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Chemical Composition, Cholesterol Profile and Sensory Quality of Meat from Rabbits Fed Aidan (Tetrapleuratetraptera) as Dietary Additive

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Abstract
Inclusion of phytogenic feed additives in feeds could transfer their positive sensory and nutritional attributes toproducts obtained from animals consuming the additive-supplemented diet. This study evaluated the proximate, mineral and cholesterol contents as well as sensory value of meat from rabbits fed aidan (Tetrapleuratetraptera) as dietary phyto-additive. Forty-eight, 6-week old New Zealand rabbit bucks were used for the 56-day study. The animals were shared into four groups (T1 to T4) of twelve animals each. They were further split into three replicates of four animals each. T1 group were fed the control diet which did not containaidan. Groups T2, T3 and T4 were fed diets in which aidan was added to diets at 0.5, 1.0 and 1.5 % levels, respectively. Each animal was offered 400 g of forage per day. On last day of the study, one rabbit per group was slaughtered and the meat used to assess the proximate, cholesterol, mineral and sensory values for the rabbit meat. The grouping of animals followed a Completely Randomized Design arrangement. Data were subjected to Analysis of Variance (ANOVA). Significant means ($p<0.05$) were separated using Least Significant Difference (LSD) in Statistical Package for Social Sciences (SPSS) software. Results showed that inclusion of aidan in the diets of rabbit bucks had no effect ($p>0.05$) on the dry matter, crude protein, Zn, Na, Cu and Fe contents of the meat nor its colour, tenderness and texture. Mostly, from the 1.0% inclusion level, meat fat and cholesterol contents decreased ($p<0.05$) while ash, Ca, K, P and Mgcontents increased ($p<0.05$). Also, the odour and acceptability increased and juiciness score fell($p<0.05$) from the 1.0% level whileflavourvalues decreased as inclusion level rose above 0.5%. We conclude that aidan could be included in rabbit diets up to1.0% to minimize meat fat and cholesterol, increase ash (especially Ca, K, P and Mg), and enhance the odour and acceptability by consumers.

***Keywords**:Phytogenic, organoleptic, mineral nutrients, bucks*

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I. Introduction

Feed additives are a huge and diverse set of compounds included in feeds so that the feed, animals and animal products can benefit from the positive sensory, nutritional, technological and zootechnical attributes of the additives (1). Feed additives can be classified as sensory (those impacting the organoleptic properties of animal products e.g. colourants and flavours), nutritional (supply specific nutrients needed by the animal for optimal growth e.g. vitamins, microminerals and amino acids), zootechnical (e.g. growth promoters and anti-coccidials) and technological (e.g. antioxidants, preservatives and emulsifiers) additives [2]. Feeding animals diets supplemented with phyto-additives could impact the nutritive value of the animal products [1] observed through a change in the proximate composition, mineral content and sensory quality of their meat[3]. While transiting from use of antibiotic-growth promoters to phyto-additives, there is need to assess the quality of the alternatives-phyto-additives[4]. To seamlessly replace antibiotic growth promoters, there is need to come up with alternatives that through comparable mechanisms, encourage growth and improve feed conversion ratio[4]. The use of antibiotic growth promoters in animal feed has significant antibiotic resistance risk with grave consequences for animal and human health[5]. Sensory additives influence food odour, colour and palatability while nutritional additives focus on improving meat quality as a functional product [1].Demand for animal products, especially for those with health-promoting features (functional food) is increasing and will continue as consumer awareness on the role of food in nutrition and health increases[6]. Food they seek is that which has desirable fatty acids, and high content of vitamins, minerals and has sensory appeal. One way of enriching the food with such ingredients is through supplementation in feed either directly or through compounds containing the nutrients. The desirable form of delivery nowadays is through organic forms which are sometimes better absorbed than inorganic forms[6]. Phyto-additives are natural feed additives from plant sources used for their remarkable phytochemicals. Across the world, they are affordable than other types of additives[7]. The phytochemical content and mixture of each phyto-additive differ, hence, will potentially have different effects on the animals, animal products and feed they are included[8]. Among the prospective feed additives is aidan (Tetrapleuratetraptera). This study therefore evaluated the proximate, mineral and cholesterol contents as well as sensory value of meat from rabbits fed aidan as dietary phyto-additive.

II. Materials and Methods

Experimental Site

The study took place in University of Port Harcourt Teaching and Research Farm, Choba, Port Harcourt, Rivers State Nigeria. The coordinates of Choba are latitude 4.89437^{o}N and longitude 6.91053^{o}E, while average altitude and twelve-month temperature are 16m and 28^{o}C [9].

Feed Materials and Trial Diets

Aidan fruits from one batch were purchased from a spice kiosk in Choba, Port Harcourt. The fruits were sliced to tiny pieces and dehydrated to stable weight in an oven set at 70℃ for 48 hours. The pieces were ground to flour for addition to diets. Other dietary ingredients such as palm kernel cake, yellow maize, wheat offal, soybean meal, bone meal, table salt, and palm oil were purchased from feedstuff stalls in Rumuokoro, Port Harcourt. The diets were compounded to give 16 % and 2700 kcal/kg crude protein and energy, respectively (Table 1).

Table 1: Trial diets for rabbits containingaidan as feed additive

Feed constituents	Inclusion levels of aidan (%)			
	T1	**T2**	**T3**	**T4**
Aidan flour	-	0.50	1.00	1.50
Maize flour	57.00	56.50	56.00	55.50
Palm kernel cake	10.00	10.00	10.00	10.00
Soybean meal	16.50	16.50	16.50	16.50
Wheat offal	12.00	12.0	12.00	12.00
Bone meal	2.50	2.50	2.50	2.50
Premix (minerals & vitamins)	0.50	0.50	0.50	0.50
Palm oil	1.00	1.00	1.00	1.00
Table salt	0.50	0.50	0.50	0.50
Total	**100**	**100**	**100**	**100**
Computed composition				
Crude protein (%)	16.45	16.44	16.47	16.49
Energy (kcal ME/kg)	2,710	2,750	2,767	2,798
Crude fibre (%)	16.80	16.61	16.48	16.46
Determined composition				
Crude protein (%)	16.44	16.42	16.46	16.46
Energy (kcal ME/kg)	2,700	2,755	2,760	2,795
Crude fibre (%)	16.85	16.70	16.76	16.77

Animal Management Procedures

The rabbits were kept in a hutch made from wire gauze and wood. The animals, housed at one for a cage, were managed under similar conditions with only exception being the trial diets. The water and trial diets were offered the rabbits *ad libitum*. Guinea grass, the sole forage wascollected by 4.00 pm and wilted for 16 hours and fed to the rabbits at specificamount to all animals. The rabbits were offered the trial diets at 8:00 am and 4.00 pm every day while the wilted forage was offered to them at 12:00 pm (all times were in local time or GMT +1.00, West African Time). The feeding and drinking equipment were cleaned once a day before fresh feed and water were offered. The trial rabbits were weighed at the start of the study to take initial weight and subsequently each seventh day till the end of the study.

Experimental Design

The growth trialutilized forty-eight New Zealand White rabbit bucks that were 6-weeks old. The animals were shared into four groups comprising twelve animals per group. A balance in the mean starting weight of animals across groups was ensured to avoid bias. The twelve animals were furthered split into three replicates of four animals each. Animals in group 1 or T1 were fed the control diet which contained no aidan flour. Groups T2, T3 and T4 animals were fed diets in which aidan flour was added at 0.5, 1.0 and 1.5 % levels, respectively. All animals were given 400 g of forage each day. The grouping of animals followed a Completely Randomized Design format. The trial was eight weeks long.

Data Collection

On the final day of the experiment, a rabbit, whose weight was nearest to the group's average weight was picked for assessment of proximate, mineral and organoleptic indices of the rabbit meat. The animals were not fed for 12 hours but offered drinking waste. They were then rendered unconsciousby quickly clubbing the back of the head. This was followed by slaughtering and bleeding by suspending them by their hind legs. Thereafter, carcasses were de-furred, cleaned, disemboweledand split into parts. The meat portions for the three evaluations were obtained from the loin part of the carcass.

Organoleptic Indices

Meat portions for sensory analysis were further sliced to 3-centimeter-long cubes. The meat was cooked in metal pots over camp gas fire according to their groups. Boiling was done in 300 ml of water and 3 g of salt for 10 minutes. After cooking, the samples were cooled for 10 minutes before serving the testers. A semi-trained panel of 20 persons was used for the exercise. They were informed to rate the meat samples using structuredquestionnaires. Each panel member was given the questionnaire using nine-point Hedonic scale where 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely. The testers were then requested to chew bread and drink water after each tasting round. This was to mask the remains of previous meat chewed. The marks were gathered and averages computed for further statistical analyses. The sensory analysis parameters evaluated included meatcolour, odour, texture, tenderness,juiciness and acceptability 9-point scale [10].

Proximate Composition Analysis

The moisture, ether extract, ash and crude protein contents were assessed using oven drying wet samples for 24 hours, Soxhlet method, burning using muffler furnace (calcination of 20 g of sample at 550 ^{o}C to constant weight), and Kjeldahl method, respectively according to procedures of AOAC [11].

Mineral Analysis

The ash was liquefied using hydrochloric acid, dried by evaporation, re-liquefied in hydrochloric acid and mixed to 200 ml with Milli-Q water and filtered. The various minerals were analyzed using standard methods (11, 12].

Data Analyses

All data were measured in replicates and averages used for each group scores. Data were collected and subjected to the Analysis of Variance (ANOVA). Significant treatment means (p<0.05) were separated using Least Significant Difference (LSD) in Statistical Package for Social Sciences (SPSS) softwareversion 24 [13]. Results are presented in tables.

III. Results and Discussion

Proximate and cholesterol content of rabbit meat

The proximate composition and cholesterol contents of meat from rabbits fed dietary aidan are presented (Table 2). It shows that dry matter and crude protein values ranged from 28.00±2.02 (T2) to 26.98±1.99 (T3) and 22.90±1.05 (T1) to 21.99±1.11 (T2), respectively. There were no differences (p>0.05) in the dry matter and crude protein contents of the rabbit meat.

Ether extract values showed differences (p<0.05) among the treatment means. Group T1 had the highest value (11.89±1.40), which was not different (p>0.05) from that of T2 (10.99±0.98), while T4 had the least value (2.17±0.67) which was not different (p>0.05) from that of T3 (2.40±0.81). The range of ether extract in this study was higher than that obtained for rabbits fed extracts of oregano, sage, and *E.senticosus* as dietary spice additives[14]. Differences could be due to ether extract content of the dietary additives as ether extractin an additive can be transferred to the muscle of spice-consuming animal[15]. As the level of spice increased in the diet, the ether extract content reduced. This agrees with [16] that increasing levels of certain spices in diets of turkey reduced fat content of muscles and consequently fat content of the meat.

Theash content differed significantly (p<0.05) among the treatment means. Group T4 (2.53±1.01) had the highest ash content, while T1 (0.98±0.01) had the least. However, the ash content for T1 was not different (p>0.05) from that of T2, while that of T3 was also not different (p>0.05) from those of T1, T2 and T4.The ash content was similar to values reported for rabbits of both sexes, different ages, and genotype[17]. The ash content of the meat increased (p<0.05) with increasing level of aidan in the feed. Aidan is rich in ash[18]. Hence, the increasing level of aidan in the diets could be responsible for the increasing level of ash in the meat. This is because the nutrient content of meat is influenced by contents of diets eaten by the animals[15].

There were significant differences (p<0.05) in the cholesterol content of meat from rabbits fed aidan in diets. Group T1 had the highest (68.99±3.12) cholesterol content, which was not different (p>0.05) from that of T2, while group T4 had the least (53.90±1.29) value, that was also not different (p>0.05) from that of T3. The cholesterol content was within the range reported for rabbits elsewhere[15, 19]. The level of cholesterol decreased as aidan level in diets increased. Generally, the cholesterol level in rabbit meat is lower than those of chicken beef and pork[19]. However, the decrease in the level of cholesterol as the level of aidan in diets increased could indicate that aidan plays a role in cholesterol metabolism in rabbits. Taken further, it means that inclusion of aidan in diets may have reduced the cholesterol content of rabbit meat since according to [20], phytogenic feed additives inclusion in diet could minimize the cholesterol content of meat from animals such as broiler chicken.

Table 2: Proximate composition and cholesterol content of meat from rabbits fed dietary aidan

Component	Dietary levels of aidan (%)			
	0.0 (T1)	**0.5 (T2)**	**1.0 (T3)**	**1.5 (T4)**
Dry matter (%)	27.56±1.22^{NS}	28.00±2.02^{NS}	26.98±1.99^{NS}	27.01±1.45^{NS}
Crude protein (%)	22.90±1.05^{NS}	21.99±1.11^{NS}	22.00±1.02^{NS}	22.59±0.99^{NS}
Ether extract (%)	11.89±1.40^{a}	10.99±0.98^{a}	2.40±0.81^{b}	2.17±0.67^{b}
Ash (%)	0.98±0.01^{b}	1.21±0.00^{b}	1.89±0.30^{ab}	2.53±1.01^{a}
Cholesterol (mg/100g)	68.99±3.12^{a}	67.57±2.22^{a}	54.80±2.30^{b}	53.90±1.29^{b}

^{a,b}Means in same row with different superscript are significantly different (p<0.05); ^{NS}Not significantly different (P>0.05)

Mineral nutrients content of rabbit meat

Table 3 shows the mineral content of meat from rabbits fed aidan as dietary additive. Calcium values showed significant differences (p<0.05) among treatment means with T4 (19.29±1.99) being the highest, while T1 (8.99±0.98) was the least.Compared to rabbit meat from other reports[19, 12], the present values are within the reported range.The calcium content of the meat increased with increasing levels of aidan in the diets of rabbits. Aidan is rich in calcium[21, 22]. Increasing calcium levels in the meat could be attributed to the inclusion of aidan as additive, as according to [15], the nutrient content of meat is influenced by contents of diets eaten by the animals.

Potassium values were significantly different (p<0.05) among the treatment means. T4 (575.55±10.11) was the highest while T1 (434.25±12.23) was the least.These values were higher than those reported for rabbit meat elsewhere[12]. Potassium is one the most abundant mineral nutrient in aidan[21, 22]. This high potassium content could have increased the potassium content of meatof rabbits consuming the aidan-supplemented feed.

The phosphorus content of the rabbit meat differed significantly (p<0.05) among the treatment means. Group T4 (345.87±15.32) had the highest value, while T1 (245.09±10.34) had the least. Phosphorus values were lower than those reported by [19], but within the range of those reported by[12]for rabbit meat. Differences can be attributed to feed consumed and breeds of the animals. This is because the reports emanated from different countries with different feeding systems for rabbits, which could have influenced the phosphorus content of the meat. The phosphorus content of the meat improved (p<0.05) with higher levels of dietary aidan. It implies that the phosphorus content of the meat could have been influenced by the inclusion of aidan powder.

The zinc, iron, sodium and copper contents ranged from 12.09±1.11 (T2) to 10.67±1.01 (T1), 38.01±2.30 (T1) to 36.00±3.40 (T3), 61.07±1.97 (T4) to 57.20±1.87 (T1) and 3.89±0.00 (T2) to 3.00±0.98 (T3), respectively. The differences in the values of zinc, iron, sodium and copper among the treatment groups were not significant (p>0.05).

Among the treatment means, there was significant difference (p<0.05) in magnesium content. T4 had the highest value (57.89±2.33), while T1 had the least (36.77±2.01). These values were higher than the values reported for meat from rabbits fed normal diets[12]. Generally, rabbit meat is high in magnesium, compared to meat from other animals [12]. In this case it was higher and differences could be attributed to inclusion of aidan in diets compared to that reported by [12] where the rabbit had normal diets. Aidan is rich in magnesium[22]. This high magnesium content could have been transferred to the meat through the diets. This could have been responsible for the increase in magnesium content of the meat with increasing levels of dietary aidan.

Table 3: Mineral content of meat from rabbits fed dietary aidan

Minerals(Mg/100g)	Dietary levels of aidan (%)			
	0.0 (T1)	**0.5 (T2)**	**1.0 (T3)**	**1.5 (T4)**
Calcium	8.99±0.98^{b}	10.34±1.21^{b}	17.96±1.20^{a}	19.29±1.99^{a}
Potassium	434.25±12.23^{b}	450.33±21.12^{b}	567.30±12.45^{a}	575.55±10.11^{a}
Phosphorus	245.09±10.34^{c}	260.67±13.45^{bc}	275.09±12.09^{b}	345.87±15.32^{a}
Zinc	10.67±1.01^{NS}	12.09±1.11^{NS}	11.90±2.01^{NS}	10.99±1.29^{NS}
Iron	38.01±2.30^{NS}	37.67±3.67^{NS}	36.00±3.40^{NS}	37.77±2.87^{NS}
Sodium	57.20±1.87^{NS}	59.05±1.98^{NS}	57.90±2.22^{NS}	61.07±1.97^{NS}
Copper	3.33±0.09^{NS}	3.89±0.00^{NS}	3.00±0.98^{NS}	3.12±0.01^{NS}
Magnesium	36.77±2.01^{b}	37.09±2.00^{b}	38.02±1.23^{b}	57.89±2.33^{a}

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

Sensory quality of rabbit meat

Table 4 shows the sensory quality of meat from rabbits fed aidan as dietary additive.In a nine-point hedonic scale, the scores for colour, tenderness and texture ranged from 5.30±0.09 (T1) to 5.11±0.11 (T3), 5.61±0.13 (T1) to 5.39±0.33 (T3), and 6.35±0.45 (T3) to 6.04±0.22 (T1), respectively. There were no significant differences (p>0.05) in meat colour, tenderness, and texture among the treatment groups.

Table 4: Sensory quality of meat from rabbits fed dietary aidan

Parameter	Dietary levels of aidan (%)			
	0.0 (T1)	**0.5 (T2)**	**1.0 (T3)**	**1.5 (T4)**
Colour	$5.30±0.09^{NS}$	$5.21±0.32^{NS}$	$5.11±0.11^{NS}$	$5.25±0.41^{NS}$
Odour	$6.43±0.42^{b}$	$7.12±0.23^{b}$	$8.62±0.89^{a}$	$8.56±0.67^{a}$
Juiciness	$7.56±0.32^{a}$	$5.88±0.18^{b}$	$5.58±0.75^{b}$	$5.45±0.56^{b}$
Flavour	$8.00±0.65^{a}$	$8.21±0.91^{a}$	$5.67±0.28^{b}$	$5.77±0.34^{b}$
Tenderness	$5.61±0.13^{NS}$	$5.45±0.22^{NS}$	$5.39±0.33^{NS}$	$5.55±0.31^{NS}$
Texture	$6.04±0.22^{NS}$	$6.34±0.34^{NS}$	$6.35±0.45^{NS}$	$6.25±0.55^{NS}$
Acceptability	$6.06±1.67^{b}$	$6.33±1.30^{b}$	$7.99±1.33^{a}$	$8.45±1.07^{a}$

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

Colour, tenderness and texture were not affected by inclusion of aidan in diets. Odour and acceptability increased from 1.0% level while juiciness score fell with inclusion of aidan and flavour decreased as inclusion level rose above 0.5%.

There was significant difference (p<0.05) in the rabbit meat odour. Group T3 (8.62±0.89) scored the highest, while T1 scored the least (6.43±0.42). The least acceptable odour (T1) was not different (p>0.05) from that of T2, while the most appreciated odour (T3), was not different from that of T4. Meat odour is the distinctive quality of smell of meat. A combination of taste and odour will give rise to flavour. The odour acceptability increased as aidan level in the diet increased.Odour could be influenced by fat content of the meat, diet, breed, sex and cooking conditions[23, 24]. In this case, the higher odour acceptability as aidan level increased could be due to aidaninclusion sinceaidan is an aromatic spice. The odour of aidan is one reason why aidan is used to make meat delicacy soups[22].

Juiciness scores for rabbit meat showed significant difference (p<0.05) among treatment means. Group T1 (7.56±0.32) had the highest score while T4 scored the least (5.45±0.56). However, the juiciness score for T4 was not different (p>0.05) from those recorded for T2 and T3. All juiciness values were within the range reported for rabbit meat from different genotypes[25]. Juiciness reduced (p<0.05) when aidan powder was included in the diets of rabbits. Juiciness is common with fatter carcasses and is determined by marbling (intramuscular fat). Marbling increases when animals are fed diets whose energy to essential amino acids ratio is high[24]. In this case, aidan inclusion reduced fat deposition. This could have been responsible for the dwindling juiciness as aidan level in diets increased.

The flavour of the meats differed significantly (p<0.05) among the treatment means. Group T2 (8.21±0.91) scored the highest for flavour, while T4 score (5.67±0.28) was the least. The T2 was not different (p>0.05) from that of T1, while the least score (T4) was also not different from that of T3. The values were within the range reported for different breeds of rabbits[25]. The flavour reduced as the quantity of aidan increased in diets. This could be due to the reducing fat content of the meat. Fat and the fatty acids are important original components responsible for meat flavour and flavour is determined by taste and odour[23].

Overall acceptability of the rabbit meat was significantly different (p<0.05) among treatment means. T4 had the highest score (8.45±1.07) while T1 scored the least (6.06±1.67).Consumer acceptance is compromised when fat is substantiallylow in meat because a certain amount of fat is needed to make meat tender, juicy, flavourful and acceptable[26]. Overall acceptability of the meat improved with increase in inclusion level of aidan. This could be due to the highly acceptable odour of the meat impacted by volatile compounds present in aidan. According to[23], those compounds are responsible for improving the meat flavour which is chiefly responsible for meat acceptability.

IV. Conclusion

The experiment assessed the chemical composition, cholesterol content and sensory value of meat from rabbits fed aidanas dietary phyto-additive. We conclude that aidan could be included in rabbit diets up to1.0% for the meat to have minimal fat and cholesterol, more ash (especially Ca, K, P and Mg), better odour and acceptability by consumers.

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