b}	4.25^{b}	5.80^{a}	6.25^{a}	1.62
Globulin (g/dl)	4.35^{b}	5.08^{ab}	6.40^{a}	6.37^{a}	1.45
Albumin/Globulin	1.44	1.04	0.64	0.70	0.31
Cholesterol (mg/dl)	35.10	34.31	37.20	34.06	3.40
Creatinine (mg/dl)	1.01	1.03	0.92	1.05	0.21
Glucose (mg/dl)	118.50	134.50	116.00	113.50	17.07
Urea (mg/dl)	2.60^{b}	2.50^{b}	2.70^{b}	3.69^{a}	0.58
ALT (IU/l)	52.40	51.45	52.70	52.48	2.28
AST (IU/l)	60.75^{b}	61.55^{b}	62.85^{ab}	63.25^{a}	1.41

^{ab}Means on same row with different superscripts differ significantly (P<0.05)
ALT: Alanine aminotransferase, AST: Aspartate aminotransferase,
SEM: Standard Error of Mean

Effects of monosodium glutamate on pre-weaning performance of the kits

The effect of monosodium glutamate on pre-

Table 4: Reproductive performance of does orally gavaged different levels of MSG

Parameter	Monosodium Glutamate Treatment				
	Control A	1ml B	2ml C	4ml D	±SEM
Litter Size	5.38[a]	5.25[a]	4.25[b]	4.15[b]	0.61
Gestation Length (days)	30.75[c]	32.25[bc]	36.00[b]	41.00[a]	0.83
Total Litter Weight (g)	225.96[a]	215.25[ab]	206.68[b]	198.44[c]	21.58

[abc]Means on same row with different superscripts differ significantly (P<0.05)
SEM: Standard Error of Mean

weaning performance of rabbit is shown in Table 5. The average weights of the kittens from the does administered 2 and 4 ml MSG/kg BW were significantly ($p<0.05$) enhanced at birth, 7th and 21st day when compared with those in the 1 ml MSG/kg BW and control groups. This could not be said about the average weight at the 21st day because a significant ($p<0.05$) decrease was noted in rabbits gavaged 4 ml MSG/kg BW in comparison with those in group C. For the litter size, administration above 1 ml MSG/kg BW caused a significant ($p<0.05$) decrease at birth, 7th and 21st day with increase in dosage facilitating a further decrease. At birth, no mortality was recorded across the entire experimental group. However, the administration of 2 and 4 ml MSG/kg BW caused a significant ($p<0.05$) increase in mortality at 7th and 21st day in a dose-dependent manner when compared with the control group.

Table 5: Pre-weaning performance of kittens of does orally gavaged different levels of MSG

Parameter	Monosodium Glutamate Treatment				
	Control A	1ml B	2ml C	4ml D	±SEM
Average Weight at birth	42.00[b]	41.00[b]	46.75[a]	43.50[a]	2.64
Average Weight at 7th day	90.74[b]	92.88[b]	98.63[a]	96.88[a]	6.69
Average Weight at 21st day	197.75[c]	196.88[c]	213.13[a]	205.63[b]	7.46
Litter size at birth	5.38[a]	5.25[a]	4.75[b]	4.25[b]	0.61
Litter size at 7th day	4.25[a]	4.20[a]	3.15[b]	3.00[c]	0.58
Litter at 21st day	4.00[a]	3.70[ab]	2.95[b]	1.65[c]	1.70
Mortality at birth (%)	0.00	0.00	0.00	0.00	0.00
Mortality at 7th day (%)	21.00[c]	20.95[c]	25.88[b]	36.84[a]	2.28
Mortality at 21st day (%)	25.65[c]	28.88[c]	42.85[b]	65.26[a]	8.07

[a]
[abc]Means on same row with different superscripts differ significantly (P<0.05)
MSG: Monosodium Glutamate, SEM: Standard Error of Mean

DISCUSSION

Growth performance of the rabbits

The results of the present study indicated that low level of oral administration of MSG (1 ml/kg BW) best enhanced weight gain in rabbits than the medium (2 ml/kg BW) and high (4 ml/kg BW) levels of administration. Furthermore, the best feed conversion ratio recorded among the rabbits that received the low dose clearly indicated that 1 ml/BW MSG administration enhanced better growth performance in rabbit production. The increase in feed intake up to 2 ml MSG/kg BW administration level showed the appetite enhancing ability of MSG on rabbits but the significant drop in feed intake at 4 ml MSG/kg BW was indicative that high dose of MSG could result in appetite depression. This study agreed with Moore (2003) who reported that MSG affects the appetite positively as well as improving the palatability of meals by stimulating the orosensory receptors and consequently enhances weight gain. Gbore *et al.* (2016) equally reported enhanced weight gain, feed intake and feed conversion ratio in rabbit does orally administered low to medium dosage of MSG. In another development, Olateju *et al.* (2019) reported an increase in weight gain among broiler chickens fed MSG at 0.25 to 0.50 g/kg diet with corresponding better feed conversion ratio as opposed to the birds fed higher dosage of MSG.

The least feed intake observed among the animals in the group that received 4 ml MSG/BW was in agreement with FSANZ (2003) which stated that the excessive use of MSG could be self-limiting as it reduces palatability. Soltan (2009) equally buttressed this view by stating that over use of MSG could trigger toxicity, thereby, preventing palatability. The MSG in this study was not included in the diets, so, the increased feed intake and weight gain could be explained to be due to improved appetite enhancement as a result of the

positive influence of MSG on the appetite control center of the brain (Reddy *et al.,* 1986).

Haematological variables of the rabbits

The low dose (1 ml/kg BW) of MSG administered in this study did not lower the PCV of the rabbits below the range values of 31.0-48.6 % for female rabbits while the high level of administration depressed the Hb of the rabbits below the range values of 98.0-158 g/L for female rabbits (Özkan *et al.,* 2012). This agreed with the report of Olarotimi (2019) who observed that MSG inclusion at 1.00 and 1.25 g/kg diet significantly reduced the PCV, RBC and Hb of the broiler chickens. This result was indicative that the rabbits given above 1 ml MSG/kg BW were anaemic. The decrease in PCV, Hb and RBC indicated that high level of MSG administration could generate reactive oxygen species which may lead to oxidative stress and consequent lysis of RBC as reported by Ibrahim *et al*. (2012). Furthermore, the significant decrease in MCHC and MCH at 2 and 4 ml MSG/kg BW was suggestive of macrocytic anaemia which was as a result of the toxicity of increased levels of MSG administration to the erythrocytes (Ashaolu *et al*., 2011).

The obvious significant reduction in WBC at 4 ml MSG/kg BW below the normal range of 5.80 - 20.10 $\times 10^9$/L for female rabbits reported by Özkan *et al.* (2012), suggested that MSG could cause impairment of the normal function of the body immune system thereby predisposing the animals to high risks of infections. The significant alteration observed in the WBC values at 4 ml MSG/kg BW was in consonance with the report of Gbore *et al.* (2016) that observed significant incease in the WBC values of rabbits administered varied levels of MSG when compared with the control. While significant increase in WBC indicates the immune system's fight against a stress factor, significant reduction in WBC values suggests a compromised immune system. Hence, it is instructive that MSG at high dose of 4 ml/kg BW and above could impair the normal function of the body immune system and increase body susceptibility toinfections.

Serum biochemistry of the rabbits

The significant decrease in serum proteins observed among the rabbits given above 1 ml MSG/kg BW indicated the adverse potential of high MSG consumption to normal functioning of the liver. The primary function of the liver is to synthesize the blood proteins. The consistent reduction in the serum proteins above 1 ml MSG/kg BW was indicative of disturbance of protein synthesis. This could be as a result of damaging effects of high consumption of MSG on the liver cells. This result was further highlighted by the report of Okediran *et al.* (2014) who opined that high administration of MSG could cause an impaired hepatic function which is noticeable in lowered serum protein concentrations. The result of the present study was in line with the observation of Gbore *et al.* (2016) who equally noted reduced serum protein concentrations given medium to high concentrations of MSG.

In another development, Olarotimi (2019) reported adverse effect of MSG in cocks given dietary MSG above 0.50 g/kg diet. Another possible reason for the reduction in the serum proteins as occasioned by the high administration MSG was explained by Eweka and Adjene (2007) who opined that since the intestine regulates the uptake of amino acids, the significant decrease in the concentrations of serum proteins could be attributed to reduced uptake of dietary protein by the intestinal mucosa. The perceived bleaching properties of MSG could be injurious to the intestinal mucosa, especially, when administered at high concentration.

A significant elevation in serum aspartate aminotransferase (AST) as observed in the present study further strengthened the suspicion that there was an alteration in liver functions at a level beyond 1 ml MSG/kg BW. This result also agreed with Olarotimi (2019) who revealed that there was a sign of hepatocellular damage among the cocks fed diets containing MSG inclusion in excess of 0.50 g/kg diet. Inuwa *et al.* (2011) equally reported hepatocellular damage in Wistar rats treated with 200 to 400 mg MSG/kg body weight. Furthermore, an elevation in the concentrations of serum urea, which is a result of decline in the ability of the kidney to filter fluid within the body (Edwards and Bouchier, 1991), was evident among the rabbits that received 2 ml MSG/kg BW. This suggested a possibility of renal damage among the rabbits that received above 2 ml MSG/BW.

The insignificant difference observed in serum total cholesterol across all the treatment groups did not highlight the possibility of impairment of cholesterol synthesis in the treated rabbits. This, however, contradicted the result of the findings of

Gbore *et al.* (2016) who reported a dose-dependent increase in serum total cholesterol concentrations of the treated rabbits.

Reproductive and pre-weaning performance of the rabbit

The significant reduction in the litter size and litter weights from the rabbits administered 2 ml MSG/kg BW and above indicated that high level of MSG had adverse effects on reproductive indicators. At these levels of administration, the gestation period was equally lengthened which further revealed that high dose administration of MSG is potentially toxic to normal reproductive development and strengthened the observation of Gbore *et al.* (2019) that highlighted an elongated gestation lengths in female mice administered above 1 mg MSG/g BW. The increase in mortality rate at 7th and 21st days at the level of 2 to 4 ml MSG/kg BW was suggestive of neonatal toxicity of MSG at high level of administration. This result agreed with the findings of Park and Choi (2016) who reported that treating pregnant mice with excess MSG induced lower neonate body weight gain during lactation. This also agreed with Vinicius and Manoel (2010) who reported that the weights of neonatal Wistar rat at 21 days of life were significantly lowered when MSG concentration was increased. The monosodium glutamate presented a dose-dependent relationship in the average weights, litter sizes and mortality rate. The significant reduction in litter sizes at birth, 7th and 21st day observed in the groups that received 2 and 4 ml MSG/kg BW was in agreement with Gbore *et al.* (2019) which also reported dose-dependent decrease in the average number of pups of the mice administered MSG as well as Diemen and Trindade (2010) who observed that the female Wistar rats in the control group recorded a significantly higher number of pups when compared to those giving 10 and 20% of MSG. It is clearly evident by this study that medium to high doses oral MSG administration could lead to reduction of litter size in rabbits.

Though no mortality was recorded at birth across all the treatment groups, the significant mortality rate at 7th and 21st day among the groups that received 2 and 4 ml MSG/kg BW was indicative of neonatal toxicity potentials of MSG in rabbits at high administration dose. However, Gbore *et al.* (2019) reported mortality of pups in mice administered 2mg of MSG/g BW, which the autors attributed to the ability of MSG to cross the placenta barrier in rat. The difference between this and our result might be that of specie difference. It is possible that MSG at the doses employed in our study might not have the ability to cross the placental barrier in rabbits unlike in the case of mice. There is the possiblilty, however, that higher administration of MSG above 4 ml/kg BW in rabbits might have similar effects on the kittens as reported by previous studies in mice (Sharma and Deshmukh, 2015; Gbore *at al.,* 2019). The significant higher average weights recorded among the kittens from groups that received 2 and 4 ml MSG/kg BW is indicative of neonatal obesity which might be related to the increased neonatal mortality recorded among kittens from the groups that received 2 and 4 ml MSG/kg BW.

CONCLUSION

From the results of this study, it could be concluded that low level administration of MSG (1 ml/kg BW) as taste enhancing agent in female rabbit production may result in enhanced weight gain, feed intake and feed conversion ratio without necessarily compromising the health status of the animals or offsetting any of the physiological processes thereby posing any productive and reproductive risk to the animals.

Acknowledgement: The authors are grateful to the management and staff of the Nutrition Laboratory of the Department of Animal Production and Health of the Federal University of Technology, Akure for their assistance during the bench work.

Conflict of interest: All authors indicate that there is no any actual or potential conflict of interest that could inappropriately or possibly influence this work after publication.

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