



Leverage of Chromium Supplementation on Growth and Blood Profiles in Weaned Rabbits

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Abstract | Animal performance has considerably deteriorated as a result of recent, ongoing consequences of climate change that are raising temperatures. Chromium (Cr), especially when added to animal diets, can halt the lipid peroxidation caused by climate change because of its strong antioxidant qualities. A four-week study to determine the response of weaned rabbits at 5 weeks old on varying levels of organic and inorganic chromium supplementations was conducted. One hundred and twenty-six composite breeds of weaned rabbits of both sexes were randomly divided into seven groups. This was replicated thrice with six rabbits per replicate and was assigned to 7 diets in a completely randomized arrangement. The diets involved three levels of organic chromium (0.02, 0.04 and 0.06g/kg diet) and three inorganic chromium levels (0.02, 0.04 and 0.06g/kg diet), and the treatment without chromium was the control in a completely randomized design. Feed and water were supplied to the animals' ad libitum. Data were collected on performance and blood indices. Dietary inclusion of organic and inorganic chromium supplementation had a significant ($p < 0.05$) effect on all parameter measured respectively. The diet containing 0.04g/kg and 0.06g/kg organic chromium produced the superior weight gains per day and better feed conversion ratio. It was concluded and recommended that an addition of organic chromium at 0.04g/kg and 0.06g/kg can be successfully supplemented in weaned rabbit's diets without any negative effect on their performance and their blood biochemical.

Keywords | Blood indices, Climate change, Growth performance, Inorganic chromium, Organic chromium, Weaned rabbits

Received | June 21, 2023; **Accepted** | October 17, 2023; **Published** | October 23, 2024

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Citation | Irikefe-Ekeke EP, Obakanurhe O, Moemeka AM, Sorhue UG, Amata IA, Onwumelu IJ (2024). Leverage of chromium supplementation on growth and blood profiles in weaned rabbits. Adv. Anim. Vet. Sci. 12(12): 2356-2363.

DOI | <https://dx.doi.org/10.17582/journal.aavs/2024/12.12.2356.2363>

ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331



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INTRODUCTION

Chromium is the 21st most abundant mineral in the Earth's crust. Theoretically, chromium may occur in the oxidation states from -2 to +6, however, it is mostly found in

the trivalent and hexavalent forms (Amata, 2013). Trivalent chromium (Cr³⁺) happens to be the more stable oxidation state in which chromium is found in living organisms and is considered to be a highly safe form of chromium (Amata, 2013) as trivalent chromium (Cr(III)) plays a primary

role in animal metabolism as a constituent of the Glucose Tolerance Factor (GTF), and as an enzymatic complex able to increase insulin activity (Monga *et al.*, 2022). Trivalent chromium exist in organic and inorganic complexes, which exists in small insignificant quantities in grains. The principal problem of this research is that Chromium supplementation is usually not considered an essential trace mineral for our livestock, however, studies (Sun *et al.*, 2018) have provided evidence that suggests that it has a nutritional (micronutrient) and physiological role in animal nutrition.

Chromium supplementation has been found to reduce the negative effects of stress (Sahin *et al.*, 2001; Shima *et al.*, 2019; Hashem and Al-saadi, 2019) in rabbits, and in recent years, there has been considerable research interest in the utilization of Chromium (Cr) in animal feeds, however, its intake in feeds is relatively low because of its insignificant quantities in feedstuffs. Several authors have established its possible inclusion for optimum growth performance in both animals and man (Sahin *et al.*, 2001; Moeini *et al.*, 2011; Rao *et al.*, 2012; Rajalekshmi *et al.*, 2014; Shima *et al.*, 2019; Hashem and Al-saadi, 2019; Van Hoeck *et al.*, 2020) with the recommended quantity of chromium for adult human consumption been up to 200ppb of trivalent chromium (Moghanapriya *et al.*, 2018).

However, in rabbit nutrition, there have been no levels of inclusion recommended (NRC, 1994; Shittu *et al.*, 2022), although in ruminants, supplementation during heat stress periods, early lactation, and during infections has shown significant results, Its administration up to 5mg/head/day at the last three weeks pre-partum and about 6mg/head/day at the first few weeks post-partum has been effective. Thus, it became necessary to investigate the role of chromium in its organic and inorganic forms in weaned rabbits with a view to its potential toxicity (Amata, 2013; Zoroddu *et al.*, 2019), with an aim to investigate the effects of organic and inorganic chromium supplementation in the weaned rabbit's diets.

MATERIALS AND METHODS

EXPERIMENTAL LOCATION AND HOUSE

The experiment was carried out in the Rabbit unit, Department of Animal Science Farm, Delta State University Asaba Campus, Delta State, which is located on longitude 6° Celsius 45°E and Latitude 6° Celsius 12°N with the average monthly temperature varying between 27.5 and 32.9° Celsius, and an average relative humidity of 60- 85% (Asaba Metrological Station, 2023). The Rabbit unit is dwarf-walled and fully netted for proper ventilation and to prevent birds and rodents from coming in contact with the experimental animals. The entrance of the rabbit unit has a foot dip to ensure proper disinfection (EndoSan Disinfectant) when accessing the unit, which contains well-constructed

hutches of 1m by 1m made of wooden poles to house the animals, and each hutch having a drinker and two feeders made from aluminum and secured to the walls of the hutches to avoid toppling.

EXPERIMENTAL ANIMALS AND ETHICAL APPROVAL

This experiment was approved by the Board of Studies (BOS), Department of Animal Science 0021/27, Delta State University, Abraka Nigeria. A total of 126 composite breeds of weaned rabbits (35 days old) were used for this experiment.

ANIMALS MANAGEMENT

The rabbits were treated against internal parasites using albendazole, and against external parasites using diazintol. Animals were also given treatments against coccidiosis. The animals were exposed to the experimental diets a week before data collection, to acclimate them to the diets. Feeds were weighed and offered to the animals twice a day (8:00 am and 5:00 pm) and the left-over were also weighed the next morning prior to fresh feed. The water administered were certified for consumption from the farm's bore-hole by the Ethical Committee on Animal Welfare in the School.

EXPERIMENTAL DIETS AND DESIGN

Using a completely randomized design, the weaned rabbits were allotted into 7 treatments with 3 replicates of 6 animals per replicate (126 animals). The control (T1) had no chromium supplementation, while the other treatments had graded levels of organic and inorganic chromium supplementation. Brewer's dry grains (BDG) (4.381g/kg embedded chromium) and chromium chloride were used as organic and inorganic sources of Chromium, respectively.

Treatment groups consisted of chromium supplementation levels as follows: Control Group (T1) no supplementary chromium in the experimental diet, T2 contained 0.02 g/kg chromium in BDG in the experimental diet, T3 contained 0.02g/kg of supplemental chromium chloride, T4 contained 0.04g/kg of chromium in BDG, T5 contained 0.04g/kg of supplemental chromium chloride, T6 contained 0.06g/kg of chromium in BDG, and lastly, T7 contained 0.06g/kg of supplemental chromium in the diet.

The entire feeding trial lasted for four weeks. During the experiments, the animals were fed with the different experimental feeds and provided with fresh drinking water *ad libitum*.

DATA COLLECTION

PERFORMANCE CHARACTERISTICS FED EXPERIMENTAL DIETS:

The animals were weighed once a week in the morning before feeding. Live weight changes were estimated as the difference between the initial and final body weights of the animals, feed intake, and feed conversion were analyzed according to Helen *et al.* (2020) and Obakanurhe *et al.* (2022).

Table 1: Compositions of dietary treatments fed the weaned rabbits.

Ingredients	T1	T2	T3	T4	T5	T6	T7
Maize (kg)	42.40	38.00	42.40	37.54	42.40	36.70	42.00
Wheat offal (kg)	28.60	29.70	28.20	26.40	28.76	24.00	29.50
Soya bean meal (kg)	15.50	14.40	15.50	14.00	15.30	13.80	15.34
Groundnut cake (kg)	9.00	8.80	9.00	8.36	9.00	7.20	9.00
Fish meal (kg)	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bonemeal (kg)	2.50	2.50	2.48	2.50	2.48	2.50	2.30
BDG (kg)	----	4.60	---	9.20	---	13.80	---
Salt(kg)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Oil(kg)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Premix(kg)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Chromium (g/kg)	-----	-----	0.02	----	0.04	----	0.06
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated values							
Crude Protein (%)	19.13	19.63	19.14	19.72	19.17	19.78	19.19
Crude fibre (%)	5.14	5.62	5.12	5.63	5.13	5.66	5.22
Ether Extract (%)	4.64	4.81	4.64	4.83	4.66	4.88	4.68
Metabolizable energy/Kcal.Kg	2598.05	2535.16	2596.01	2554.06	2599.60	2588.35	2604.17

Provided: Vit A:20500000iu; vit D3: 4,250,000iu; Vit E: 250,000iu; Vit K: 8000mg; Vit B1:- 20,000mg; Vit B2: 15,000mg; Vit B6: 20,000mg; Vit B12: 15.00mcg; Vit B3: 90,000mg; Vit B5: 40.00mg; Vit B4: 4,000 mg; Vit C: 350,000mg; Vit B7: 500mcg; Choline Chloride: 600,000mg; Iron: 40,000mg; Manganese: 30,000mg; Zinc: 40,000mg; Magnesium: 60,000mcg; Copper: 4,000mg; Iodine: 2,000mg; Cobalt: 750mg; Selenium: 200mcg; Molybdenum: 100mg; Inositol: 50,000mg; Methionine; 50,000mg; Lysine: 50,000mg; Antioxidant: 125,000mg.

Table 2: Proximate compositions of dietary treatments fed to weaned rabbits.

Parameters	T1	T2	T3	T4	T5	T6	T7
Moisture (%)	9.81	13.44	12.34	13.01	10.34	12.34	10.23
Crude Protein (%)	17.50	17.52	17.25	18.01	17.55	17.85	17.60
Crude fibre (%)	8.58	9.06	9.66	8.87	8.92	8.76	8.56
Ether Extract (%)	5.34	5.67	4.88	4.67	4.23	4.98	4.67
Ash (%)	4.25	4.94	4.35	4.88	5.04	3.86	4.54
Nitrogen free extracts	54.52	49.37	51.52	50.56	53.92	52.21	54.40
Metabolizable energy/Kcal.Kg	2453.00	2217.81	2284.74	2256.76	2275.70	2230.35	2276.04

BLOOD INDICES OF WEANED RABBITS FED EXPERIMENTAL DIETS: At the end of the feeding period, at 9 weeks old, blood samples were collected from three rabbits per replicate for haematological and blood biochemical analysis (63 blood samples). The ear marginal vein was used to bleed the rabbits, the samples were divided into two lots and used for haematological and biochemical research . Each sample's initial 2.5 ml was taken and utilized for haematological examination in a labeled, sterile, universal vial containing 1.0 mg/ml ethyldiaminetetracetic acid. A further 2.5 ml was taken from the anticoagulant-free bottle. Within three hours of collection, the blood was allowed to clot at room temperature before the serum was

separated by centrifugation. Using the Beckman Coulter Ac-T10 Laboratory Haematology Blood Analyzer and the Bayer DCA 2000+ HbA1c analyzer, respectively, serum biochemistry and haematological parameters were assessed according to [Onwumelu et al. \(2022\)](#).

DATA ANALYSIS

According to [Obakanurhe and Akpodiete \(2021\)](#), all Data collected during this study were subjected to analysis of Variance (ANOVA) in a Completely Randomized Design (CRD) using GenStat (Release 4.24) statistical package ([Genstat, 2014](#)). Differences between means were separated by Duncan's Multiple Range Test (DMRT).

PROXIMATE COMPOSITIONS OF EXPERIMENTAL DIETS

As the inclusion levels (brewers dry grains and chromium chloride), increased across the experimental treatments, there were varying values of DM, CP, EE and CFof the proximate compositions of experimental diets, with treatment T3 and T4 recording the least and highest values respectively. The ash and ether extract recorded range from 3.86% – 5.04% and 4.23% – 5.67% respectively.

PERFORMANCE CHARACTERISTIC OF WEANED RABBIT FED EXPERIMENTAL DIETS

The performance characteristics of rabbits on dietary treatments showed significant ($p < 0.05$) differences in all parameters analysed in Table 3. There was an increase in the final body weight, with Treatment 6 being significantly ($p < 0.05$) higher than treatments 2, 4, and 7, with treatments 6 and 7 recording the highest and least values respectively. For weight gain, it was observed that the final weight results recorded followed a similar trend as to the weight gain result, with treatments 2, 4 and 6 had higher mean values compared to the other treatments; this could be attributed to the organic chromium which is absorbed better than the inorganic sources (Irikefe *et al.*, 2020; 2024). Daily feed

intake results observed showed that treatments 2 and 5 recorded the highest and lowest mean values among the treatment means, however, treatment 6 showed a superior feed conversion ratio, which can be an indication that organic chromium supplementation up to 0.06 g/kg in the diet did not negatively influence consumption, while treatments 3 and 7 which had the lowest values respectively could be an indication of the negative effect of inorganic chromium on feed intake.

HAEMATOLOGY AND SEROLOGY PARAMETERS OF WEANED RABBIT FED EXPERIMENTAL DIETS

Dietary treatments had significant ($p < 0.05$) effects on all haematological and serological parameters as shown in Table 4. The haemoglobin, RBC and WBC of weaned rabbits on treatment 6 showed significantly ($p < 0.05$) higher values than in other treatments.

The values generated for the daily weight gains of the weaned rabbits in this study were comparable with values of 9.31 – 12.71g obtained by Evans *et al.* (2022), in their research on the evaluation of weaned rabbit's growth performance and some haematological characteristics fed pawpaw peel meal-based diets in cross river rain forest zone, and also with values of 10.38– 15.18g by Ebegbulem *et al.* (2017),

Table 3: Performance characteristics of weaned rabbits fed experimental diets.

Parameters	T1	T2	T3	T4	T5	T6	T7
IWT(g)	413.3±17.63 ^{ab}	415±8.6 ^{ab}	406±7.26 ^b	414±13.38 ^{ab}	387±6.61 ^c	437±3.14 ^a	391±5.49 ^c
FWT(g)	744.6±10.12 ^b	761±8.66 ^b	676±4.30 ^{cd}	758±6.74 ^b	694±3.28 ^c	814±5.72 ^a	643±3.81 ^d
TWG(g)	331±7.57 ^{ab}	346±3.55 ^{ab}	275±9.52 ^{cd}	331±10.7 ^{ab}	307±13.36 ^{bc}	377±2.59 ^a	251±2.69 ^d
ADG(g)	11.82±0.20 ^b	12.35±0.08 ^a	9.82±0.22 ^c	11.82±0.25 ^b	10.96±0.82 ^{bc}	13.46±0.06 ^a	8.96±0.05 ^d
DFI(g)	42.87±0.34 ^{bc}	45.12±0.11 ^a	43.14±0.02 ^{bc}	44.28±0.58 ^{ab}	41.69±0.40 ^c	42.8±0.80 ^{bc}	43.05±0.76 ^{bc}
FCR	3.71±0.12 ^b	3.65±0.07 ^b	4.38±0.18 ^b	3.75±0.31 ^b	3.80±0.87 ^b	3.17±0.15 ^c	4.80±0.10 ^a

a,b,c,d Means within the row with different superscripts are different at $P < 0.05$; **IWT**: initial weight; **FWT**: final weight; **TWG**: total weight gains; **ADG**: average daily gains; **DFI**: daily feed intake; **FCR**: feed conversion ratio.

Table 4: Haematology and serology parameters of weaned rabbits fed the experimental diets.

Parameters	T1	T2	T3	T4	T5	T6	T7
PCV(%)	36.17 ± 0.03 ^b	36.20 ± 0.06 ^b	35.17 ± 0.20 ^c	36.23 ± 0.03 ^a	34.33 ± 0.17 ^d	36.17 ± 0.03 ^b	34.03 ± 0.03 ^c
HB(g/dl)	11.51 ± 0.02 ^b	11.02 ± 0.02 ^c	11.52 ± 0.01 ^b	10.88 ± 0.01 ^d	10.54 ± 0.06 ^e	11.63 ± 0.06 ^a	10.89 ± 0.03 ^d
RBC($\times 10^{12}/l$)	5.54 ± 0.03 ^c	5.64 ± 0.003 ^b	5.34 ± 0.06 ^f	5.45 ± 0.03 ^d	5.38 ± 0.03 ^e	6.02 ± 0.06 ^a	5.38 ± 0.03 ^e
WBC($\times 10^9/l$)	6.13 ± 0.03 ^d	6.25 ± 0.01 ^b	6.18 ± 0.003 ^c	5.85 ± 0.01 ^g	5.95 ± 0.02 ^f	6.84 ± 0.03 ^a	6.10 ± 0.00 ^e
cholesterol(g/dl)	71.84 ± 0.01 ^b	69.51 ± 0.01 ^d	70.17 ± 0.02 ^{cd}	70.38 ± 0.05 ^c	72.88 ± 0.28 ^a	71.73 ± 0.06 ^b	69.55 ± 0.05 ^d
Total protein (g/100ml)	6.40 ± 0.01 ^b	6.40 ± 0.01 ^b	6.17 ± 0.02 ^c	6.42 ± 0.03 ^b	6.53 ± 0.06 ^a	6.52 ± 0.03 ^a	6.43 ± 0.03 ^c
Creatine (mg/dl)	1.52 ± 0.03 ^a	1.51 ± 0.03 ^a	1.45 ± 0.01 ^b	1.52 ± 0.01 ^a	1.44 ± 0.01 ^b	1.52 ± 0.03 ^a	1.41 ± 0.03 ^c
Urea (mmol/l)	23.8 ± 0.01 ^a	23.25 ± 0.03 ^{ab}	22.32 ± 0.27 ^c	23.32 ± 0.34 ^{ab}	22.71 ± 0.06 ^{cb}	23.50 ± 0.33 ^a	22.65 ± 0.01 ^{cb}
Albumin (g/l)	40.76 ± 0.40 ^a	38.64 ± 0.02 ^c	37.32 ± 0.10 ^d	38.55 ± 0.02 ^c	37.11 ± 0.33 ^d	39.45 ± 0.05 ^b	36.53 ± 0.01 ^c
Glucose (g/dl)	83.58 ± 0.31 ^a	82.67 ± 0.10 ^a	81.40 ± 0.01 ^b	79.04 ± 0.54 ^c	75.85 ± 0.67 ^d	82.83± 0.00 ^a	76.51 ± 0.05 ^d

a-b-c-d Means within the row with different superscripts are different at $P < 0.05$; **PCV**: packed cell volume; **HB**:haemoglobin; **RBC**: red blood count; **WBC**: white blood count.

on the growth performances and carcass characteristics of weaned rabbits fed *Alchornea cordelia* leaf meal but was higher than the values 4.48 – 6.32g obtained by [Wafer et al. \(2018\)](#) and [Adedeji et al. \(2006\)](#), on their research on performance and blood indices of weaned rabbits fed boiled castor seed cake diets. This is a clear indication of the chromium playing a role of a metabolic modulator to balance metabolism ([Guo et al., 2020](#)). It is noted that the values of average daily weight gains from this research were different from the values (17.8 – 21.3g) obtained by [Mervat Ghazal et al. \(2013\)](#), in their research on growing rabbit's productive and physiological responses to dietary organic chromium addition. Also, similar values (32.91g – 33.44g) were obtained in a separate study by [Amer et al. \(2019\)](#) on the effect of dietary chromium supplementation on performance, some blood indices and tissue chromium contents of rabbits. These observed values could be attributed to the time frame during which these researches were carried out (16 weeks) without distinction between weaner phase and grower phase which was in contrast to this study that specified the weaner phase as the first four weeks, afterwards the grower phase.

Based on average feed intake, values from this research (41.69 – 45.12g) were comparable to several authors ([Oyawoye and Ogunkunle, 1998](#); [Adedeji et al., 2006](#); [Onyekwere et al., 2010](#); [Ozung et al., 2012](#)) but lower than the values obtained by [Ebegbulem et al. \(2017\)](#). Feed efficiency performance were comparable for the control, treatments 2, 4, 5, and 6, which was different from the values reported by several authors ([Adedeji et al. 2006](#); [Ozung et al. 2012](#); [Amer et al. 2019](#)) were lower. The results for feed intake and efficiency in this research were similar to results reported by [Van Hoeck et al. \(2020\)](#), who used organic chromium in the form of chromium propionate in the broiler finishing phase. These results from this experiment however, differ from the reports of [Ibrahim et al. \(2022\)](#) and [Şahin et al. \(2001\)](#), who observed that chromium-yeast supplementation did not affect daily weight gain, and feed efficiency during the rabbit fattening period. Although, their results are not clear, since most researchers agree that chromium supplementation during periods of higher stress has a significant effect on weight gain. These discrepancies could be attributed to an increase in the glucose conversion to acetyl-CoA brought on by the addition of organic chromium ([Moffett et al., 2020](#)). Acetyl-CoA is essential for biological reactions and is employed in many of them ([Moffett et al., 2020](#)). The changes observed in the final body weight across treatments with organic chromium could be as a result of the influence of organic chromium addition to the biological activity of insulin by improving the insulin-sensitive cell receptors or binding activity ([Levina and Lay, 2019](#)). This could account for the significantly better final body weight of weaned rabbits during the entire fattening period. Overall, experimental animals on

the organic chromium sources compared favourably to the control. This indicates the place of organic over inorganic. However, the values recorded in this experiment were still within the normal range. The values recorded from adding organic and inorganic chromium in this study were in agreement with a separate study involving broiler-fed chelated chromium ([Ibrahim et al., 2022](#)), which confirms that chelated chromium inclusion could enhance immune system activity.

In contrast to these present results, [Adebisi and Makanjuola \(2011\)](#) and [Sarai et al. \(2022\)](#), recorded no significant ($P \leq 0.05$) differences in the Hb, WBCs, and RBCs for broiler chickens fed with 0.25 mg/kg chromium chloride. In general, chromium inclusion increases the total RBCs, which also revealed increase in the Hb values ([Shah et al., 2020](#)), this is linked to the positive interaction between RBCs and Hb. The inclusion of chromium increases the Haemoglobin values (within a normal range) which aligned with its effects on haematological parameters ([Feldman et al., 2000](#)). Cholesterol levels showed significant differences ($p < 0.05$). The level increases as the chromium level increases (organic and inorganic). This trend was also observed by [Anthony and Ashawe \(2014\)](#), in their experiment on the effect of *Moringa oleifera* leaf meal (MOLM) on the haematological parameters and the cholesterol level of rabbits, which also agrees with the work of [Anthony and Ashawe, \(2014\)](#).

All values for cholesterol in this experiment fell within the range reported by [Medirabbits \(2011\)](#), it can therefore be concluded that the supplementation of these levels of chromium can conveniently be used in feeding weaned rabbits without any detrimental effects on cholesterol levels. This study's results therefore indicate that 0.02g/kg, 0.04g/kg and 0.06g/kg of organic chromium and 0.04g/kg of inorganic chromium supplementation did not influence the protein, urea, and cholesterol concentrations of rabbits, which also agrees with results by other authors using other animals ([Saeed et al., 2017](#); [Lashkari et al., 2018](#)). [Lashkari et al. \(2018\)](#) reported that serum total protein, urea, and triglycerides were not affected by supplementation of chromium, this is in contrast with this research and several other studies which have documented that chromium supplementation decreased serum triglycerides ([Lashkari et al., 2018](#); [Staniek et al., 2020](#)). Also, in a separate study on cow, chromium supplementations in the diets of calves did not affect the serum cholesterol, protein, urea, and triglycerides ([Ansari et al., 2022](#)).

CONCLUSIONS AND RECOMMENDATIONS

This study revealed that while the different levels of chromium inclusion significantly influenced the performance characteristics and blood indices of weaned rabbits studied,

organic chromium inclusion especially at 0.04g/kg (T4) and 0.06g/kg (T6) had a greater influence on the various parameters studied. It is recommended that the inclusion levels in this study were very tolerable without no detrimental effects on the rabbit.

ACKNOWLEDGMENTS

We acknowledge the entire laboratory staffs for their time and assistance.

NOVELTY STATEMENT

To our knowledge, this study is the first to evaluate the presence of chromium in brewers dried grains in Nigeria, also the influence and recommendation of 0.04- 0.06g/kg of organic chromium for weaned rabbits are published for the first time by this study.

AUTHOR'S CONTRIBUTIONS

Efe Peterson Irikefe- Ekeke assisted in conceptualization, methodology, writing original draft, Efe Peterson Irikefe- Ekeke and Oghenebrorhie Obakanurhe assisted in data collection, Data Analysis and designing of the manuscript. Ifo Alex Amata supervised and evaluated the manuscript content. UfuomaGodstimeSorhue, Adimabua Mike Moemeka and Ifeoma Jane Onwumelu proof read and drafted the manuscript.

FUNDING

The research received no external funding.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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