Journal of Advances in Microbiology

8(2): 1-15, 2018; Article no.JAMB.38662
ISSN: 2456-7116

Studies on Tigernut-Ogi Incorporated into Basal Feed as a Potential Animal Growth Enhancer Using Wistar Albino Rats as Experimental Animal

N. Maduka[1*] and F. S. Ire[1]

[1]Department of Microbiology, Faculty of Science, University of Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Authors NM and FSI designed the study while author NM performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NM managed the analyses of the study under the supervision of author FSI. Author NM managed the literature searches. Author FSI proofread and corrected the draft manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMB/2018/38662
Editor(s):
(1) Bechan Sharma, Department of Biochemistry, University of Allahabad, Allahabad, India.
(2) Zeb Saddiqe, Professor, Phytochemistry Lab, Department of Botany, Lahore College for Women University, Lahore, Pakistan.
(3) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
(4) Foluso O. Osunsanmi, Department of Biochemistry and Microbiology, University of Zululand, South Africa.
Reviewers:
(1) Shittu M. Daniel, Ladoke Akintola University of Technology, Nigeria.
(2) Mube Kuietche Hervé, University of Dschang, Cameroon.
(3) Juxing Chen, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history/23161

Original Research Article

Received 15th November 2017
Accepted 9th February 2018
Published 13th February 2018

ABSTRACT

This study investigated the effect of using tigernut-ogi incorporated into basal feed as a potential animal growth enhancer. Tigernut-ogi in the ratio 70:30 blended with basal feed (Top feed brand, growers mash) in the ratio 10:90, 30:70 and 50:50 was administered on G1A, G2A and G3A grouped rats orally infected with *Escherichia coli* as well as non-infected G1B, G2B and G3B grouped rats, respectively for 28 Days. Non-infected grouped rats fed 100% basal feed was the control. This animal feeding experiment revealed that Feed intake (FI) and Average daily feed consumption (ADFC) of the grouped rats reduced with increased proportion of tigernut-ogi incorporated into their feed ration. Meanwhile, increase in proportion of tigernut-ogi in the feed ration administered on both the infected and non-infected grouped rats resulted in slower increase in rat body weight than the control. Tigernut-ogi played a significant role towards improvement of Feed efficiency ratio (FER), Feed conversion ratio (FCR), Specific growth rate (SGR) and Protein

**Corresponding author: E-mail: maduks.mn@gmail.com;*

efficiency ratio (PER) of infected grouped rats whereas the quality of the feed ration (less quantity tigernut-ogi) positively influenced FER, FCR and SGR of non-infected grouped rats. Average weight gain (AWG) of the grouped rats was significantly affected by orally infecting the rats with *Escherichia coli*. Among the infected and non-infected grouped rats, G1A and G1B rat group recorded the highest body weight 233.86 g and 259.71 g, respectively whereas the control was 278.14 g. There was no significant difference between G2A and G2B grouped rats in terms of SGR and FER. In conclusion, tigernut-ogi incorporated into basal feed in the ratio 30:70 and 10:90 could suitably be used as growth enhancer in infected and non-infected rats, respectively.

Keywords: Animal growth enhancer; probiotics; antibiotic growth promoters; lactic acid bacteria; tigernut, ogi.

1. INTRODUCTION

Livestock farmers especially in developing countries over the years have been facing the challenge of increasing cost of animal feed. Sourcing cheaper and readily available plant materials locally as animal feed will certainly reduce the cost of feeding animals. Apart from utilizing tigernut tubers in diverse ways as a source of food for humans, it can also be used to feed animals. In fact, tigernut can be used directly or combined with other food materials to feed livestock [1,2,3,4].

Some decades ago, the spread of antibiotic resistance (ART) microbes among the human populace increased at an alarming rate. This was attributed to the consumption of poultry products over a long period bred with antibiotic growth promoters (AGPs). In order to arrest the situation, a total ban on AGPs usage in poultry was implemented in most European countries [5]. Consequently, the use of probiotics as an alternative to AGPs was encouraged [6,7]. It is a safe practice to feed poultry with probiotics. Food materials fermented by probiotic can be useful in stabilizing microbiota in the small intestine of animals. This might reduce the effect of pathogenic microbes in the intestine competing with the host for nutrients which might translate to enhanced growth in animals [8,9].

'Ogi' is an acid gruel indigenous to Nigeria and few other West African countries. It is usually a product of fermented maize, but other cereals such as sorghum and millet could also be used. Probiotic lactic acid bacteria are present in raw ogi [10,11]. The main purpose of fermenting cereals to produce ogi is for human consumption. The usefulness of ogi could be extended as a source of potential probiotic bacteria that could be beneficial to animals.

Animal growth enhancer are beneficial probiotic microorganisms which is added to animal feed to bring about positive effect in the animal small intestine by competitively eliminating detrimental microorganisms which nourish themselves with available nutrients and generate toxic substances. As a result of the activity of these beneficial microorganisms, the animal will experience better nutrient utilization, increased feed conversion ratio and growth rate which result in improvement of the general health status of the animal [12].

In poultry, *Bacillus* sp. is often used as a probiotic feed additive [13]. Fermented feeds account for high number of lactic acid bacteria (approximately1 x 10^9 cfu/ml) in animal feed. *Lactobacillus* sp. are predominantly present in ogi compared with other fermenting microorganisms in the ogi [14,15,16]. The use of probiotic powder as animal feed additive is gaining more acceptability among farmers [17, 18,19]. Animal feed incorporated with beneficial microorganisms identified to strain level is usually applied in animal husbandry in a regulated manner [20]. The practice of mixing microorganisms with animal feed for the benefit of animals is known as direct fed microbial (DFM) supplementation. Bacterial probiotics commonly used in animals is *Bacillus* sp. [21].

Menconi [22] described the mechanism of action of probiotics as an alternative to the use of AGPs in animals. Generally, AGPs is grouped into four based on their mechanism of action [23]. A novel alternative to the use of antibiotics involves the use of live biotherapeutic agents such as *Saccharomyces* spp and bacterial isolates such as *Lactobacillus* spp or *Bifidobacterium* spp [24]. The use of AGPs is linked to the spread of ART in humans. Therefore, farmers involved in animal husbandry are discouraged from extensive use of AGPs [25].

In the light of the above, this study is aimed at determining the effectiveness of using tigernut-ogi blended with basal feed as animal feed ration

to function as growth enhancer in order to reduce overdependence in therapeutic antibiotics as a growth promoter in animals.

2. MATERIALS AND METHODS

2.1 Source of Materials

Big yellow variety tigernut tubers, freshly prepared ogi and basal feed (Top brand, growers mash) were purchased from a reputable dealer in animal feed at Choba, Rivers State. The procedure described by [26] was used to prepare 'ogi' from maize. Wistar rats (*Rattus norvegicus*) were purchased from Department of Human Physiology, University of Port Harcourt. *Escherichia coli* used to orally infect Wistar albino rats before tigernut-ogi basal feed ration was administered on the rats were obtained from Medical Laboratory Department, University of Port Harcourt Teaching Hospital, Rivers State.

2.2 Preparation of Feed Ration Administered on the Rats

The tigernut tubers were manually crushed using a grinder. Tigernut-ogi in the ratio 70:30 (w/w) was first formulated and this portion incorporated into basal feed (Top feed; growers mash) in the ratio 10:90, 30:70 and 50:50 which constitute different feed compositions. The final feed compositions 10:90, 30:70 and 50:50 were administered on *Escherichia coli* infected rats in G1A, G2A and G3A treatment group, respectively. Similarly, the non-infected rats in G1B, G2B and G3B treatment group were administered 10:90, 30:70 and 50:50 fed compositions, respectively. The control being non-infected rats were administered 100% (w/w) basal feed.

2.3 Ethical Approval

University of Port Harcourt Research Ethics Committee gave approval for the use of Wistar albino rats in a manner that will ensure their well being and avoid unwarranted suffering of the animals during the period of the feeding experiment. Thirty five (35) male and female Wistar albino rats that have weights ranged between 192-205 g were used for this study.

2.4 Rat Feeding Experiment

The procedure used in carrying out rat feeding experiment described by [27] was adopted. Initial weights of rats in each group were noted. The Wistar albino rats were kept in a wooden cage on a 12 hour light/dark cycle at room temperature (28 ±2°C). The rats were fed growers mash (Top Feed) and water *ad libitum.* The grouped rats comprise of 5 rats each. The rats in each group were kept separately in a partitioned wooden cage in such a way that the feacal droppings and spilled food could easily be collected. The feeding experiment commenced after the grouped rats were allowed to get used to each other for 7 Days to avoid fights among them. Rats in G1A, G2A and G3A treatment group were orally infected daily with *Escherichia coli* (0.2 ml of 1 x 10^6 cfu) for 3 Days whereas rats in G1B, G2B and G3B treatment group including the control were not orally infected with *Escherichia coli.* The rat feeding experiment lasted for 28 Days. Feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER), growth rate and specific growth rate was determined using standard methods. Feed intake, daily weight and average weight of the rats was determined. Daily feed consumption and average daily feed consumption of the grouped rats was determined [28,29,30].

2.5 Determination of Proximate Composition of Tigernut, Ogi and Basal Feed

The protein, fat, crude fibre and moisture content of tigernut, ogi and basal feed used in formulating the feed ration administered on the rats were determined using AOAC methods. The carbohydrate content of the samples was determined by difference method [31].

2.6 Determination of Mineral Content of Tigernut, Ogi and Basal Feed

The magnesium, potassium, phosphorus, sodium and calcium content of tigernut, ogi and basal feed were determined by dry ash acid extraction method as described by [32].

3. RESULTS AND DISCUSSION

The results presented in Figs. 1 and 2 show the proximate composition and mineral content, respectively of tigernut, basal feed and ogi. These materials were used in different proportion to formulate a feed ration that were administered on infected and non-infected Wistar albino rats in different treatment groups. The percentage nutritional composition of tigernut and ogi depicted in Fig. 1 is close to the results obtained in previous studies carried out by [33] and [34], respectively. There is unavailability of data from previous studies on proximate composition of basal feed (Top brand, grower's mash).

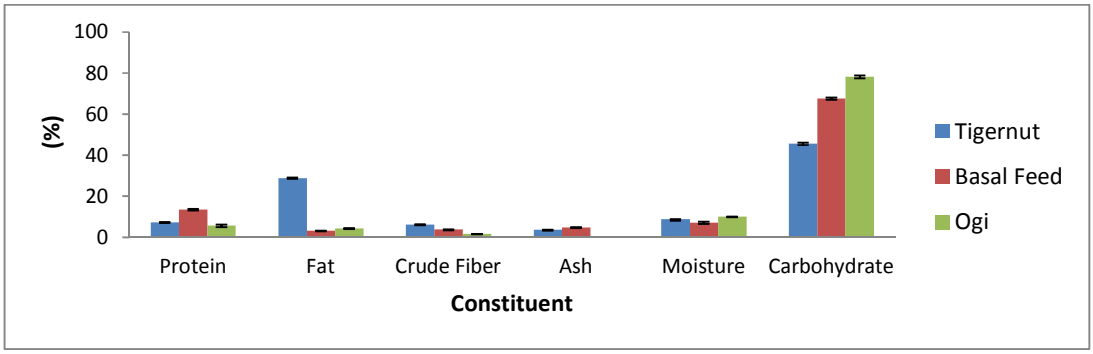

Fig. 1. Proximate composition of tigernut, basal feed and ogi used in different proportion as feed ration

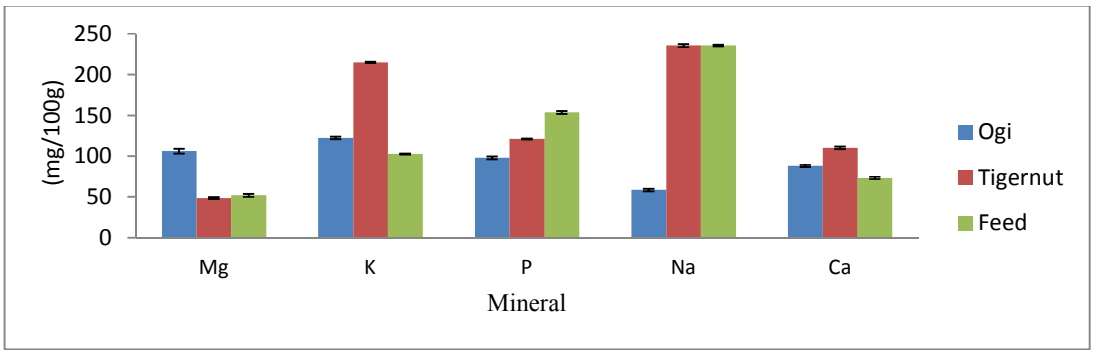

Fig. 2. Mineral content of tigernut, basal feed and ogi used in different proportion as feed ration

Tables 1 and 2 show the proximate composition and mineral content, respectively of feed ration administered on infected and non-infected Wistar albino rats in different treatment groups. The results show that there was reduction in percentage nutrient composition of the various feed ration as the proportion of tigernut-ogi incorporated into basal feed except carbohydrate, sodium and phosphorus content. However, magnesium content of the various feed ration were relatively stable. Increase in the proportion of ogi characterized by high carbohydrate content but low amount of other nutrients in the various feed ration could be the reason for reduction in most of the nutrient composition of the feed ration [34]. Furthermore, high carbohydrate content of tigernut could also be a contributory factor. Meanwhile, the major raw material used for preparing ogi is cereals of which in Southern Nigeria, maize which is rich in carbohydrate content is commonly used [35]. According to [36,37], phosphorus and sodium content of tigernut is high. This could be the reason increase in the quantity of tigernut in the various feed ration also resulted in increased sodium and phosphorus content of the feed ration.

3.1 Average Daily Feed Consumption and Feed Intake of the Grouped Rats

The result presented in Table 3 revealed that there was reduction in average daily feed consumption (ADFC) and feed intake (FI) of the infected and non-infected Wistar albino rats in different treatment groups as the proportion of tigernut-ogi incorporated into the basal feed administered on the grouped rats increased except the non-infected grouped rats used as control. This study revealed that among the infected and non-infected rats in different treatment groups, G1A and G1B grouped rats respectively, administered 90% (w/w) basal feed incorporated with 10% (w/w) tigernut-ogi recorded the highest FI whereas G3A and G3B rat treatment group administered 50% (w/w) tigernut-ogi mixed with 50% (w/w) basal feed had the lowest FI. The taste, smell and texture of feed ration administered on rats in G3A and G3B treatment group could have resulted in low FI by the rats. In other words, the feed ration

administered on G3A and G3B grouped rats were of low quality. According to [38], factors such as amino acid pattern which constitute dietary protein, smell, taste and texture of tigernut-ogi might have influenced the reduction in ADFC and FI of the rats. The level of antinutrients in tigernut-ogi blended with basal feed could have influenced the reduction in FI among the various rat treatment groups. Tadele [39] reported that antinutritional factors in animal feed could cause FI reduction in animals. In a related study, [38] reported FI reduction in rats administered a formulated diet which comprise of treated and raw jatropha curcas seed. Based on the report of [39], it could be that the quantity of tannin as a result of increasing proportion of tigernut-ogi in the feed ration administered on infected and non-infected rats in different treatment groups influenced FI reduction by the Wistar albino rats. The control achieved the highest FI of 19.36 g. This could be as a result of high palatability and quality of the feed ration administered on the rats. The control not to have been orally infected with *Esherichia coli* could also have resulted in high FI. This result trend is in agreement with the study carried out by [40]. According to [41], birds consume more quantity of common feeds that are usually available than feeds that are not usually available which they are unfamiliar with. In a related study, [42] reported that FI in broiler chicks reduced as the level of tigernut used to substitute maize in the diet consumed increased. According to [43], administering probiotics in animals increases its FI. However, in this study it was observed that tigernut-ogi might not have functioned optimally as a probiotic in Wistar albino rats because it did not result in increased FI by the rats. The palatability of tigernut blended with ogi could be one of the limitations in achieving enhanced FI by the rats. Detailed comparison of infected and non-infected grouped rats in terms of feed intake revealed that the later recorded higher FI than the former. Based on this observation, it can be inferred that orally infecting the rats with *Escherichia coli* had more influence on the feed intake of the infected rats in different treatment groups than feed composition administered on the infected rats. This study revealed that there is a relationship between ADFC and composition of feed ration administered on both the infected and non-infected grouped rats. It was demonstrated that the ADFC of non-infected rats in different treatment group was higher than infected grouped rats. This could be as a result of orally infecting the rats with *Escherichia coli* which resulted in lower ADFC compared with non-infected rats in different treatment groups.

Table 1. Proximate composition of basal feed blended with tigernut-ogi as animal feed ration

Feed ration	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Moisture (%)	Carbohydrate (%)
T/O	5.84±0.90^{d}	22.06±0.30^{d}	4.81±0.30^{c}	3.22±0.18^{ab}	9.69±0.37^{b}	54.38±0.48^{a}
90:10	5.19±0.28^{c}	19.41±0.16^{c}	4.34±0.21^{b}	3.15±0.27^{a}	9.55±0.29^{b}	58.35±0.33^{b}
70:30	4.14±0.28^{b}	15.23±0.18^{b}	4.27±0.18^{b}	3.71±0.34^{c}	9.64±0.13^{b}	63.00±0.45^{c}
50:50	3.44±0.28^{a}	12.05±0.28^{a}	3.98±0.18^{a}	3.49±0.45^{bc}	9.62±0.18^{a}	67.42±0.53^{d}

Values show means of triplicate analysis ±SD. Figures with different superscript down the column, are significantly different (P<0.05). : T/O represents 70% tigernut blended with 30% ogi.
Key: 90:10 represent 90% basal feed blended with 10% T/O; 70: 30 represent 70% basal feed blended with 30% T/O; 50:50 represent 50% basal feed blended with 50% T/O

Table 2. Mineral content of basal feed blended with tigernut-ogi in different proportion as animal feed ration

Feed ration	Ca	Mg	K	Na	P
		(mg/100 g)			
T/O	122.91±1.37^{d}	53.33±1.94^{a}	198.72±2.29^{d}	125.47±1.90^{a}	118.50±1.26^{a}
90:10	114.89±1.37^{c}	49.33±1.37^{a}	189.13±1.24^{c}	186.93±0.87^{b}	122.60±1.25^{b}
70:30	106.88±1.37^{b}	50.67±1.37^{a}	168.57±1.58^{b}	228.27±2.46^{c}	128.61±1.25^{c}
50:50	98.86±1.37^{a}	52.00±1.81^{a}	148.27±1.62^{a}	230.23±1.59^{c}	131.32±1.10^{c}

Values show means of triplicate analysis ±SD. Figures with different superscript down the column, are significantly different (P<0.05). T/O represents 70% tigernut blended with 30% ogi.
Key: 90:10 represent 90% basal feed blended with 10% T/O; 70: 30 represent 70% basal feed blended with 30% T/O; 50:50 represent 50% basal feed blended with 50% T/O

Table 3. Effect of tigernut-ogi as a source of probiotic incorporated into basal feed on growth performance of wistar albino rats

Parameter	G1A	G2A	G3A	G1B	G2B	G3B	Control
ADFC (g)	17.92±0.291^{d}	16.56±0.166^{c}	14.45±0.050^{a}	19.20±0.107^{f}	18.39±0.0889^{e}	16.05±0.076^{b}	19.36±0.131^{f}
FI (g)	522.03±7.25^{d}	472.67±5.38^{c}	404.76±3.37^{a}	537.49±6.283^{e}	514.91±3.490^{d}	425.06±4.785^{b}	542.16±1.386^{e}
FER	0.077±0.010^{c}	0.099±0.013^{d}	0.042±0.025^{b}	0.138±0.037^{e}	0.091±0.033^{d}	0.028±0.075^{a}	0.166±0.007^{f}
FCR	12.99±0.05^{e}	10.06±1.61^{c}	23.81±0.076^{f}	7.26±0.031^{b}	10.96±0.076^{d}	35.42±0.067^{g}	6.024±0.006^{a}
SGR (%)	0.083±0.18^{a}	0.331±0.003^{c}	0.127±0.004^{b}	0.490±0.008^{d}	0.330±0.004^{c}	0.091±0.025^{f}	0.581±0.146^{e}
PER	1.66±0.032^{c}	2.45±0.030^{f}	1.87±0.025^{d}	2.58±0.025^{g}	2.35±0.025^{e}	0.68±0.015^{a}	1.23±0.025^{b}
Initial Wt (g)	199.80	199.80	198.80	199.40	198.20	198.20	198.00

Values show means of replicate analysis ±SD. Figures with different superscript along the row, are significantly different (P<0.05).

Key: G1A -Infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2A-Infected rats fed 70% (w/w) basal feed blended with 30% (w/w) tigernut-ogi; G3A-Infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; G1B-Non-infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2B-Non-infected rats fed 70% (w/w) basal feed blended with 30% (w/w) tigernut-ogi;G3B-Non-infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; Control –Non-infected rats fed 100% (w/w) basal feed; Tigernut-ogi ration comprise of 70% (w/w) tigernut blended with 30% (w/w) ogi

3.2 Feed Efficiency Ratio of the Grouped Rats

Among the infected grouped rats, Table 3 shows that the highest and lowest feed efficiency ratio (FER) 0.0994 and 0.042 was achieved by infected rats in G2A and G3A treatment groups, respectively. High proportion of tigernut-ogi in the feed ration which translated to poor quality feed ration administered on rats in G3A treatment group could be the reason for its low FER. The FER achieved by infected rats in G2A treatment group could be as a result of a suitable proportion of tigernut-ogi in the feed mix consumed by the grouped rats. The probiotic lactic acid bacterial (LAB) population ingested by rats in G2A treatment group based on 30% (w/w) tigernut-ogi which constitute part of the feed ration administered on the grouped rats might have positively influenced rat intestinal microflora which enhanced nutrient absorption using their digestive enzymes. This might have resulted in better FER in the infected rats in G2A treatment group compared with other infected rats in different treatment groups. The slightly lower FER 0.077 of infected rats in G1A treatment group compared with infected rats in G2A treatment group could be as a result of lower proportion of tigernut-ogi in the feed mix administered on the infected rats in G1A treatment group which is a representation of LAB population ingested by the rats. The population of LAB ingested by infected rats in G1A treatment group might not be adequate to bring about improvement in the intestinal microflora of the infected rats that will enhance FER. The feed intake and average daily feed consumption of infected rats in G1A treatment group being the highest compared with other infected rats in different treatment groups did not translate to enhanced FER possibly as a result of the rats being orally infected with *Escherichia coli.* Among the non-infected grouped rats, G3B recorded the lowest FER 0.028. Poor quality of the feed ration required for animal growth and low feed intake as a result of texture, aroma and taste of tigernut-ogi blended with basal feed in the ratio 50:50 administered on the grouped rats might have resulted in FER of the rats being the lowest compared with other non-infected rats in different treatment groups. In a related study, [37] reported that texture, aroma and taste of animal feed could affect FER of rats. The non-infected rats in G1B treatment group achieved the highest FER of 0.1377 compared with other non-infected rats in different treatment groups. This probably was as a result of the feed ration administered on the grouped rats enhanced their growth by ensuring that high FER was maintained. It could also be that the feed ration was very palatable which resulted in higher feed intake (FI) and average daily feed consumption by the rats in G1B treatment group compared with other non-infected rats in different treatment groups. These factors might have contributed significantly in the FER of non-infected rats in G1B treatment group. The control achieved the highest FER 0.166 compared with infected and non-infected rats in different treatment groups. The ability of the control to have achieved the highest FER could be as a result of palatability and nutritional composition of 100% (w/w) basal feed compared with basal feed blended with tigernut-ogi in different proportion. In a related study, [39] reported slightly higher FER during feeding of broiler chicken with ogi.

Comparison between infected and non-infected grouped rats that achieved the highest FER revealed that the FER of non-infected rats in G1B treatment group was higher than that of infected rats in G2A treatment group. This could be as a result of orally infecting rats in G2A treatment group with *Escherichia coli* and not infecting rats in G1B treatment group. It could also be that variation in feed composition administered on the rats in G1B and G2A treatment groups was responsible for higher FER in rats in G1B treatment group than rats in G2A treatment group. However, the FER of non-infected rats in G3B treatment group which was the lowest among the non-infected rats in different treatment groups was also lower than FER of infected rats in G3A treatment group which had the lowest FER among the infected rats in different treatment groups. Considering FER of G3A and G3B grouped rats, the quality of the feed ration administered on rats in both groups seem to have more effect than the rats being orally infected with *Escherichia coli* or not.

3.3 Feed Conversion Ratio of the Grouped Rats

The result in Table 3 revealed that the feed conversion ratio (FCR) of non-infected rats in different treatment groups increased as body weight of the rats reduced. A related study by [42] reported that there is a relationship between FCR and rat body weight. Feed conversion ratio 23.81 recorded by infected rats in G3A treatment group was the highest compared with other infected rats in different treatment groups. This could be as a result of low feed intake and nutrient composition of the feed ration

administered on the infected rats in G3A treatment group which resulted in low weight gain and high FCR. It could also be that low feed intake by the infected rats in G3A treatment group was as a result of the texture, smell and aroma of the feed ration administered on the grouped rats. The results in Table 3 further shows that average daily feed consumption (ADFC) and feed intake (FI) of infected rats in G3A treatment group was the lowest compared with other infected rats in different treatment groups. Although the quality of feed ration administered on infected rats in G2A treatment group was not of a higher quality than feed ration administered on infected rats in G1A treatment groups but, 30% (w/w) tigernut-ogi which contain what could be considered adequate probiotic lactic acid bacterial (LAB) population ingested by the infected rats in G2A treatment group might have resulted in enhanced nutrient absorption by inhibiting the effect of *Escherichia coli* infection on FCR. Furthermore, the palatability of the feed ration administered on infected rats in G2A treatment group could also have contributed in better FCR of the rats. Since the feed intake and average daily feed consumption of infected rats in G1A treatment group was the highest among the infected rats in different treatment groups, it was expected that infected rats in G1A treatment group to have achieved better FCR than infected rats in G2A treatment group because the diet administered on the former which comprise of 90% basal feed and 10% tigernut-ogi was of a higher quality than feed ration administered on the later which comprise of 70% basal feed and 30% tigernut-ogi. This was not the case. This could be a result of 10% (w/v) tigernut-ogi in the feed ration administered on infected rats in G1A treatment group was not adequate to reduce the negative effect of *Escherichia coli* infection in terms of FCR of the infected grouped rats. Higher FCR of infected rats in G1A treatment group compared with infected rats in G2A treatment group could be as a result of severe effect of *Escherichia coli* in G1A treatment grouped rats as a result of consuming only 10% tigernut-ogi considered to have lower LAB population than 30% (w/w) tigernut-ogi separately incorporated into 90% (w/w) and 70% (w/w) basal feed, respectively. By implication, 30% (w/w) tigernut-ogi contains higher LAB population than 10% (w/w) tigernut-ogi. In other words, severity of infecting rats in G1A treatment group with *Escherichia coli* possibly translated into higher FCR as a result of inadequate 10% tigernut-ogi incorporated into the feed ration administered on the grouped rats compared with infected rats in G2A and G3A treatment group which seemed to have experienced less severity effect from *Escherichia coli* infection as a result of being administered a feed ration that contained higher proportion of tigernut-ogi.

Among the non-infected grouped rats, the rats in G1B treatment group achieved the most efficient FCR 7.26. It could be that high portion 90% (w/w) basal feed in the feed mix consumed by non-infected rats in G1B treatment group as well as the fact that rats in G1B treatment group were not orally infected with *Esherichia coli* resulted in G1B grouped rats to achieve most efficient FCR compared with FCR by other non-infected rats in different treatment groups. Table 3 revealed that FCR of the non-infected rats in different treatment groups reduced as the proportion of tigernut-ogi incorporated into their feed ration increased. The reason for this could be that non-infected rats were less efficient in converting increasing quantity of tigernut-ogi in their feed mix into body weight gain. The result in Table 3 revealed that non-infected rats in different treatment groups had better FCR than corresponding infected rats in different treatment groups administered the same feed ration. Less efficient FCR by infected rats in different treatment groups could be as a result of oral infection of the rats with *Escherichia coli*. In other words, orally infecting Wistar albino rats with *Escherichia coli* affected the FCR of the grouped rats.

The control achieved FCR of 6.024. This shows that non-infected rats used as control was efficient in converting 100% (w/w) basal diet consumed into body weight gain. In other words, 100% (w/v) basal feed was of higher quality than basal feed incorporated with tigernut-ogi in different proportion administered on non-infected and infected rats in different treatment groups. Based on the report of feeding experiment carried out by [41], FCR of the rats was a function of quality of feed administered on the rats. The higher the quality of feed administered on rats, the better the feed conversion ratio of the rats. According to [43], administering probiotic to poultry can result in improved nutrient digestibility. However, very limited information is available regarding different feedstuff acting together with probiotics as animal feed ration.

3.4 Specific Growth Rate of the Grouped Rats

Table 3 shows that highest specific growth rate (SGR) amongst the infected rats in different

treatment groups was achieved by rats in G2A treatment group. This could be as a result of synergetic effect of high population lactic acid bacteria (LAB) in the feed ration consumed by infected rats in G2A treatment group as well as high quality of their feed ration. According to [43], administering probiotics on animals in the form of growth enhancer encourages the growth of beneficial microorganisms which brings about a positive result by inhibiting the growth of some pathogenic microorganisms through a mechanism known as competitive exclusion. According to [41], rats can adjust their feed intake per energy demand through efficient regulatory mechanism based on specific range of caloric density. Addass [41] pointed out that rats do not meet their dietary protein requirements by consuming feed. The protein content of feed ration consumed by infected rats in G1A treatment group was the highest among the infected rats in different treatment groups. Also, the feed intake of infected rats in G1A treatment group was the highest compared with other infected rat treatment group. Unfortunately, these two factors were not sufficient to make the infected rats in G1A treatment group to achieve the highest SGR. Rather, the infected rats in G1A treatment group recorded lowest SGR. It could be that 10% (w/w) tigernut-ogi incorporated into the feed ration administered on the infected rats in G1A treatment group was not sufficient to provide adequate lactic acid bacteria population that would have been effective in reducing the effect of G1A grouped rats being orally infected with *Escherichia coli* in terms of SGR of the rats. This could have resulted in SGR of infected rats in G1A treatment group being the lowest compared with other infected rats in different treatment groups. Among the non-infected rats in different treatment groups, the rats in G1B achieved the highest SGR. This could be as a result of high quality feed ration administered on the grouped rats. Despite being administered with the same feed ration, non-infected rats in G1B treatment group achieved higher SGR than infected rats in G1A treatment group. This observation could be as a result of rats in G1B was not orally infected whereas rats in G1A treatment group were orally infected with *Escherichia coli.* It was observed in Table 3 that as the proportion of basal feed incorporated into feed ration consumed by the non-infected grouped rats reduced, there was corresponding reduction in SGR. This could be as a result of tigernut-ogi incorporated into the basal feed was of low quality in terms of nutrient composition required for increase in growth rate of the rats. The control achieved highest SGR compared with basal feed blended with different proportion of tigernut-ogi administered on infected and non-infected rats in different treatment groups possibly as a result of high quality 100% (w/w) basal feed was administered on the grouped rats used as control. The fact that the control was not orally infected with *Escherichia coli* could also have contributed in the rat group achieving the highest specific growth rate compared with infected rats in different treatment groups.

3.5 Protein Efficiency Ratio of the Grouped Rats

The protein efficiency ratio (PER) of infected rats in G2A treatment group was the highest among the infected rats in different treatment groups. Although the protein content of the feed ration administered on infected rats in G2A treatment group was low, the influence of large population of lactic acid bacteria (LAB) due to the proportion of tigernut-ogi that constitute the feed ration administered on the rats might have resulted in enhanced protein absorption in the rat intestine. The quantity of protein consumed by infected rats in G2A treatment group is a function of their feed intake. An indication that population of LAB in ogi contributed significantly in improvement of PER of the infected rats was observed in rats in G3A treatment group. Despite lower feed intake by infected rats in G3A treatment group and lower protein content of the feed ration administered on the grouped rats compared with infected rats in G1A treatment group, the PER of infected rats in G1A treatment group was lower than infected rats in G3A treatment group. It could be that high proportion tigernut-ogi in the feed ration administered on infected rats in G3A treatment group enhanced protein absorption in the rat intestine which ensured that available nutrients such as protein was optimally utilized which resulted in slightly higher PER of infected rats in G3A treatment group than infected rats in G1A treatment group. The PER of non-infected rats in G1B treatment group was the highest among the non-infected grouped rats. High protein content in the feed ration administered on rats in G1B treatment group, the fact that the rats were not orally infected with *Escherichia coli* as well as high feed intake of the grouped rats might be the reason the grouped rats achieved the highest PER compared with other non-infected rats in different treatment groups. Table 3 revealed that PER of non-infected rats in different treatment groups reduced as the proportion of tigernut-ogi incorporated into the

feed ration administered on the rats in different treatment groups increased. It could be that among the non-infected rats in different treatment groups, the nutritional composition of the feed ration administered on the rats had more effect than lactic acid bacterial population in the feed ration consumed by the rats in terms of PER. This could be as a result of rats in treatment group G1B, G2B and G3B were not orally infected with *Escherichia coli*. Table 3 revealed that PER of grouped rats used as control was the lowest compared with non-infected rats in different treatment groups. Similarly, the PER of the grouped rats used as control was the lowest compared with non-infected rats in different treatment groups except rats in G3B treatment group. The absence of tigernut which contains essential amino acids in the 100% (w/w) basal feed consumed by the grouped rat used as control could be the reason for low PER of the rats. Generally, the PER of a feed ration administered on animals is an indication of the quality of protein in that particular feed ration. According to [44], high protein efficiency ratio is an indication of high quality protein content.

3.6 Average Body Weight of the Grouped Rats

Table 4 revealed that there was reduction in body weight of infected and non-infected grouped rats as the proportion of tigernut-ogi blended with basal feed increased. This could be attributed to increasing quantity of less quality tigernut-ogi incorporated into the basal feed administered on both infected and non-infected rats in different treatment groups in terms of palatability and nutritional composition. In a related study, [42] observed that there was reduction in body weight of broiler chicken as the proportion of tigernut used to substitute maize in their diets increased. Table 4 shows that throughout the period of rat feeding experiment, the infected and non-infected rats in different treatment groups experienced increase in body weight except at Week 2 when infected rats in G1A treatment group experienced slight body weight loss. The body weight loss could be as a result of synergetic effect of rats in G1A treatment group being orally infected with *Escherichia coli* and the rats being administered feed ration containing 10% (w/w) tigernut-ogi which might not to be sufficient to effectively reduce the effect of the infection on rat body weight at Week 2. Among the infected rats in different treatment groups, it was observed that infected rats in G2A treatment group had the most significant increase in body weight gain. This could be as a result of synergetic effect of what could be considered adequate population of lactic acid bacteria (LAB) present in the feed ration administered on the infected rats in G2A treatment group which reduced the effect of *Escherichia coli* on rat body weight. Therefore, 30% (w/w) tigernut-ogi in the feed ration consumed by infected rats in G2A treatment group reduced the effect of orally infecting the rats with *Escherichia coli* which possibly contributed in rat body weight gain. Going by the body weight gain of infected grouped rats administered basal feed incorporated with different proportion of tigernut-ogi monitored at four weeks interval, it could be generalized that increase in body weight of the infected rats in different treatment groups were more influenced by the population of LAB in the feed ration consumed based on proportion of tigernut-ogi incorporated into the feed ration than the nutritional composition of feed ration administered on the infected rats in different treatment groups. This study strongly indicates that LAB present in tigernut-ogi in synergy with nutritional composition of the feed ration consumed by the infected rats in different treatment groups functioned as a growth enhancer by inhibiting pathogenic microorganisms such as *Escherichia coli* in the gastrointestine (GIT) from competing with beneficial microbes for available nutrients.

Among the non-infected rats in different treatment groups, Table 1 revealed that the non-infected G1B grouped rats experienced the most significant increase in body weight. This could be as a result of high feed intake by non-infected rats in G1B treatment group as well as high protein content and other essential amino acids in the feed ration consumed by the non-infected rats in G1B treatment group. Among the non-infected rats in different treatment groups, it could also be generalized that increase in body weight of the non-infected rats were influenced majorly by the nutritional composition of the feed ration consumed by the rats than the population of LAB population in the feed ration in terms of quantity of tigernut-ogi. This study demonstrated that adequate nutrients should be available for animals to absorb into their body system and not majorly depending on the population of probiotic LAB ingested together with animal feed to compete with pathogenic microorganisms for limited nutrients in the animal intestine in order to achieve rat body weight gain. That could be the

reason feed ration which comprise of 50% (w/w) tigernut-ogi incorporated into 50% (w/w) basal feed did not result in appreciable increase in rat body weight. The increase in rat body weight as a result of feed ration incorporated with different proportion of tigernut-ogi administered on the rats in different treatment groups is an indication that poultry farmers can achieve a similar result using similar feed ration. Based on the outcome of this feeding experiment, it is suggestive that the level of antinutrients in tigernut-ogi incorporated into basal feed did not cause much interference in protein metabolism which resulted in body weight increase. A similar observation was made by [39] in a study which involved feeding rats with diets formulated from treated and raw samples of jatropha curcas seed. In a related study, [45] reported that using tigernut oil to feed rats resulted in increase of initial body weight of the rats from 92.06-196.23 g. Chukwuma [46] in a related study also reported increase in body weight of rats fed extract of (*Cyperus esculentus* L.). The control experienced most significant increase in body weight. This could be attributed to palatability and nutritional composition as well as the fact that the rats were not orally infected with *Escherichia coli.*

3.7 Weekly Growth Rate of the Grouped Rats

The negative growth rate experienced by infected rats in G1A treatment group at Week 2 depicted in Fig. 3 could be as a result of orally infecting the rats with *Escherichia coli.* The population of LAB in 10% (w/w) tigernut-ogi incorporated into basal feed administered on infected rats in G1A treatment group might not have been effective against the influence of *Escherichia coli* on growth rate of the grouped rat. This might have resulted in negative growth rate of infected rats in G1A treatment group at Week 2. The infected rats in G2A treatment group also experienced negative growth rate at Week 2 possibly as a result of less quality feed ration administered on the rats. Interestingly, the infected rats in G2A treatment group attained the highest growth rate at Week 1 compared with other infected rats in different treatment groups. The highest growth rate achieved by infected rats in G2A treatment group at Week 1 could be as a result of synergy between quality of feed ration in terms of nutrient composition, palatability and population of LAB ingested by the grouped rats. Among the infected grouped rats, it was only the infected rats in G3A treatment group that experienced negative growth rate twice at Week 1 and 3. This could be as a result of less quality feed ration administered on infected rats in G3A treatment group compared with feed ration administered on other infected rats in different treatment groups. It could be that the feed ration administered on infected rats in G3A treatment group resulted in negative growth rate at Week 1 and 3 because of poor nutritional composition of their feed ration which might not be adequate to maintain positive growth rate in the rats throughout the period of the feeding experiment. Remarkably, the negative growth rate of rats in G3A treatment group was better than negative growth rate of infected rats in G1A and G2A treatment groups. This could be as a result of

Table 4. Weekly average body weights of rats in different treatment groups

Group	Wk 1	Wk 2	Wk 3	Wk 4
			(g)	
G1A	213.43^{ba*}	212.29^{aa*}	222.29^{bb*}	233.86^{bc*}
G2A	223.00^{bca*}	227.57^{ba*}	229.43^{ba*}	244.86^{cb*}
G3A	201.14^{aa*}	206.86^{aa*}	208.00^{aa*}	208.00^{aa*}
G1B	203.63^{ca*}	235.14^{bca*}	250.00^{cb*}	259.71^{dc*}
G2B	234.86^{ca*}	236.29^{ca*}	229.43^{ba*}	235.86^{ba*}
G3B	212.86^{ba*}	213.43^{aa*}	204.86^{aa*}	208.29^{aa*}
Control	220.14^{ba*}	230.86^{bcb*}	250.43^{cc*}	278.14^{ed*}

Values show means of quintuple weight of rats per group analysis. Figures with different superscript down the column, are significantly different (P <0.05). Figures with different superscript with asterisk along the row, are significantly different (P <0.05).

Key: G1A -Infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2A-Infected rats fed 70% (w/w) basal feed blended with 30 % (w/w) tigernut-ogi; G3A-Infected rats fed 50% (w/w) basal feed blended with 50 % (w/w) tigernut-ogi; G1B-Non-infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2B-Non-infected rats fed 70% (w/w) basal feed blended with 30% (w/w) tigernut-ogi; G3B-Non-infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; Control –Non-infected rats fed 100% (w/w) basal feed; Tigernut-ogi ration comprise of 70% (w/w) tigernut blended with 30% (w/w) ogi

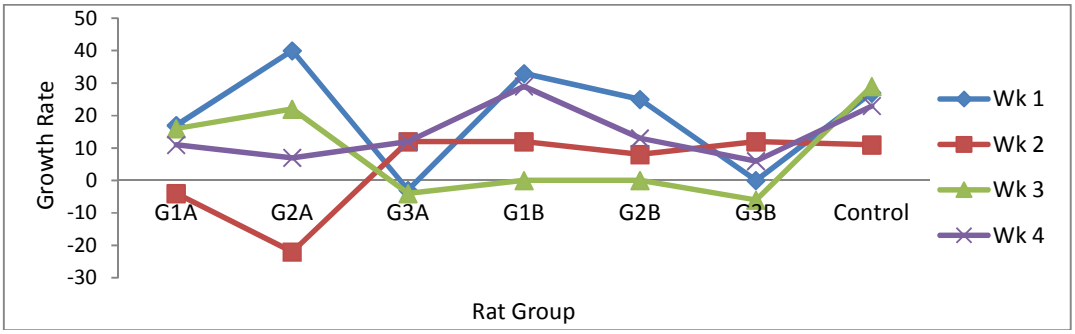

Fig. 3. Weekly growth rate of grouped rats in four weeks

Key: G1A -Infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2A-Infected rats fed 70% (w/w) basal feed blended with 30 % (w/w) tigernut-ogi; G3A-Infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; G1B-Non-infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2B-Non-infected rats fed 70 % (w/w) basal feed blended with 30% (w/w) tigernut-ogi; G3B-Non-infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; Control –Non-infected rats fed 100% (w/w) basal feed; Tigernut-ogi ration comprise of 70% (w/w) tigernut blended with 30% (w/w) ogi

higher proportion of tigernut-ogi in the feed ration administered on rats in G3A treatment group which provided the infected rats LAB population that could be considered adequate to significantly reduce the effect of *Escherichia coli* infection on the growth rate of the infected rats compared with the feed ration administered on infected rats in G1A and G2A treatment group.

The non-infected rats in G1B treatment group attained the highest growth rate at Week 1 compared with other non-infected rats in different treatment groups administered tigernut-ogi in different proportion. This could be as a result of high quality feed ration which was administered on the grouped rat. The non-infected rats in different treatment groups did not experience negative growth rate except non-infected rats in G3B treatment group. The negative growth rate of non-infected rats in G3B treatment group at Week 3 could be as a result of low quality feed ration administered on the grouped rats. Since rats in G3A and G3B treatment group were administered the same feed ration, the negative growth rate experienced by non-infected rats in G3B treatment group could have occurred more than once as it was the case in infected rats in G3A treatment group if not that the rats in G3B treatment group was not orally infected with *Escherichia coli*. The rat group used as control did not experience negative growth rate throughout the period of the rat feeding experiment. This could be as a result of high quality 100% (w/w) basal feed administered on non-infected rats. Therefore, consistent positive growth rate of rats used as control throughout the 28 Day feeding experiment could be as a result of the rats were not orally infected with *Escherichia coli* and nutrient composition of the feed ration administered on the rats.

3.8 Average Weekly Weight Gain of the Grouped Rats

Fig. 4 show the average weight gain (AWG) of infected and non-infected grouped rats in twenty eight days monitored at 1 Wk interval. The infected rats in G1A and G2A treatment group experienced negative weight gain twice at Week 2 and 4 whereas the G3A grouped rats only experienced negative weight gain at Week 3. Infected rats in G3A treatment group to experience negative weight gain only at Week 3 could be as a result of high proportion of tigernut-ogi 50% (w/w) in their feed ration. However, the feed ration administered on infected rats in G1A and G2A treatment group were incorporated with a lower proportion 10% (w/w) and 30% (w/w) tigernut-ogi, respectively which possibly resulted in negative weight gain of G1A and G2A grouped rats that occurred at Week 2 and 4.

The non-infected rats in G1B and G2B treatment group experienced negative weight gain twice at Week 2 and 3 whereas the non-infected rats in G3B treatment group experienced negative growth rate only at Week 3. This result trend is similar to AWG of infected rats in G1A, G2A and G3A treatment groups except that negative weight gain of the infected group rats was lower than non-infected G1B, G2B and G3B grouped rats. Therefore, orally infecting the rats with *Escherichia coli* significantly affected AWG of the rats. The lowest and highest weight gain among the infected and non-infected grouped rats including the control during the period of the

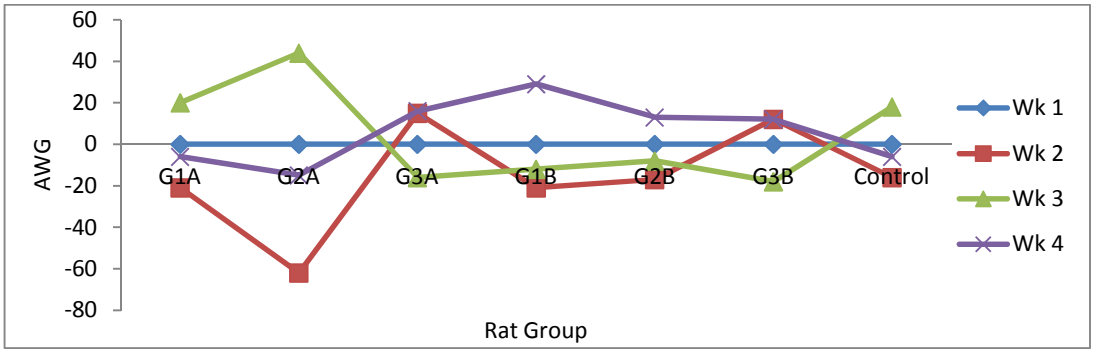

Fig. 4. Average weekly weight gain of grouped rats in twenty eight days

Key: G1A -Infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2A-Infected rats fed 70% (w/w) basal feed blended with 30 % (w/w) tigernut-ogi; G3A-Infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; G1B-Non-infected rats fed 90% (w/w) basal feed blended with 10% (w/w) tigernut-ogi; G2B-Non-infected rats fed 70% (w/w) basal feed blended with 30% (w/w) tigernut-ogi; G3B-Non-infected rats fed 50% (w/w) basal feed blended with 50% (w/w) tigernut-ogi; Control –Non-infected rats fed 100% (w/w) basal feed; Tigernut-ogi ration comprise of 70% (w/w) tigernut blended with 30% (w/w) ogi

feeding experiment was achieved by infected rats in G2A treatment group in Week 2 and 3, respectively. Fig. 4 revealed that within the period of the feeding experiment, the infected rats in G3A treatment group and non-infected rats in G3B treatment group experienced positive weight gain in Week 2 and 4, respectively but negative weight gain in Week 3. The proportion of tigernut-ogi in the feed ration administered on G3A and G3B grouped rats might have influenced positive weight gain that occurred twice at 2 weeks interval during the period of the feeding experiment. An important observation during the period of feeding experiment is the fact that both infected and non-infected grouped rats including the control experienced positive weight gain at least once within the interval of monitoring.

Based on the results obtained from this study, it is suggested that variation in nutrient composition of treatment diets formulated using tigernut, ogi and basal feed administered on both infected and non-infected rats shown in Table 1 and 2; Figs. 1 and 2 resulted in variation in rat growth performance depicted in Tables 3 and 4; Figs. 3 and 4.

4. CONCLUSION

This study demonstrated that feed ration which comprise of tigernut-ogi in the ratio 70:30 blended with basal feed in the ratio 30:70 administered on Wistar albino rats orally infected with *Escherichia coli* is a recommended animal growth enhancer. Among the non-infected grouped rats, tigernut-ogi in the ratio 70:30 blended with basal feed in the ratio 10:90 is recommended as a suitable animal growth enhancer. However, 100% basal feed administered on non-infected Wistar albino rats resulted in better growth performance than basal feed incorporated with tigernut-ogi in different proportion.

ACKNOWLEDGEMENTS

I sincerely appreciate Dr. F. A. Orji for his wonderful contributions to the success of this research. This publication is part of the PhD thesis of the author who personally funded the research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Onunkwo DN, Ugwuene MC. The effect of feeding different levels of tigernut (*Cyperus esculentus L.*) seed meal on carcass and organ weights characteristics of Japanese quails (*Coturnix coturnixjaponica*). Int. Multidiscip. Resear. Rev. 2015;1(1):31-35.
2. Agbabiaka LA, Madubuike FN, Ekenyem BU, Esonu BO. Effect of feeding different levels of tigernut (*Cyperus esculentus* L) meal on growth of broiler chicks. Ameri. J. Experi. Agric. 2013;3(4):1-9.
3. Alagbe JO. Effects of feeding varying levels of tigernut (*Cyperus esculentus*) seed meal on the performance and blood profile of weaner grass cutters. Schor. J. Agric. Sci. 2017;7(1):15-19.

4. Onovo JC, Ogaraku AO. Studies on some microorganisms associated with exposed tigernut (*Cyperus esculentus* L.) milk. J. Bio. Sci. 2007;7(8):1548-1550.
5. Dibner JJ, Richards JD. Antibiotic growth promoters in agriculture: History and mode of action. Poultry Sci. 2005;84:634-643.
6. Soccol CR, Vandenberghe LPS, Spier MR, Medeiros ABP, Yamaguishi CT, Lindner JDD, Pandey A, Thomaz-Soccol V. The potential of probiotics: A review. Food Tech. Biotech. 2010;48(4):413-434.
7. Borriello SP, Hammes WP, Holzapfel W, Marteau P, Schrezenmeir J, Vaara M, Valtonen V. Safety of probiotics that contain *lactobacilli* or *bifidobacteria*. Clinical Infect. Dis. 2003;36:775-780.
8. Gunal M, Yayli G, Kaya O, Karahan N, Sulak O. The effects of antibiotic growth promoter, probiotic or organic acid supplementation on performance, intestinal microflora and tissue of broilers. Int. J. Poultry Sci. 2006;5(2):149-155.
9. Ananthanarayanan L, Dubhashi A. Characterization of *Bacillus* species isolated from natural sources for probiotic properties. Int. J. Curr. Biotech. 2015; 3(8):22-27.
10. Mokoena MP, Mutande T, Olaniran AO. Perspectives on the probiotic potential of lactic acid bacteria from African traditional fermented foods and beverages. Food Nutri. Resear. 2016;60:29630-29642.
11. Ladunni E, Aworh OC, Oyeyinka SA, Oyeyinka AT. Effects of drying method on selected properties of ogi (gruel) prepared from sorghum (*Sorghum vulgare*), millet (*Pennisetum glaucum*) and maize (*Zea mays*). J. Food Process Tech. 2013;4(7): 1-4.
12. Wenk C. Recent advances in animal feed additives such as metabolic modifiers, antimicrobial agents, probiotics, enzymes and highly available minerals. Asian-Austr. J. Animal Sci. 2000;13:86-95.
13. Vazquez AP. *Bacillus* species are superior probiotic feed-additives for poultry. J. Bacterio. Myco. 2016;2(3):00023-00026.
14. Oyedeji O, Ogunbanwo ST, Onilude AA. Predominant lactic acid bacteria involved in the traditional fermentation of fufu and ogi, two Nigerian fermented food products. Food Nutri. Sci. 2013;4:40-46.
15. Ijabadeniyi AO, Adebolu TT. The effect of processing methods on the nutritional properties of 'ogi' produced from three maize varieties. J. Food Agric. Environ. 2005;3(1):108-109.
16. Okpalla J, Onyeneto TC. Microorganism in primary fermentation of maize for ogi production. Global Resear. J. Sci. 2013; 2(2):47-55.
17. Niba AT, Beal JD, Kudi AC, Brooks PH. Potential of bacterial fermentations as a biosafe method of improving feeds for pigs and poultry. Afri. J. Biotech. 2009;8(9): 1758-1767.
18. Puphan K, Somplang P, Uriyapongson S. Cultivation of *Lactobacillus* sp. and production of probiotic powder as animal feed additive. Pak. J. Nutri. 2013;12(6): 567-570.
19. Ashraf M, Arshad M, Siddique M. Muhammad G. *In vitro* screening of locally isolated *Lactobacillus* species for probiotic properties. Pakist. Vet. J. 2009;29(4):186-190.
20. Bernardeau M, Vernoux JP. Overview of differences between microbial feed additives and probiotics for food regarding regulation, growth promotion effects and health properties and consequences for extrapolation of farm animal results to humans. Clinical Microbio. Infect. 2013; 19(4):321-330.
21. Somplang P, Piyadeatsoontorn S. Probiotic isolates from unconventional sources: A review. J. Ani. Sci. Tech. 2016; 58(26):1-11.
22. Menconi A, Bielke LR, Hargis BM, Tellez G. Immuno-modulation and anti-inflammatory effects of antibiotic growth promoters versus probiotics in the intestinal tract. J. Microbio. Resear. Review. 2014;2(7):62-67.
23. Ragland WL, Biotek Z. Antibiotic growth promoters in poultry and their potential alternatives. Frane Petrinovica I Croatia. 2014;1-7.
24. Oyetayo VO, Oyetayo FL. Potential of probiotics as biotherapeutic agents targeting the innate immune system. Afri. J. Biotech. 2005;4(2):123-127.
25. Cervantes HM. The future of antibiotic growth promoters in poultry production. Worlds Poult. Congress. 2012;1-15.
26. Abdus-Salaam RB, Adepoju PA, Olaleye ON, Adeoye IA. Studies on the antimicrobial effect of corn steep liquor on some diarrhoea causing organisms. Afri. J. Biotech. 2014;13(2):332-335.
27. Ikpeme-Emmanuel CA, Ekpeyoung IO, Igile GO. Chemical and protein quality of

soybean (*Glycine max*) and tigernut (*Cyperus esculentus*) based weaning food. J. Food Resear. 2012;1(2):246-254.
28. Ramezani, H. Effects of different protein and energy levels on growth performance of Capsin brown trout, Salmo trutla Caspius (Kessler, 1877). J. Fisheries Aqua. Sci. 2009;4:203-209.
29. Addass PA, Midan A, Perez IKA, Magaji MY. The effect of type and levels of animal protein supplements on the growth rate of rats. Agric. Bio. J. North Ameri. 2010;1(5): 841-844.
30. Adeyemi OT, Osilesi O, Adebawo OO, Onajobi FD, Oyedemi SO. Growth performance of weaned male albino rats fed on processed atlantic horse mackerel (*Trachurus trachurus*). Adv. Life Sci. Tech. 2015;30:53-62.
31. AOAC. Association of official Analytical Chemists, 15th Edition. Wincosin USA. 1990;1298.
32. Carpenter CE, Hendricks DG. Mineral analysis in food analysis 3rd edition. ed. Harbes LH, Nielsen SS. 2003;189-203.
33. Chukwu MO, Ibiam OF, Okoi A. Studies on the fungi and phytochemical and proximate composition of dry and fresh tigernuts (*Cyperus esculentus* L.) Int. Resear. J. Biotech. 2013;4(1):11-14.
34. Edet UO, Ebana RUB, Okoro CU, Ekanemesang UM, Ikon GM, Ntukidem NW, Uduak EM. Changes in proximate composition of corn meal (ogi) assisted with *Lactobacillus* species. J. Adv. Microbio. 2017;2(1): 1-6.
35. Ogbonnaya N, Chukwu BC. Studies on akamu, a traditional fermented maize food. Chil. J. Nutri. 2012;39(4):180-184.
36. Bado S, Bazongo P, Son G, Kyaw MT, Forster BP, Nlelen S, Lykke AM, Ouèdragon A, Bassole IHN. Physicochemical characteristics and composition of three morphotypes of *Cyperus esculentus* tubers and tuber oils. J. Anal. Methods Chem. 2015;1-8.
37. Adejuyitan JA. Tigernut processing: Its food uses and health benefits. Ameri. J. Food Tech. 2011;6(3):197-201.
38. Nwala CO, Akaninwor JO, Monanu MO. Nutritional studies on rats fed diets formulated from treated and raw samples of *Jatropha curcas* seed. Int. J. Engr. Sci. Inv. 2013;2(11):14-19.
39. Tadele Y. Important anti-nutritional substances and inherent toxicants of feeds. Food Sci. Quality Mgt. 2015;36:40-48.
40. Akanbi BO, Agarry OO, Garba SA. Quality assessment of selected cereal-soybean mixtures in ogi production. New York Sci. J. 2010;3(10):17-26.
41. Addass PA, Midau A, Perez IKA, Magaji MY. The effect of type and levels of animal protein supplements on the growth rate of rats. Agric. Bio. J. North Ameri. 2010;1(5): 841-844.
42. Agbabiaka LA, Madubuiko CU, Anyanwu CN. Replacement value of tigernut meal (*Cyperus esculentus*) with maize in catfish (*Clarias gariepinus*) diets. Sci. Resear. Reporter. 2013;2(2):130-134.
43. FAO. Bajagai YS, Klieve AV, Dart PJ, Bryden WL. Probiotics in animal nutrition-Production, impact and regulation. Makkar, H. P. S. editor. FAO. Animal Production and Health Paper No. 179, Rome; 2016.
44. James DB, Ameh DA, Agbaji AS. Effect of dietary substitution with solvent extracted neem seed cake on growth and nitrogen metabolism of albino rats (wistar strain). Afri. J. Biotech. 2009;8(13):3048-3052.
45. El-Anany AM, Ali RFM. Studies on the hypolipidemic effects of coconut oil when blended with tigernut oil and fed albino rats. GRASAS Y ACEITIES. 2012;63(3): 303-312.
46. Chukwuma ER, Obioma N, Ononogbu IC. The phytochemical composition and some biochemical effects of Nigerian tigernut (*Cyperus esculentus* L.) tuber. Pak. J. Nutri. 2010;9(7):709-715.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23161