RESPONSE OF RABBIT BUCKS TO DIETS CONTAINING AIDAN (*TETRAPLEURA TETRAPTERA*) AS FEED ADDITIVE

INGWEYE, Julius Naligwu, ANAELE, Oluchi and OLOGBOSE, Festus Imonkhei
Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, PMB 5323, Choba, East-West Road, Port Harcourt, Nigeria.

Corresponding Author: Ingweye, J. N. Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, PMB 5323, Choba, East-West Road, Port Harcourt, Nigeria. **Email**: jiningweye@gmail.com **Phone**: +234 8032573003

***Received** April 12, 2020; **Revised** May 24, 2020; **Accepted** May 26, 2020*

ABSTRACT

Response of rabbits to diets containing Aidan pod powder was assessed. Forty-eight New Zealand White bucks, aged 42 ± 5 days, were used for the 56-day trial. Animals were shared into four groups of three replicates with four rabbits per replicate. Groups were randomly allotted to four treatments (T_1 to T_4) diets. T_1 (control) had no Aidan. Aidan was included at 0.5, 1.0 and 1.5 % in T_2, T_3 and T_4, respectively. All diets were formulated to provide 17 % crude protein and 2,700 (ME) kcal/kg of energy. Diets and water were given ad libitum. Animal weights, balanced across groups, were taken initially, then every 7 days. Performance, carcass, organ and economics of production indices were assessed. Final weight, total and daily weight gains, dressed weight and cost of feed increased ($p<0.05$) with increasing Aidan levels, while daily feed intake and feed conversion ratio decreased ($p<0.05$). Carcass and relative organ weights gave mixed results that mostly reflect final live and dressed weights. T_3 had the highest weight gain, lowest feed intake, lowest cost of feed consumed and, best feed conversion ratio. Hence, 1.0 % inclusion of Aidan is recommended for better growth, weight gain and feed efficiency in rabbits. But, high inclusion levels should be with caution as such may deposit abdominal fat that could jeopardize the status of rabbit meat as a functional food.

Keywords: Phytobiotic, Phytogenic, Natural additive, Aidan, *Tetrapleura tetraptera,* Growth promoter

INTRODUCTION

The success of rabbit farms depends on rabbit breed, climate of the area, producer's managerial ability, products marketing, animal growth rate, health condition, mortality rates and cost of rabbit feeding (Gidenne *et al*., 2017).

Feed contributes more than seventy-percent to cost of rabbit production (Karaskova *et al*., 2015). Hence, different strategies have been used to reduce cost of feeding. These include government feed subsidy to farmers (Becker, 2008), converting agro wastes and agro-industrial by-products to feed, control of anti-nutrients and their residues in animal feed (Rivin *et al*., 2014; Gunn and Schwab, 2016), and rearing feed efficient breeds (Gunn and Schwab, 2016). Others include using cheaper alternative feed ingredients (Ibitoye *et al*., 2010), increasing use of forage (Ibitoye *et al*., 2010), reducing nutrient losses to environment (Gidenne *et al*., 2017), and optimizing diet digestibility (Spring, 2013). Furthermore, strategies other strategies are closely observing feeding standards, maximizing animal health and productivity, speeding the growth rate of animals, reducing quantity of feed they consume and increasing efficiency of feed utilization (Spring, 2013; Gidenne *et al*., 2017).

One way of increasing feed efficiency to reduce cost and simultaneously improve animal productivity and environmental health is by using feed additives. Feed additives are feed ingredients of nutritional and or pharmaceutical value, not usually consumed as feed on their own, nor used as a typical ingredient but, deliberately added in small amounts to livestock feeds, to improve feed and animal product quality, animal productivity, as well as animal and environmental health (Amlund *et al*., 2012; Rivin *et al*., 2014; FEFANA, 2018).

There are two kinds of additives based on function and source. Based on function, there are technological (e.g. preservatives), nutritional (e.g. vitamins), sensory (e.g. colourants) and zootechnical (e.g. digestibility enhancers) additives (Rychen *et al*., 2018). Based on source, there are antibiotic and non-antibiotic feed additives. Antibiotics are drugs usually produced by or synthesized from microorganisms, such as moulds and given to animals to treat infections caused by microorganisms (Butaye *et al*., 2003; Hughes and Heritage, 2004). Antibiotics become feed additives when they are added to livestock feed below therapeutic levels, to destroy or weaken undesired microorganisms and promote animal health, growth and efficient nutrient utilization (Butaye *et al*., 2003; Hughes and Heritage, 2004; Reinhardt, 2020).

Abuse of antibiotic feed additives could poison animals, deposit undesirable residues in animal products, cause microbial resistance to drugs and pollute the environment (Butaye *et al*., 2003; Demir *et al*., 2005; Amlund *et al*., 2012). Due to these side-effects, in 2006, the European Union banned the use of antibiotic growth promoters in animal feed (USGAO, 2011; Mayer, 2020). Since then, researchers and farmers began examining alternatives to antibiotics to provide benefits of antibiotics without side-effects (Verstegen and Williams, 2002). These non-antibiotic feed additives (natural growth promoters) include plant parts or extracts and live beneficial microbes (Wenk, 2000; Verstegen and Williams, 2002). Examples of non-antibiotic growth promoters include acidifiers, microbials, feed enzymes, immunity modulators, prebiotics, probiotics, feed cleaners, vitamins, micro-nutrients, anticoccidials, anthelmintic, antioxidants, minerals and phytobiotics (Verstegen and Williams, 2002; Menegat *et al*., 2019).

Phytobiotics or phytogenics are various plant-derived products, in powder or liquid oil forms, with pungent or sweet-smelling aroma, obtained from leaves, barks, fruits, flowers, seeds, nuts, roots and woody parts of plants, added to feed to improve livestock performance through amelioration of feed properties, improving health and quality of food from the animals. They also demonstrate antimicrobial, antifungal, coccidiostatic, anthelmintic, anti-inflammatory, antiviral, antioxidant or sedative activity. Some have flavouring and appetizing effects by increasing palatability of feed and enhance animal immune system (Windisch *et al*., 2008). They also enable beneficial gastrointestinal microbes to flourish. Content and concentration of active substances in phytobiotics differ extensively dependent on plant, plant part, place of origin, season of harvest, storage conditions and processing techniques.

Active secondary metabolites in phytogenics include isoprine derivatives, flavonoids and glucosinolates (Windisch *et al*., 2008). These additives must be used in specified amount and form and properly screened to assure expected results. Suitable candidates must be proven, cost-effective, fit for the circumstances, available at farm level and at quantity needed for long-term use (Verstegen and Williams, 2002; Karaskova, *et al*., 2015). Also, long-term experimental use is needed to prove their efficacy and safety (Karaskova *et al*., 2015).

Feed additives have been extensively used in pigs, chickens and cattle (Verstegen and Williams, 2002) but less in rabbit (Jouany and Morgavi, 2007). One reason is that rabbits have in their caecum beneficial gram-positive bacteria which could be negatively affected by oral antibacterials (Mayer, 2020). Hence, the number of phyto-additives tested on rabbits is small and include turmeric (Földešiová *et al*., 2015; Alagawany *et al*., 2016; Ogbuewu *et al*., 2017; Kaegon *et al*., 2018), ginger (Zeweil *et al*., 2016; Mancini *et al*., 2018; Abd EL-Latif *et al*., 2019; Ogbuewu and Mbajiorgu, 2019), garlic (Alagawany *et al*., 2016; Bello *et al*., 2016; Hossian *et al*., 2020), gliciridia leaf meal (Oloruntola *et al*., 2018), probiotics and minerals (Matusevicius *et al*., 2011; Shrivastava *et al*., 2012). To compound the problem, ginger, garlic and turmeric are commercially used in human drugs, food and teas, thus, increasing their prices, and cost of animal feed and products produced with them.

There is need to increase the number of phyto-additives used in rabbit nutrition to reap the benefits of these natural products. The research could assess lesser-known and neglected locally available phytogenics. One of such potential phyto-additive is Aidan (*Tetrapleura tetraptera* Taub) pod.

Aidan, locally called *Aridan* in Yoruba, *Oshosho* in Ibo, *Dawo* in Hausa and *Uyayak* in Efik and Ibibio is a single-stemmed, robust, tree of about 30 meters tall with grey to brown and smooth to rough bark and glaborous round branchlets (Aladesanmi, 2007). Aidan tree is common in the lowland forests of tropical Africa. The flower is yellow-pink with white racemes, while fruit is a dark-brown, four-winged pod, measuring 12 to 25 cm by 3 ½ to 6 ½ cm. Furthermore, the fruit has fleshy pulp with insect repelling pungent odour and little black-brown seeds. The pod is used as food spice, fishing poison, for perfumes and as molluscicide. It is also used for management of convulsion, leprosy, inflammation and rheumatism as well as for its cardiovascular, neuromuscular, hypotensive, trypanocidal, antiulcerative, anthelminthic, hypoglycaemic, food emulsification and birth control and antimicrobial properties (Achi, 2006; Aladesanmi, 2007). The fruit extract showed antimicrobial activity against *Salmonella typhii*, *Escherichia coli*, *Shigella* spp., *Staphylococcus aureus*, *Pseudomonas aeruginosa* and common foodborne microbes (Achi, 2006; Oguoma *et al*., 2015).

Proximate assessment of Aidan pod indicates it has 5, 14, 11, 8 and 62 % moisture, ash, crude protein, fat and crude fibre, respectively. The amino acid profile reveals that it contains per 100 g protein 2.45 g cysteine, 6.21 g isoleucine, 5.57 g leucine, 5.97 g lysine, 0.83 g methionine, 4.05 g phenylalanine, 4.75 g threonine, 5.50 g valine and 3.65 g tyrosine, 6.15 g alanine, 6.39 g arginine, 11.41 g aspartic acid, 13.10 g glutamic acid, 6.15 g glycine, 3.47 g histidine, 3.15 g proline and 5.86 g serine (Oguoma *et al*., 2015). Active ingredients in Aidan fruit extracts include saponin, glycosides, tannins, and oleanolic acid, aglycone (Achi, 2006; Aladesanmi, 2007).

Aidan pod extract and powder singly or in combination with other non-antibiotic growth promoters have been tested on performance, blood chemistry, and anti-microbial activity in albino rats and broiler chickens (Nweze *et al*., 2011; Adeyemo, 2014; Olorunleke *et al*., 2016; Kana *et al*., 2017; Nwangwa *et al*., 2018). Similar studies on rabbits are rare. Assessing hepatotoxic effect of 10 days oral administration of ethanolic extract of Aidan on male rabbits, Odesanmi *et al*. (2009) reported that Aidan treatment increased serum AST, total protein, direct bilirubin and alkaline phosphate but decreased ALT as dose increased without obvious pathological lesions in the liver. This study therefore evaluates the response of rabbit bucks to diets containing Aidan pod powder as feed additive.

MATERIALS AND METHODS

Location of Study: The experiment was carried out at University of Port Harcourt Research and Demonstration Farm, Choba, Port Harcourt. The farm is at latitude 4.89437°N and longitude 6.91053°E located at 16 m altitude and 28.0 ± 2.4°C mean annual temperature (Oyegun and Adeyemo, 1999).

Test Ingredients and Experimental Diets: Aidan pods were bought from single batch in a spice shop in Choba. The pods were chopped to small pieces and oven dried at 70℃ for 48 hours to constant weight. The pieces were ground to powder for dietary inclusion. Other feed ingredients (palm kernel cake, yellow maize, wheat offal, soybean meal, bone meal, table salt and palm oil) were bought from feedstuff shops in Rumuokoro, Port Harcourt. The proximate composition of the ingredients was carried out according to the methods of AOAC (2005) and results shown in Table 1.

Table 1: Proximate composition of feed ingredients

Ingredient	Components [% Dry matter except energy (kcal (ME) kg]						
	CP	EE	NFE	CF	Ash	DM	Energy
Aidan	10.69 ± 0.21	5.93 ± 0.21	34.87 ± 0.32	41.59 ± 0.08	6.92 ± 0.00	96.55 ± 0.91	1156
Maize	9.00 ± 0.90	5.90 ± 0.32	79.44 ± 0.67	3.54 ± 0.06	2.12 ± 0.01	86.88 ± 1.91	3432
PKC	19.13 ± 1.01	6.92 ± 0.23	53.60 ± 0.55	11.19 ± 1.20	9.15 ± 0.03	91.55 ± 2.34	2298
Soybean	49.38 ± 3.02	0.90 ± 0.00	36.25 ± 1.20	7.30 ± 0.99	6.17 ± 0.20	90.05 ± 1.20	2420
Wheat offal	18.02 ± 1.11	5.31 ± 0.03	57.52 ± 1.23	13.13 ± 0.08	6.02 ± 0.11	91.00 ± 1.22	1256
Bone ash	0.00	0.00	0.00	0.00	100.0 ± 2.12	98.59 ± 2.22	0.00
Premix	3.50 ± 0.11	0.00	0.00	0.00	96.50 ± 2.34	91.12 ± 2.11	0.00
Palm oil	5.14 ± 0.09	92.77 ± 0.01	0.00	0.00	2.09 ± 0.21	97.96 ± 2.10	8,998
Salt	0.00	0.00	0.00	0.00	100.0 ± 2.22	99.56 ± 1.23	0.00

PKC=palm kernel cake; NFE=nitrogen free extract; CP=crude protein; EE=ether extract; CF=crude fiber; DM=dry matter

The diets were formulated to provide 17 % crude protein and 2700 kcal/kg energy per diet. The percentage composition of the dietary ingredients as well as the proximate composition of the diets are shown in Table 2.

Experimental Animals and Management: Forty-eight (48) New Zealand White weaner rabbit bucks were used for this experiment. They were housed in a hutch made of wire and wood at one animal per cage and subjected to same management conditions except experimental concentrate feed. Management of the animals was done according to Indian National Academy's guidelines for care and use of animals for scientific research (INSA, 2000) wherein the animals were (i) procured from recognized farm (ii) housing sited away from human habitation and not exposed to dust, noise, smoke and wild species. Cages made of suitable metal, size and exposed to acceptable temperature, light and humidity (iii) stock obtained from reputable breeder and animals certified healthy by veterinarian (iv) fed according to their nutritional requirements with balanced diets using quality ingredients (v) animal house provided with appropriate biosecurity measures and barriers of entry for pathogens and wild species (vii) animals managed by well-trained and qualified staff (viii) animal records properly kept (ix) animals given appropriate veterinary and experimental care (x) animals properly transported in special cages (xi) animals anaesthetized and euthanized appropriately (xii) animal wastes properly disposed and (xiv) all activities executed according to legal and ethical provisions. Concentrate diets and water were given *ad libitum*. Forage (*Panicum maximum*), harvested at about 16.00 hours and wilted overnight was fed at same fixed quantity to all animals. Animals were fed experimental concentrate diets in the morning at 8:00 and 16.00 hours and forage in the afternoon at 12:00 hours. Feeders and drinkers were washed on daily basis before giving fresh feed and water. The experimental animals were weighed at the beginning of the study (initial weight) and every other 7th day, thereafter.

Experimental Design: The experiment was laid down in a Completely Randomized Design of four treatment groups (T_1, T_2, T_3, and T_4) replicated thrice, with each replicate having four rabbits. T_1 was designated as the control diet had no Aidan powder. Groups T2, T_3 and T_4 were placed on diets with Aidan pod powder at 0.5, 1.0 and 1.5 % of deit (wg/wg) respectively. Forty-eight, 6-week old weaner rabbit bucks were divided into four groups of 12 animals each.

Table 2: Feed ingredients percentage and proximate compositions of experimental rabbit diets with Aidan as additive

Feed Ingredients	Aidan inclusion levels (%)			
	0.0 (T_1)	0.5 (T_2)	1.0 (T_3)	1.5 (T_4)
Aidan powder	-	0.50	1.00	1.50
Maize	57.0	56.50	56.00	55.50
Palm kernel cake	10.0	10.0	10.0	10.0
Soybean meal	16.50	16.50	16.50	16.50
Wheat offal	12.0	12.0	12.0	12.0
Bone Meal	2.50	2.50	2.50	2.50
Vitamin/mineral premix	0.50	0.50	0.50	0.50
Palm oil	1.0	1.0	1.0	1.0
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Proximate Composition				
Dry matter	92.00 ± 2.00	94.54 ± 2.09	93.33 ± 2.03	92.44 ± 2.09
Crude protein	17.54 ± 1.05	17.48 ± 0.13	17.46 ± 1.06	17.45 ± 1.05
Crude fibre	21.18 ± 0.11	21.19 ± 0.12	21.16 ± 0.13	21.19 ± 0.14
Ether extract	3.18 ± 0.06	3.19 ± 0.08	3.19 ± 0.07	3.27 ± 0.05
Nitrogen free extract	52.17 ± 1.04	52.18 ± 1.06	52.17 ± 1.09	52.15 ± 1.22
Ash	5.93 ± 0.12	5.96 ± 0.13	5.92 ± 0.19	5.94 ± 0.14
Energy [kcal (ME) /kg]	2700.00	2755.00	2760.00	2795.00

The average initial weight of animals across the groups was balanced. The experiment lasted for eight weeks. All treatment group animals were given 400 g of wilted forage (*Panicum maximum*) per day.

Data Collection and Analyses: The feed offered and leftover were weighed to determine animal feed intake. Feed intake was calculated by subtracting leftover from feed offered to the animals. The initial weight at start of experiment and weekly weight of rabbits were taken. Weekly weight gain of the animals was calculated by subtracting previous week's weight from weight at the present. The feed conversion ratio was calculated by dividing average weekly feed intake by average weekly weight gain.

On the last day of the feeding trial, three animals per group i.e. one per replicate were selected for carcass and organ evaluation. They were starved for 12 hours but given drinking water to clear the gut of undigested feed. They were then made unconscious by exposing them to Carbon dioxide gas in enclosed chamber. The flow rate did not displace more than 30% of the chamber per minute. This was followed by cervical dislocation, decapitation and bleeding by hanging them by their forelegs. They were then de-furred, cleaned, eviscerated and cut into different parts for carcass evaluation (AVMA, 2020). The heart, kidney, lungs, liver, spleen and intestine were removed and weighed for assessment of organ weights.

Cost Benefit Analysis: The prices of the ingredients in kilogramme at the time of their purchase were used to calculate cost of feed per kilogram diet, cost of feed consumed per animal and, cost of feed per kilogramme weight gain.

Data Analysis: All data collected were subjected to the Analysis of Variance (ANOVA). Significant treatment means ($p<0.05$) were separated using Least Significant Difference (LSD). IBM SPSS Statistics for Windows, Version 24.0 (IBM, 2016) was used for all statistical analyses. Results are presented in tables.

RESULTS AND DISCUSSION

Performance Characteristics of Rabbit Bucks Fed Diets with Aidan as Additive: The performance of rabbit bucks on diets containing Aidan as feed additive (Table 3) indicated that the initial weight ranged from 806.10 ± 14.11 (T_4) – 810.42 ± 12.20 g (T_1). There was no significant difference ($p>0.05$) in the treatment means.

Table 3: Performance indices of rabbit bucks fed diets with Aidan as additive

Parameters	Aidan levels in diets (%)			
	0.0 (T_1)	0.5 (T_2)	1.0 (T_3)	1.5 (T_4)
Initial weight (g)	810.42 ± 12.20^{NS}	809.32 ± 12.10^{NS}	807.92 ± 11.01^{NS}	806.10 ± 14.11^{NS}
Final weight (g)	1960.00 ± 21.33^{b}	2000.00 ± 22.10^{b}	2160.00 ± 24.00^{a}	2220.00 ± 19.30^{a}
Total weight gain (g)	1149.58 ± 14.33^{b}	1190.68 ± 15.00^{b}	1352.08 ± 18.99^{a}	1413.90 ± 23.90^{a}
Average daily weight gain (g)	20.53 ± 0.22^{b}	20.53 ± 0.22^{b}	24.14 ± 1.10^{a}	25.25 ± 0.70^{a}
Average daily feed intake (g)	77.23 ± 2.44^{a}	67.79 ± 1.99^{b}	58.73 ± 1.89^{c}	65.54 ± 1.22^{bc}
Feed conversion ratio (g)	3.76 ± 0.50^{a}	3.30 ± 0.01^{a}	2.43 ± 0.03^{b}	2.59 ± 0.00^{b}
Mortality (%)	0.00^{NS}	0.00^{NS}	0.00^{NS}	0.00^{NS}

$^{a, b, c}$ Means in the same row with different superscripts are significantly different (p<0.05); ^{NS} Not significantly different (p>0.05)

This was because, to avoid bias, thus initial weights were balanced across groups at beginning of experiment.

Final weight (g) ranged from 1960.00 ± 21.33 – 2220.00 ± 19.30 g. There were significant differences (p<0.05) in final weights. T_4 had the highest value while T_1 had the least. However, there were no significant differences between T_4 and T_3 (2160.00 ± 24.00 g) as well as between T_1 and T_2 (2000.00 ± 22.10 g) values. The final weights increased as dietary Aidan levels increased. The increase in final weights could be due to growth-promoting effect of Aidan on rabbits, similar to what was reported for chickens fed dietary Aidan (Kana *et al*., 2017) and rabbits fed dietary ginger, another phyto-additive (Mancini *et al*., 2018).

Total weight gain ranged from 1149.58 ± 14.33 – 1413.90 ± 23.90 g. There were significant differences (p<0.05) in total weight gain among treatment means. T_4 had the highest weight gained, while T_1 gained the least. Nevertheless, T_1 and T_2 (1190.68 ± 15.00) values were similar as T_3 (1352.08 ± 18.99) and T_4 were equally similar. Total weight gain increased as Aidan inclusion level increased. This trend is similar to that of final weight and was in agreement with reports of Mancini *et al*. (2018) that ginger powder inclusion in diets increased total weight gain of rabbits. According to Assan (2018), plant-based feed additives, given at the right dosage, can improve the weight gain of rabbits compared to diets without them.

Average daily weight gain spanned between 20.53 ± 0.22 – 25.25 ± 0.70 g. Significant differences (p<0.05) were observed among treatment means as T_2 had the least value, while T_4 recorded the highest. However, T_4 and T_3 (24.14 ± 1.10 g) were not significantly different. Similarly, T_2 and T_1 (20.53 ± 0.22 g) were not significantly different. As Aidan levels in diets increased, daily weight gains increased. This was in line with the trend in total weight and was in agreement with reports of Mancini *et al*. (2018) that inclusion of ginger in rabbit diets increased daily weight gain. Similarly, Assan (2018) reported that phytogenics in rabbit diets caused increased daily weight gains.

Average daily feed intake ranged from 58.73 ± 1.89 – 77.23 ± 2.44 g. There was significant difference (p<0.05) in daily feed intake among treatment groups. T_3 consumed the least feed, while T_1 consumed the most. But, T_2 and T_4 were similar as T_4 and T_3 were. Feed intake seems to decrease as dietary Aidan levels increased. Gidenne *et al*. (2010) reported that feed aroma affects rabbit feed acceptability and intake only in the short-run as the intake is not affected on the long-run when the animals must have become used to the offensive odour. Nevertheless, Ignatova *et al*. (2005) reported that phytogenic aroma inclusion in rabbit diets increased feed intake. If intake can be increased due to feed aroma as reported in Ignatova *et al*. (2005), it follows that intake can reduce when odour is not acceptable to the animal. Hence, in this present study, reduction in feed intake as Aidan levels increase in diets could be due to the pungent insect-repellant aroma of Aidan pod (Aladesanmi, 2007).

The feed conversion ratio ranged from 2.43 ± 0.03 – 3.76 ± 0.50. There were significant differences (p<0.05) among treatment means. T_3 had the least value, while T_1 had the highest FCR. However, there was no significant difference between T_1 and T_2 values as well as between T_4 and T_3 values. The FCR decreased with increase in Aidan level. This was in agreement with Ignatova *et al*. (2005) when phytogenic aroma was included in rabbit diets but in contrast with Mancini *et al*. (2018) that feed conversion ratio remained unchanged when ginger was included in rabbit diets at different levels as additive. Differences between the trends in this study and the ginger study may be due to the type of additive and inclusion levels. Also, since feed intake and weight gain are used in calculating FCR, the FCR values were only mirroring feed intake and weight gain used in the calculation. This was expressed in this study where weight gain increased as feed intake decreased, whereas in the ginger study, weight gain increased as feed intake increased.

No mortality was recorded in all the groups. This implied that inclusion of Aidan in rabbit diets did not evoke mortality. The zero mortality could be due to immunity-boosting and antibacterial activity of Aidan (Achi, 2006) and general hygiene and biosecurity measures in the experimental unit. These could have increased the vitality and health of the experimental animals (Assan, 2018).

Carcass Characteristics of Rabbit Bucks Fed Diets with Aidan as Additive: The carcass characteristics of rabbit bucks fed diets with Aidan as feed additive revealed that dressed weights ranged from 1778.60 ± 2.31 – 1986.23 ± 1.15 g (Table 4).

There were significant differences ($p<0.05$) among dressed weights. T_2 had the least value, while T_4 had the highest. The least weight was, however, not significantly different from that of T_1 (1779.88 ± 1.15 g). Dressed weight increased as level of dietary Aidan increased, following same trend as final weight. When different dietary levels of ginger were used as additive for rabbits, dressed carcass weight did not increase (Mancini *et al*., 2018) contrary to observations in this study. But, Aidan pod extract inclusion in water and powder inclusion in diets improved dressed carcass in broiler chickens (Nweze *et al*., 2011).

Table 4: Carcass indices of rabbit bucks fed diets with Aidan as additive

Parameters	Aidan levels in diets (%)			
	0.0 (T1)	0.5 (T2)	1.0 (T3)	1.5 (T4)
Dressed weight (g)	1779.88 ± 1.15^{c}	1778.60 ± 2.31^{c}	1883.09 ± 2.89^{b}	1986.23 ± 1.15^{a}
Dressing percentage	90.81 ± 1.15^{NS}	88.93 ± 0.58^{NS}	87.18 ± 1.15^{NS}	89.47 ± 0.58^{NS}
Shoulder (g)	366.18 ± 2.89^{a}	343.36 ± 2.89^{b}	347.05 ± 2.89^{b}	367.12 ± 1.73^{a}
Thigh (g)	590.62 ± 2.31^{a}	502.78 ± 1.15^{b}	439.60 ± 2.89^{c}	509.22 ± 2.89^{b}
Back (g)	543.37 ± 1.73^{c}	649.93 ± 1.15^{b}	809.78 ± 2.31^{a}	805.29 ± 2.89^{a}
Head (g)	271.68 ± 1.15^{ab}	269.78 ± 0.58^{b}	266.07 ± 1.15^{b}	284.22 ± 1.73^{a}
Tail (g)	8.03 ± 0.06^{b}	12.75 ± 0.06^{a}	12.26 ± 0.06^{a}	11.61 ± 0.12^{ab}
Belly fat (g)	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	8.33 ± 0.10^{a}	8.76 ± 0.06^{a}

[a, b, c] Means in same row with different superscripts are different ($p<0.05$); [NS] Not significantly different ($p>0.05$)

This implied that the increases in dressed weights observed in this study could be due to interplay of type of animal (chicken vs rabbit) and type of additive (ginger vs Aidan). This implies that Aidan inclusion in rabbit diets could increase dressed carcass weight as in broiler chickens, though ginger could not in rabbits. This could be so because according to Wenk (2003), the effect of natural feed additives on performance of monogastrics is influenced by type of additive and type of animal.

Dressing percentage values ranged from 87.18 ± 1.15 g (T_3) to 90.81 ± 1.15 (T_1) g. The values did not differ ($p>0.05$). This agreed with reports by several authors feeding rabbits with different phyto-additives (Hashem *et al*., 2017; Dabbou *et al*., 2018; Abd EL-Latif *et al*., 2019).

Shoulder weights ranged from 343.36 ± 2.89 – 367.12 ± 1.73 g. There was significant difference ($p<0.05$) among treatment means. T_2 weighed the least while T_4 was the heaviest. However, the weights of T_4 and T_1 were not significantly different ($p>0.05$) just like those of T_2 and T_3. Aidan inclusion in diets increased shoulder weights. Shoulder weight trend was similar to that of carcass weight and was in agreement with several studies (Földešiová *et* *al.*, 2015; Abd EL-Latif *et al.*, 2019; Ogbuewu and Mbajiorgu, 2019).

Thigh weights ranged from 590.62 ± 2.31 – 439.60 ± 2.89 g. There was significant difference ($p<0.05$) among treatment means. T_3 had the least value, while T_1 had the highest. But there was no significant difference between T_2 (502.78 ± 1.15 g) and T_4 (509.22 ± 2.89 g) values. Aidan supplemented diets had lower thigh weight than control. However, Adeyemo (2014) reported that rabbits administered Aidan pod extract in drinking water showed no significant difference in thigh weight. Therefore, differences observed in this present study could be due to means of administration (liquid vs powder) or human error in carcass parts seperation, which depends on the skill of the butcher (Pobiner *et al.*, 2018). This last reason could be more plausible and further buttressed by the lack of a specific trend in the changes.

Back weights ranged from 543.37 ± 1.73 – 809.78 ± 2.31 g. There were significant differences ($p<0.05$) among back weights. Rabbits in T_3 recorded the highest weight, while T_1 had the least weight. Nevertheless, T_3 and T_4 (805.29 ± 2.89 g) values were not significantly different. Inclusion of Aidan in diets improved the back weights compared to control. This trend was similar to those for dressed and final weights. Results of this study disagreed with Adeyemo (2014) that Aidan pod extract administered in drinking water did not affect back weights in rabbits. Differences could be due to means of administration (extract in drinking water vs pod powder in concentrate diets). This may be so because Hutjens (2005) observed that the impact of phyto-additive administration on animals can be influenced by means of administration.

The head weights ranged from 266.07 ± 1.15 – 284.22 ± 1.73 g. There was significant difference ($p<0.05$) among treatment means. Rabbits in T_3 had the least head weight, while rabbits in T_4 had the highest head weight. But there were no significant differences ($p>0.05$) between the head weights of T_3, T_2 (269.78 ± 0.58 g) and T_1 (271.68 ± 1.15 g) as well as between T_4 and T_1. The head weights were directly proportional to level of Aidan in diets, which agreed with reports by Hossian *et al.* (2015) and Adeyemo (2014). The trend was similar to that of dressed weight and most carcass parts, and possibly may be due to the same reasons. In addition, Lindstedt (1987) reported that head of animals, like other body parts, grow proportionately to other parts and the entire body.

Tail weights ranged from 8.03 ± 0.06 – 12.75 ± 0.06 g. There were significant differences ($p<0.05$) in tail weights among treatment means. Rabbits in T_2 had the heaviest tail weight and T_1 rabbits had the least. Nevertheless, the tail weight values for rabbits in T_2, T_3 and T_4 were statistically similar, like those of T_4 and T_1. Administration of Aidan pod powder increased the tail weights above the control group. This aligns with increases in other body parts, dressed weight and final weight and agreed with reports by several authors (Lindstedt, 1987; Adeyemo, 2014; Hossian *et al.*, 2015).

Belly fat weights was between 0.00 – 8.76 ± 0.06 g. There were significant differences ($p<0.05$) in the belly fat among treatment groups. Only rabbits in T_4 and T_3 had belly fat, while rabbits in T_1 and T_2 had none. Reports by Hashem *et al.* (2017) indicated that all rabbits fed phyto-additives deposited abdominal fat. The non-deposition of fat in some groups (T_1 and T_2) of present study contradicted Hashem *et al.* (2017) but agreed with Assan (2018) who reported that phyto-additives suppress fat deposition. The implication of observations from this study is that including more than 0.5 % of Aidan in diets is may not be advisable if rabbits are to be grown for use as functional food.

Percentage Organ Weights of Rabbit Bucks Fed Diets with Aidan as Additive: The percentage organ weights of rabbit bucks fed dietary Aidan are shown in Table 5.

The percentage organ weight relative to the body weight is presented on Table 5. Percentage liver weight ranged from 1.99 ± 0.04 (T_2) to 2.73 ± 0.02 % (T_4). There were no significant differences ($p>0.05$) among treatment means. This implied that Aidan inclusion had no influence on percentage liver weight.

Table 5: Organ weights of rabbit bucks fed diets with Aidan as additive

Parameters (% of final weight)	Aidan levels in diets (%)			
	0.0 (T_1)	0.5 (T_2)	1.0 (T_3)	1.5 (T_4)
Liver	2.63 ± 0.03^{NS}	1.99 ± 0.04^{NS}	2.61 ± $.04^{NS}$	2.73 ± 0.02^{NS}
Kidney	0.40 ± 0.01^{b}	0.34 ± 0.00^{b}	0.52 ± 0.01^{a}	0.42 ± 0.01^{b}
Lungs	0.64 ± 0.02^{a}	0.41 ± 0.01^{b}	0.46 ± 0.00^{b}	0.62 ± 0.01^{a}
Heart	0.16 ± 0.01^{b}	0.16 ± 0.00^{b}	0.26 ± 0.00^{a}	0.17 ± 0.01^{b}
Spleen	0.05 ± 0.00^{NS}	0.04 ± 0.00^{NS}	0.05 ± 0.00^{NS}	0.05 ± 0.00^{NS}
Intestine	5.31 ± 0.02^{c}	8.15 ± 0.03^{a}	8.92 ± 0.02^{a}	7.26 ± 0.02^{ab}

a, b, c *Means in same row with different superscripts are different (p<0.05);* ***NS*** *Not significantly different (p>0.05)*

The liver weight values in this study agreed with and were within ranges reported by Sherif (2018) when rabbit diets were supplemented with enzymes, organic acids or their combination. The percentage kidney weights were between 0.34 ± 0.00 – 0.52 ± 0.01 %. There were no significant differences (p>0.05) among treatment means. The range was a little lower than those reported by Sherif (2018) where organic acids, enzymes and bitter probiotic or their combinations were fed as additives in rabbit diets. Treatment means of Sherif (2018) report were also not significant. Differences can be explained by the type of phyto-additive used (Aidan vs. organic acids, bitter probiotic and enzymes) and form of inclusion (single vs. single and combined). This is so because according to Hutjens (2005), the effect of phyto-additives on animals can be mediated by the type of additive and the form it is offered.

The percentage lung weights spanned from 0.41 ± 0.01 – 0.64 ± 0.02 %. Among the groups, there was significant difference (p<0.05) in percentage lung weights, with rabbits in T_2 having the least values, while rabbits in T_1 had the best values. However, there were no significant differences in percentage lung weight between rabbits in T_2 and T_3 as well as between rabbits in T_4 and T_1. The range vaues were within that reported by Sherif (2018) and Orayaga *et al*. (2017). Increase in percentage lung weights as inclusion level increased to 1.5 % can only be said to follow weight increases noticed earlier. Nevertheless, a larger lung will support better repiratory function in the animal.

The percentage heart weights ranged from 0.16 ± 0.01 – 0.26 ± 0.00 %. There was significant difference (p<0.05) among treatment means. Rabbits in T_1 and T_2 had the smallest heart, while rabbits in T_3 had the biggest. But the % heart weight of rabbits in T_1 and T_2 values were not significantly different from that of rabbits in T_4 (0.17 ± 0.01 %). Compared to range values of % heart weight reported by Hashem *et al*. (2017) and Sherif (2018) these values were within the ranges. But, in the present study, differences were observed among Adian treatment groups, while in the referenced literatures, there were no observed significant differences. Differences may be attributed to type of phyto-additive used in the different studies. Nevertheless, increase in Aidan values increased percentage heart weight to peak at T_3. The trend aligned with those of weight gain and final weight and may be explained by proportionate growth of body organs, relative to entire body (Lindstedt, 1987).

Percentage spleen weight spanned from 0.04 ± 0.00 (T_2) – 0.05 ± 0.00 % in rabbits in T_1, T_3 and T_4. There was no significant difference (p>0.05) in percentage spleen weight. These implied that inclusion of Aidan in diets had no influence on percentage spleen weight. The range of values and non-effect of phyto-additive inclusion on percent spleen weight of rabbits agreed with reports of Orayaga *et al*. (2017).

Percent intestine weight ranged from 5.31 ± 0.02 – 8.92 ± 0.02 %. There were significant differences (p<0.05) among the values with T_1 being the least while T_3 was the highest. But, there was no significant difference between T_3 value and those of T_2 and T_4, as well as between those of T_4 and T_1. The range of values were lower than those reported for rabbits fed other phyto-additives (propolis, *Moringa* roots and vitamin E) at different levels and in combination (Hashem *et al*., 2017). This could be due to better intestinal health caused by combination of different phyto-additives compared to single additive in the present study. According to Assan (2018) co-administration of different additives gives a better outcome than single additive. In any case, administration of Aidan in rabbit diets improved intestine weight than in the control.

Economics of Producing Rabbit Bucks Fed Diets with Aidan as Additive: Results for economics of production of rabbits fed Aidan as dietary additive are shown in Table 6.

Table 6: Economics of producing rabbit bucks fed dietary Aidan as additive

Parameter	Aidan levels in diets (%)			
	0.0 (T_1)	0.5 (T_2)	1.0 (T_3)	1.5 (T_4)
Cost of feed (₦/kg)	114.00 ± 2.31[c]	118.50 ± 1.05[bc]	123.00 ± 1.13[ab]	127.50 ± 1.10[a]
Cost of feed consumed (₦/g)	8.80 ± 0.09[a]	8.03 ± 0.08[a]	7.22 ± 0.02[b]	8.35 ± 0.03[a]
Feed cost/weight gain (₦/g)	0.43 ± 0.00[NS]	0.23 ± 0.00[NS]	0.30 ± 0.00[NS]	0.33 ± 0.00[NS]

a, b, c *Means in same row with different superscripts are different (P<0.05);* ***NS*** *Not significantly different (p>0.05)*

They reveal that cost of feed ranged from ₦ 114.00 ± 2.31 – ₦ 127.50 ± 1.10. There was significant difference (p<0.05) in cost of feeds. T_1 was the least costly diet, while T_4 was the most expensive. However, there was no significant difference between diets T_4 and T_3 (₦ 123.00 ± 1.13) diets T_3 and T_2 (₦ 118.50 ± 1.05) as well as diets T_2 and T_1. Cost of feed was inversely proportional to Aidan level in diet. This could be explained by high market cost of Aidan pod. This agreed with some reports of Munro (1988) and Elhence (2017) that some spices (aidan inclusive), weight-for-weight, are costlier than major food crops.

Cost of feed consumed ranged from ₦ 7.22 ± 0.02 – 8.80 ± 0.09. Among the treatment means, cost of feed consumed was significantly different (p<0.05). T_1 recorded the costliest intake, while T_3 recorded the least cost. T_1 values were not significantly different from those of T_2 and T_4. The differences mirrored the cost of Aidan and quantity of feed consumed and agreed with Hashem *et al*. (2017) that reported differences in cost of feed consumed (a reflection of cost of feed and feed intake) when some additives and vitamin E were included in rabbit diets. It implies that 1.0 % dietary Aidan in rabbit diets gave the cheapest feed consumed, highest weight gain, lowest feed intake and best (lowest) feed conversion ratio.

Cost of feed on weight gain ranged from ₦ 0.23 ± 0.00 (T_2) to ₦ 0.43 ± 0.00 (T_1). There were no significant differences (p>0.05) in treatment means, implying that this parameter was not affected by dietary Aidan. Also, Hashem *et al*. (2017) did not report differences for this parameter when vitamin E, propolis and *Moringa* roots were used in rabbit diets.

Conclusion: The study assessed effect of Aidan powder as feed additive on male rabbits. It is concluded that T_3 (1.0 %) inclusion level may better support growth, weight gain and feed efficiency in growing rabbits. But, using upper limit inclusion levels may enhance belly fat deposition, which may weaken the status of rabbit meat as functional food.

ACKNOWLEDGEMENTS

The authors are grateful to farm workers in the Rabbit Unit, Faculty of Agriculture Teaching and Research farm, University of Port Harcourt, for helping with day-to-day management of the animals throughout the experimental period.

REFERENCES

ABD EL-LATIF, S. A., TOSON, A. M., ELWAN, H. A. M. and HELPAWY, E. S. (2019). Effect of dietary growth promoters on digestibility of nutrients and economic efficiency of growing rabbits. *ACTA Scientific Nutritional Health*, 3(9): 98 – 101.

ACHI, O. K. (2006). Composition and antibacterial activities of *Tetrapleura tetraptera* Taub pod extracts. *Research Journal of Microbiology*, 1(5): 416 – 422.

ADEYEMO, G. O. (2014). Effect of aqueous *Tetrapleura tetraptera* (African porridge fruit) on carcass characteristics and organ weights of broiler chickens. *Nigerian Journal of Rural Extension and Development*, 8: 75 – 78.

ALADESANMI, A. J. (2007). *Tetrapleura tetraptera*: molluscicidal activity and chemical constituents. *African Journal of Traditional, Complementary and Alternative Medicines*, 4(1): 23 – 36.

ALAGAWANY, M., ASHOUR, E. A. and REDA, F. M. (2016). Effect of dietary supplementation of garlic (*Allium sativum*) and turmeric (*Curcuma longa*) on growth performance, carcass traits, blood profile and oxidative status in growing rabbits. *Annals of Animal Science*, 16(2): 489 – 505.

AMLUND, H., BERNTSSEN, M. H., LUNESTAD, B. T. and LUNDEBEYE, A. K. (2012). Aquaculture feed contamination by persistent organic pollutants, heavy metals, additives and drug residues. Pages 205 – 229. *In*: FINK-GREMMELS, J. (Ed.). *Animal Feed Contamination: Effects on Livestock and Food Safety*. Woodhead Publishing Limited, Sawston, United Kingdom.

AOAC (2005). *Official Methods of Analysis.* Sixteenth Edition, Association of Official Analytical Chemists, Washington DC, USA.

ASSAN, N. (2018). Plant based feed additives (phytogenic) as a primary solution to an antibiotic free nutritional program and feeding strategy in rabbit production. *Scientific Journal of Animal Science*, 7(3): 493 – 503.

AVMA (2020). *Guidelines for the Euthanasia of Animals: 2020 Edition.* American Veterinary Medical Association (AVMA). Schaumburg, Illinoi, USA.

BECKER, G. S. (2008). *Livestock Feed Costs: Concerns and Options*. Congressional Research Services Report for Congress Prepared for Members and Committees of Congress, Washington DC., USA. https://nationalaglawcenter.org/wp-content/uploads/assets/crs/RS22908.pdf Accessed April 5, 2020.

BELLO, K. O., AKANJI, A. O., IREKHORE, O. T. and LALA, A. O. (2016). Anti-endo parasitic effects of garlic (*Allium sativum*) as supplement in the diets of rabbits reared under deep litter system. *Applied Tropical Agriculture*, 21(2): 1 – 7.

BUTAYE, P., DEVRIESE, L. A. and HAESEBROUCK, F. (2003). Antimicrobial growth promoters used in animal feed: Effects of less well known antibiotics on gram-positive bacteria. *Clinical Microbiology Reviews*, 16(2): 175 – 188.

DABBOU, S., GASCO, L., ROTOLO, L., POZZO, L., TONG, J. M., DONG, X. F., RUBIOLO, P., SCHIAVONE, A. and GAI, F. (2018). Effects of dietary alfalfa flavonoids on the performance, meat quality and lipid oxidation of growing rabbits. *Asian-Australasian Journal of Animal Science*, 31(2): 270 – 277.

DEMIR, E., SARICA, S., OZCAN, M. A. and SUICMEZ, M. (2005). The use of natural feed additives as alternative to an antibiotic growth promoter in broiler diets. *Archiv fur Geflugelkunde*, 69(3): 110 – 116.

ELHENCE, P. (2017). *7 of the World's Most Expensive Spices*. https://www.luxury-insider.com/dining/guide-most-expensive-spices Accessed March 5, 2020.

FEFANA (2018). Feed additives: what are their functions? EU Association of Specialty Feed Ingredients and their Mixtures. http://fefana.org/wp-content/uploads/ 2018/03/Feed-additivesfunctions.pdf Accessed March 28, 2020.

FÖLDEŠIOVÁ, M., BALÁŽI, A., CHRASTINOVÁ, Ľ. and CHRENEK, P. (2015). The effect of *Curcuma longa* dried powder in the diet on weight gain of rabbit does. *Slovak Journal of Animal Science*, 48(1): 43 – 48.

GIDENNE, T., GARREAU, H., DROUILHET, L., AUBERT, C. and MAERTENS, L. (2017). Improving feed efficiency in rabbit production, a review on nutritional, techno-economical, genetic and environmental aspects. *Animal Feed Science and Technology*, 225: 109 – 122.

GIDENNE, T., LEBAS, F. and FORTUN-LAMOTHE, L. (2010). Feeding behaviour of rabbits. Pages 233 – 252. *In*: DE BLAS, C. and WISEMAN, J. (Eds.). *Nutrition of* *the Rabbit*. Second Edition, CAB International Education, Oxfordshire, United Kingdom.

GUNN, P. and SCHWAB, D. (2016). Ten ways to reduce feed cost in cow-calf operations. Ag Decision Maker. https://www.extension.iastate.edu/agdm/livestock/pdf/b177.pdf Accessed February 25, 2020.

HASHEM, N. M., ABD EL-HADY, A. M. and HASSAN, O. A. (2017). Inclusion of phytogenic feed additives comparable to vitamin E in diet of growing rabbits: Effects on metabolism and growth. *Annals of Agricultural Sciences*, 62(2): 161 – 167.

HOSSIAN, M. J., KAMRUZZAMAN, M., AKBAR, M. A. and HAQUE, M. A. (2015). Feeding garlic powder on growth performance, nutrient digestibility and carcass characteristics of rabbit. *International Journal of Natural and Social Sciences*, 2(5): 74 – 81.

HOSSIAN, M. K., ALI, M. Y., KAMRUZZAMAN, M. and KHAN, M. J. (2020). Efficacy study of garlic leaf on feed utilization and growth performances of rabbits. *ACTA Scientific Nutritional Health*, 4(3): 01 – 04.

HUGHES, P. and HERITAGE, J. (2004). Antibiotic growth-promoters in food animals. Pages 129 – 152. *In*: *Assessing Quality and Safety of Animal Feed*. Animal Production and Health Paper Number 160, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. http://www.fao.org/tempref/docrep/fao/007/y5159e/y5159e05.pdf Accessed February 10, 2020.

HUTJENS, M. F. (2005). Feed additives in dairy nutrition: an industry and farm perspective. *Paper Presented at the 2005 Nutrition Conference Sponsored by Department of Animal Science, The University of Tennessee and UT Extension and University Professional and Personal Development*, The University of Tennessee. Knoxville, Tennessee, USA. http://www.inia.org.uy/estaciones/la_estanzuela/actividades/documentos/feed_additives_hutjens2.pdf Accessed March 30, 2020.

IBITOYE, E. R., OLOREDE, B. R., JIMOH, A. A. and SULEIMAN, N. (2010). The rabbit industry and alternative feedstuffs: a review. *In*: Proceedings of 35th Conference of Nigerian Society for Animal Production, held at University of Ibadan, Ibadan, Oyo State, Nigeria from March 14 – 17, 2010.

IBM (2016). *IBM SPSS Statistics for Windows, Version 24.0.* Released 2016. IBM Corporation, Armonk, New York, USA.

IGNATOVA, M., IVANOV, A., SAFTIU, M., CHOTINSKY, D. and STOILOV, I. (2005). Effect of aroma supplementation in rabbits. *Krmiva*, 47(5): 239 – 243.

INSA (2000). *Guidelines for Care and Use of Animals in Scientific Research*. Revised Edition, Indian National Science Academy (INSA). New Delhi, India. https://www.yumpu.com/en/document/read/10664148/insa-guidelines-for-care-and-indiancouncil-of-medical-research Accessed March 30, 2020.

JOUANY, J. P. and MORGAVI, D. P. (2007). Use of natural products as alternatives to antibiotic feed additives in ruminant production. *Animal*, 1(10): 1443 – 1466.

KAEGON, S. G., DIM, J. C. and GEORGE, O. S. (2018). Effects of graded levels of turmeric (*Curcuma longa*) meal on the serum metabolites of growing rabbit. *Nigerian Journal of Animal Science*, 20(3): 247 – 250.

KANA, J. R., MUBE, K. H., NGOUANA, T. R., KOMGUEP, R., YANGOUE, A., TSAFONG, F. and TEGUIA, A. (2017). Growth performances and serum biochemical response of broiler chickens fed on diet supplemented with *Tetrapleura tetraptera* fruit powder as substitute to antibiotic growth promoters. *International Journal of Innovation and Applied Studies*, 21(1): 68 – 76.

KARASKOVA, K., SUCHY, P. and STRAKOVA, E. (2015). Current use of phytogenic feed additives in animal nutrition: a review. *Czech Journal of Animal Sciences*, 60(12): 521 – 530.

LINDSTEDT, S. L. (1987). Allometry: body size constraints in animal design. Page 512. *In*: *Drinking Water and Health, Volume 8:*

Pharmacokinetics in Risk Assessment. National Research Council Subcommittee on Pharmacokinetics in Risk Assessment. Washington DC, National Academic Press, USA. https://www.ncbi.nlm.nih.gov/books/NBK218080/ Accessed April 3, 2020.

MANCINI, S., SECCI, G., PREZIUSO, G., PARISI, G. and PACI, G. (2018). Ginger (*Zingiber officinale* Roscoe) powder as dietary supplementation in rabbit: life performances, carcass characteristics and meat quality. *Italian Journal of Animal Science*, 17(4): 867 – 872.

MATUSEVICIUS, P., BARTKEVICIUTE, Z., CERNAUSKENIE, J., JEROCH, H. and KOZLOWSKI, K. (2011). Effect of probiotic preparation *ToyoCerin®* and phytobiotic preparation *Cuxarom Spicemaster* on growing rabbits. *Archiv fur Geflugelkunde*, 75(1): 67 – 71.

MAYER, J. (2020). Rabbits: nutrition of rabbits. *In*: *MSD Veterinary Manual*. Merck Sharp and Dohme Corporation a Subsidiary of Merck and Company, Kenilworth, New Jersey, USA. https://www.msdvetmanual.com/exotic-and-laboratoryanimals/rabbits/nutrition-of rabbits?network=g&matchtype=p&keyword=rabbit%20nutrition&creative=319154447746&device=c&devicemodel=&placement=&p Accessed April 2, 2020.

MENEGAT, M. B., GOODBAND, R. D., DEROUCHEY, J. M., TOKACH, M. D., WOODWORTH, J. C. and DRITZ, S. S. (2019). Feed additives in swine diets. Pages 1 – 3. *In: Kansas State University Swine Nutrition Guide*. First Edition, Kansas State University, Manhattan, Kansas, USA. https://www.asi.k-state.edu/research-and-extension/swine/swinenutritionguide/pdf/KSU%20 Feed%20Additives%20in%20Swine%20Diets%20fact%20sheet.pdf Accessed April 2, 2020.

MUNRO, J. (1988). The consumption of spices and their costs in late-medieval and early-modern Europe: luxuries or necessities? Lecture Delivered to the Canadian Perspectives Committee, Senior Alumni Association, University of Toronto, at University College. https://www.economics.utoronto.ca/munro5/SPICES1.htm Accessed March 1, 2020.

NWANGWA, J. N., UDEFA, L. N., APUYE, B. A. and ASSIM-ITA, P. I. (2018). Comparative effect of aqueous and ethanolic extracts of *Tetrapleura tetraptera* (Aidan) fruit on some haematological parameters of female wistar rats. *World Journal of Pharmaceutical Sciences*, 7(10): 30 – 39.

NWEZE, B. O., NWANKWEGU, A. E. and EKWE, O. O. (2011). The performance of the broiler chickens on African porridge fruit (*Tetrapleura tetraptera*) pod under different feeding regimes. *Asian Journal of Poultry Science*, 5(4): 144 – 149.

ODESANMI, S. O., LAWAL, R. A. and OJOKUKU, S. A. (2009). Effect of ethanolic extract of *Tetrapleura tetraptera* on liver function profile and histopathology in male Dutch white rabbits. *International Journal of Tropical Medicine*, 4(4): 136 – 139.

OGBUEWU, I. P. and MBAJIORGU, C. A. (2019). Supplementation and optimization of ginger (*Zingiber officinale*) rhizome powder in growing rabbit diets. *Indian Journal of Animal Research*, 53(3): 1 – 5.

OGBUEWU, I. P., OKEHI, I. P. and JIWUBA, P. C. (2017). Effect of phytobiotic (turmeric) supplementation on semen and blood characteristics of rabbits. *Comparative Clinical Pathology*, 26(4): 817 – 822.

OGUOMA, O. I., EZEIFEKA, G. O., ADELEYE, S. A., ORANUSI, S. and AMADI, E. S. (2015). Antimicrobial activity, proximate and amino acids analysis of *Tetrapleura tetraptera*. *Nigerian Journal of Microbiology*, 27(1): 2709 – 2718.

OLORUNLEKE, S. O., VILAWA, G. and OGERI, O. I. (2016). Comparative effect of Aidan tree fruit, rosemary and thyme on the growth performance and carcass characteristics of broiler chickens. In: Proceedings of 21st Annual Conference of Animal Science Association of Nigeria from September 18 – 22 at Port Harcourt, Nigeria.

OLORUNTOLA, O. D., AGBEDE, J. O., AYODELE, S. O., AYEDUN, E. S., DARAMOLA, O. T. and OLORUNTOLA, D. A. (2018). Gliricidia leaf meal and multi-enzyme in rabbits' diet: effect on performance, blood indices, serum metabolites and antioxidant status. *Journal of Animal Science and Technology*, 60(24): 1 – 8.

ORAYAGA, K. T., AKAU, K. J., DAFAM, J. J. and ODEH, L. O. (2017). Carcass and fur yield, internal organ characteristics and GIT morphometry of rabbits fed diets containing composite mango (*Mangifera indica*) fruit reject meal. *MOJ Food Processing and Technology*, 5(3): 307 – 312.

OYEGUN, C. U. and ADEYEMO, A. M. (1999). Port Harcourt Region. Department of Geography and Environmental Science, University of Port Harcourt, Publication Series Number One, Paragraphics, Port Harcourt, Nigeria.

POBINER, B. L., HIGSON, C. P., KOVAROVIC, K., KAPLAN, R. S., ROGERS, J. and SCHINDLER III, W. (2018). Experimental butchery study investigating the influence of timing of access and butcher expertise on cut mark variables. *International Journal of Osteoarchaeology*, 28(4): 377 – 387.

REINHARDT, C. D. (2020). Growth promotants and production enhancers: antimicrobial feed additives. *In*: MSD Veterinary Manual. Merck Sharp and Dohme Corporation, a Subsidiary of Merck and Company, Kenilworth, New Jersey, USA. https://www.msdvetmanual.com/pharmacology/growth-promotants-and-production-enhancers/antimicrobial-feedadditives# Accessed April 6, 2020.

RIVIN, J., MILLER, Z. and MATEL, O. (2014). *Using Feed Waste as Livestock Feed.* University of Wisconsin System Board of Regents and University of Wisconsin Extension, Cooperative Extension, Madison, Wisconsin, USA. https://outagamie.extension.wisc.edu/files/ 2012/10/Using-Food-Waste-as-Livestock-Feed.pdf Accessed April 8, 2020.

RYCHEN, G., AQUILINA, G., AZIMONTI, G., BAMPIDIS, V., BASTOS, M. L., BORIES, G., CHESSON, A., COCCONCELLI, P. S., FLACHOWSKY, G., GROPP, J., KOLAR, B., KOUBA, M., LOPEZ-ALONSO, M., LOPEZ-PUENTE, S., MANTOVANI, A., MAYO, B., RAMOS, F., SAARELA, M., VILLA, R. E., WALLACE, R. J., WESTER, P., ANGUITA, M., GALOBART, J., INNOCENTI, M. L. and MARTINO, L. (2018). Guidance on the assessment of the efficacy of feed additives. *EFSA Journal*, 16(5): 5274. https://doi/epdf/10.2903/j.efsa.2018.5274

SHERIF, S. K. (2018). Effect of dietary additives on growth performance, carcass traits and some blood constituents of rabbits. *Journal of Agricultural Science*, 10(1): 139 – 151.

SHRIVASTAVA, A. K., TIWARI, K. K., KUMAR, R. and JHA, R. R. (2012). Effects of feed additives on body weights at different ages in rabbit. *Scholarly Journal of Agricultural Science*, 2(11): 277 – 282.

SPRING, P. (2013). The challenge of cost effective poultry and animal nutrition: optimizing existing and applying novel concepts. *Lohmann Information*, 48(1): 38 – 46.

USGAO (2011). Antibiotic resistance: agencies have made little progress addressing antibiotic use in animals. Report to the Ranking Member, Committee on Rules, House of Representatives, US Government Accountability Office (USGAO), Washington DC, USA. http://www.gao.gov/assets/330/323090.pdf Accessed April 5, 2020.

VERSTEGEN, M. W. A. and WILLIAMS, B. A. (2002). Alternatives to the use of antibiotics as growth promoters for monogastric animals. *Animal Biotechnology*, 13(1): 113 – 127.

WENK, C. (2000). Why all the discussion about herbs? Pages 79 – 96. *In*: LYONS, T. P. (Ed.). *Proceeding of Alltech's 16th Annual Symposium, Biotechnology in the Feed Industry*, held at Nicholasville, Kentucky, USA. Alltech Technical Publications, Nottingham University Press, Nottingham, United Kingdom.

WENK, C. (2003). Herbs and botanicals as feed additives in monogastric animals. *Asian-Australian Journal of Animal Science*, 16(2): 282 – 289.

WINDISCH, W., SCHEDLE, K., PLITZNER, C. and KROISMAYR, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science*, 86(Suppl_14): E140 – E148.

ZEWEIL, H. S., ZAHRAN, S. M., AHMED, M. H., EL-GINDY, Y. M. and KHAER, A. S. (2016). Effect of organic selenium and ginger supplementation of a diet enriched with linseed oil on performance, carcass, blood lipid profile, with its traits in the meat and antioxidant property of growing rabbits. *Egyptian Poultry Science Journal*, 36(IV): 1147 – 1161.