Effects of ginger *(Zingiber officinale)*, roselle *(Hibiscus sabdariffa)* and their blends on performance, carcass and meat lipid oxidation in broiler chickens

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Abstract

The paradigm shift towards making livestock production as natural as possible has necessitated increased research into the use of plants with medicinal and other bioactive components, as feed additive in livestock production. This experiment was designed to explore the dietary inclusion of ginger rhizomes, roselle calyces and their blends on the performance, carcass and meat lipid oxidation in broiler chickens. Six identical diets (each representing a treatment) were formulated thus: Treatment 1- Control diet (No Additive), Treatment 2- Control diet+1% dried Ginger (Zingiber officinale), Treatment 3- Control diet+1% dried Roselle (Hibiscus sabdariffa), Treatment 4- Control diet+1% dried Ginger-Roselle [25:75], Treatment 5- Control diet+1% dried Ginger-Roselle [50:50], and Treatment 6 - Control diet+1% dried Ginger-Roselle [75:25]. A total of 90 one-day-old chicks were procured, with 5 allocated to each treatment in 3 replicates. The birds were fed ad libitum on respective allotted diets for eight weeks during which performance parameters were measured. At the eighth week, 2 birds per replicate were randomly selected and slaughtered for carcass analysis and meat lipid oxidation study. Birds from Treatment 1 had the highest (P<0.05) final weight (2533.20g), while birds on treatment 5 had the lowest (P<0.05) final weight (2232.67g). Birds from treatment 4 had the lowest (P<0.05) deposition of abdominal fat (2.36g). Meat from treatment 4 also had the lowest (P<0.05) level of lipid oxidation (2.25µg/g) after four weeks of storage. Treatment 4 (Ginger-Roselle [25:75]) was found to significantly reduce abdominal fat deposition and also reduce lipid oxidation up till four weeks of storage. Dietary inclusion of ginger-roselle [25:75] blend in broiler chicken diets can promote carcasses with less fat, which also retains meat quality better during short term cold storage.

Keywords*:* ginger; roselle; bioactive components; chicken; meat; lipid oxidation

Effets du gingembre (*Zingiber officinale*), de l'hibiscus (*Hibiscus sabdariffa*) et de leurs mélanges sur la performance, la carcasse et l'oxydation des lipides dans la viande des poulets de chair

Résumé

Le changement de paradigme visant à rendre la production animale aussi naturelle que possible a nécessité une intensification de la recherche sur l'utilisation de plantes aux composants médicinaux et autres bioactifs comme additifs alimentaires dans la production animale. Cette expérience a été conçue pour explorer l'inclusion alimentaire de rhizomes de gingembre, de calices d'hibiscus et de leurs mélanges sur la performance, la carcasse et l'oxydation des lipides dans la viande des poulets de chair. Six régimes identiques (chacun représentant un traitement) ont été formulés comme suit : Traitement 1 - Régime témoin (sans additif), Traitement 2 - Régime témoin + 1% de gingembre séché (Zingiber officinale), Traitement 3 - Régime témoin + 1% d'hibiscus séché (Hibiscus sabdariffa), Traitement 4 - Régime témoin + 1% de mélange de gingembre-hibiscus [25:75], Traitement 5 - Régime témoin + 1% de mélange de gingembre-hibiscus [50:50], Traitement 6 - Régime témoin + 1% de mélange de gingembre-hibiscus [75:25]. Un total de 90 poussins âgés d'un jour a été acquis, avec 5 poussins alloués à chaque traitement en 3 répliques. Les oiseaux ont été nourris ad libitum avec les régimes alloués pendant huit semaines, au cours desquelles les paramètres de performance ont été mesurés. À la huitième semaine, 2 oiseaux par réplique ont été sélectionnés au hasard et abattus pour l'analyse de la carcasse et l'étude de l'oxydation des lipides dans la viande. Les oiseaux du traitement 1 ont eu le poids final le plus élevé (P<0,05) (2533,20g), tandis que ceux du traitement 5 ont eu le poids final le plus bas (P<0,05) (2232,67g). Les oiseaux du traitement 4 ont eu la plus faible (P<0,05) déposition de graisse abdominale (2,36g). La viande du traitement 4 avait également le niveau le plus bas (P<0,05) d'oxydation des lipides (2,25µg/g) après quatre semaines de stockage. Le traitement 4 (Gingembre-Hibiscus [25:75]) a significativement réduit la déposition de graisse abdominale et a également réduit l'oxydation des lipides jusqu'à quatre semaines de stockage. L'inclusion alimentaire du mélange gingembre-hibiscus [25:75] dans les régimes alimentaires des poulets de chair peut favoriser des *carcasses avec moins de graisses, qui conservent mieux la qualité de la viande pendant un stockage court à froid.*

Mots-clés : gingembre ; hibiscus ; composants bioactifs ; poulet ; viande ; oxydation des lipides

Introduction

In recent times there has been renewed and sustained interest in reducing the use of synthetic chemicals and drugs in food production and processing due to the harmful effects of some of these synthetic chemicals on the environment and human health (Olatoye and Isaac, 2010; Aslam *et al.,* 2018;; Davis *et al.,* 2018; Atoyebi *et al.,* 2019). Also, there is a growing consciousness about the concept of food safety among consumers (Fukuda, 2015; Ezirigwe, 2018). Livestock production is an indispensable contributor of protein (which is necessary for growth and many other important biochemical processes) to the human diet (Biesalski, 2005; Elmadfa and Meyer, 2017; Leroy *et al.,* 2023; Ederer and Leroy, 2023).

The modern livestock industry has been heavily reliant on the use of antibiotics and other synthetic chemicals to optimise production and meet ever increasing protein demand. However, due to the discovery of harmful effects associated with some antibiotics and other synthetic chemicals that have been used in livestock production, which has necessitated authorities in some regions of the world banning the use of some of these synthetic chemicals in livestock production (Olatoye *et al.,* 2016; Soepranianondo *et al.,* 2019; Emeje *et al.,* 2022). Attention is gradually shifting to the replacement of these synthetic chemicals with natural products, primarily from plants which have been established or thought to be medicinal through discovery and more efficient use (Sampaio *et al.,* 2012; Falowo *et al.,* 2014; Akinwumi *et al.,* 2022).

Many of these plants contain bioactive compounds that are more easily metabolised when consumed by monogastric livestock like chicken. Some plants, like ginger, garlic, roselle and many others have also been reported to promote digestion, health, growth, and liveweight when included in livestock diets. Additional benefits that could result from incorporating these beneficial plants into livestock diets is the potential to translate the health benefits inherent in them to the final consumer. Since the useful bioactive components they contain like flavonoids and other phenolic and aromatic compounds can be absorbed directly from the gastrointestinal tracts of monogastrics and retained in the tissues upon slaughter (Gardzielewska *et al.,* 2003; Onibi *et al.,* 2009). The ability of these bioactive plant components to be retained in animal tissues post mortem can also contribute to postharvest shelf-life of meat harvested from animals raised on such diets. This is due to the antimicrobial and the antioxidant properties that they contain. Antioxidant components are of particular importance, as they can help inhibit the progress of lipid oxidation in meat, which is a major cause of quality loss in meat and is quite difficult to arrest (Wasowicz *et al.,* 2004; Domínguez *et al.,* 2019; Wu *et al.,* 2022). With varying levels of success, plants like roselle and sorghum have been noted for their antioxidant and antimicrobial effects in food processing (Omojola and Adediran, 2015; Akogou *et al.,* 2018; Akinwumi *et al.,* 2022). It is opined that blending could complement their strengths and benefits when used as additives in broiler chicken diets. Therefore, this study was designed to evaluate the effect of Ginger, Roselle and their blends on the performance, carcass and meat lipid oxidation quality of broiler chickens.

Materials and methods

Experimental site

This study was conducted at the poultry unit, Teaching and Research Farm Tai Solarin University of Education, Ijagun, Odogbolu Local Government Ogun State. Ijagun is 63 meters above sea level with a tropical climate. The short dry has little effect on the overall climate. The temperature here averages of 26.0ºC/78.8ºF. During the year the average temperature varies by 3.3ºC/37.9ºF. There is significant rainfall in most months of the year with an annual rainfall of 2020mm/79.5 inch per year. There is 37mm/1.5 inch of precipitation in January between the driest month and the wettest month.

Experimental diets and animals

Diets offered to all experimental birds were isocaloric and formulated to meet birds' requirement as recommended by NRC (1994). Six identical diets (each representing a treatment) were formulated such that Treatment 1 (Control) had no phyto-supplementation while diets 2, 3, 4, 5 and 6 were each supplemented with 1% of either ginger, roselle or their blends as highlighted. The experimental starter diet as shown in Table 1 was fed to the chicks for the first four weeks of life. While the experimental finisher diet as shown in Table 2 was fed from week five to week eight. Treatment 1 (Control diet) was without ginger or roselle, treatment 2 had 1% dried ginger (*Zingiber officinale*), treatment 3 had 1% dried roselle (*Hibiscus sabdariffa*), treatment 4 had 1% dried of ginger-roselle [25:75], treatment 5 had 1% dried ginger-roselle [50:50], and treatment 6 had 1% dried ginger-roselle [75:25].

Preparation of ginger and roselle blends

Dried specimens of ginger (rhizomes) and roselle (calyces) were obtained in sufficient quantities from a well patronized open market in Ijebu Ode, Ogun state, Nigeria. The dried ginger and roselle were then oven dried overnight (80ºC) until a constant weight was achieved. Thereafter, the dried ginger and roselle were individually milled with a kitchen blender and sieved to remove coarse particles. Parts of the blended ginger and roselle were then combined in the ratios 25:75, 50:50, and 75:25 for treatments 3,4, and 5. Finally, 1% each of the dried ginger, roselle, and ginger-roselle blends were added to diets forming individual treatments (2-5) according to the experimental design.

Experimental animal and design

A total of 90, one-day-old Arbor acres broiler chicks were obtained from a reputable hatchery in Ibadan. Prior to arrival of the day old chicks, the brooder house, feeders, and drinkers were properly cleaned and disinfected. Brooding was carried out for two weeks, during and after which the starter and finisher experimental diets were fed. Fresh cool water and feed were provided ad libitum and routine medication administered as and when due. The chicks were randomly divided into 6 groups of 5 birds each in a Completely Randomized Design. Each group was randomly assigned to one of the 3 replicates of each dietary treatment, making a total of 15 chicks per treatment and 5 birds per replicate.

Table 1. Gross composition (%) of broiler starter diet

Ingredients (%)	1 (control)	2 (+1% Ginger	3 (+1% Roselle)	4 (+25% G + 75% R	5 (+50% G +50% R	6 (+75% G +25% R
Maize	50.12	50.00	50.00	50.00	50.00	50.00
Soybeanmeal	25.06	25.00	25.00	25.00	25.00	25.00
Full fat soya	17.54	17.00	17.00	17.00	17.00	17.00
Wheat offal	4.01	4.00	4.00	4.00	4.00	4.00
Bone meal	2.51	2.51	2.51	2.51	2.51	2.51
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25	0.25	0.25
Ginger	-	1.00	-	0.25	0.50	0.75
Roselle	-	-	1.000	0.75	0.50	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition						
C.P. (%)	22.96	22.77	22.77	22.77	22.77	22.77
M.E. (kcal/kg)	2905.98	2883.01	2883.01	2883.01	2883.01	2883.01
C.F	4.05	4.02	4.02	4.02	4.02	4.02
Ca (%)	1.03	1.01	1.01	1.01	1.01	1.01
P (%)	0.77	0.60	0.60	0.60	0.60	0.60

Table 2. Gross composition (%) of broiler finisher diet

Ingredients (%)	1 (control)	2 (+1% Ginger	3 (+1% Roselle)	4 (+25% G + 75% R	5 (+50% G +50% R	6 (+75% G +25% R
Maize	66.50	66.00	66.00	66.00	66.00	66.00
Soybeanmeal	22.00	21.50	21.50	21.50	21.50	21.50
Groundnut cake	8.00	8.00	8.00	8.00	8.00	8.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	0.55	0.55	0.55	0.55	0.55	0.55
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10

Premix	0.25	0.25	0.25	0.25	0.25	0.25
Table salt	0.50	0.50	0.50	0.50	0.50	0.50
Ginger	-	1.00	-	0.25	0.50	0.75
Roselle	-	-	1.000	0.75	0.50	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated composition						
C.P. (%)	19.52	19.24	19.24	19.24	19.24	19.24
M.E. (kcal/kg)	2984.31	2955.17	2955.17	2955.17	2955.17	2955.17
C.F	3.87	3.82	3.82	3.82	3.82	3.82
Ca (%)	1.01	1.01	1.01	1.01	1.01	1.01
P (%)	0.60	0.60	0.60	0.60	0.60	0.60

Experimental design

The experimental design was completely randomized design (CRD).

Statistical model is specified thus;

Yij= U+ Tj +Eij

Where, Yij= Independent variable, assumed to be randomly distributed,

U= Overall mean,

Tj= The effect of treatment,

Eij= Experimental error containing all uncontrolled sources of variation.

Data collection

Performance evaluation

Individual chicks were weighed prior to the commencement of the study. Thereafter daily feed consumption and weekly weight gain per replicate were monitored and recorded to calculate the Feed Conversion Ratio (FCR), by dividing total feed intake with total weight gained.

Carcass evaluation

At the end of the feeding trial (8 weeks) a total of 2 birds per replicate were purposively selected for meat quality evaluation. The birds were euthanized and then immediately exsanguinated by manually severing the jugular vein at the neck region with a sharp knife, after which they were allowed to bleed thoroughly. After bleeding, the birds were scalded in hot water (85ºC), which was followed by defeathering.

Primal cuts excision and storage study

The carcasses were cut into different primal cuts and the breast cuts were selected for this experiment. Part of the meat harvested was frozen stored at -4°C for four weeks, during which lipid oxidation during storage was evaluated weekly.

Lipid oxidation/Thiobarbituric Acid Reactive Substances (TBARS) evaluation

Lipid peroxidation was determined using the thiobarbituric acid method as described by by Pikul *et al*. (1989), at intervals of 0, 10, 20, and 30 days of storage. Five grams of sample was weighed into 50 mL test tube, homogenized with 15 mL of deionized distilled water using a laboratory mortar and pestle. 1mL of homogenized sample was transferred into a disposable test tube 13 x 100mm butylated hydroxyanisole (50µL, 10%). Tricholoroacetic acid (TBA) 2mL was added.

The mixture was vortexed and then incubated in a boiling water bath for 15min to develop colour. The sample was then cooled in cold water for 10min, vortexed again and centrifuged for 15 minutes. The absorbance of the resulting supernatant solution was determined at 535nm against a blank containing 1mL of deionized distilled water and 2mL of TBA/Trichloroacetic acid solution. The amount of TBARS was expressed as milligrams of malondialdehyde (MDA) per kilogram of sample.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA). The analysis was conducted using the general linear modelling procedure (SAS, 1999) while Duncan Multiple Range Test was used to separate means where significant differences occurred (Duncan, 1955).

Results

Table 3 shows the performance of broiler chickens fed Ginger, Roselle, and their blends. There were no significant differences ($P>0.05$) across treatments for Initial body weight and FCR. However, birds on the control diet/Treatment 1 had significantly higher ($P<0.05$) Body weight change (2501.00) and final body weight (2533.20) while birds on Treatment 5 had the highest ($P<0.05$) feed intake (8055.70).

Table 3: Performance of broiler chickens fed ginger, roselle and their blends

Parameters \ Treatments	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Initial Body Weight (g)	98.87	98.60	98.86	96.80	96.35	96.00	2.79
Final Body Weight (g)	2533.20^a	2416.83^b	223280^c	2397.67^b	2354.27^b	2232.67^c	19.15
Body Weight change (g)	2501.00^a	2318.07^b	2067.27^c	2300.87^b	2257.92^b	2136.67^c	18.06
Feed Intake (g)	6942.00^c	6929.30^c	7507.60^b	6763.80^c	8055.70^a	6715.50^c	84.69
Feed Conversion Ratio	2.88^a	2.99^a	3.49^a	2.94^a	3.59^a	3.11^a	0.12

^{abc}Means along the same row with different superscripts are significantly different (P<0.05)
SEM – Standard error of mean
Treatment 1- Control diet (Control), Treatment 2- Control diet+1% dried Ginger (*Zingiber officinale*)
Treatment 3- Control diet+1% dried Roselle *(Hibiscus sabdariffa*), Treatment 4- Control diet+1% dried Ginger-Roselle [25:75]
Treatment 5- Control diet+1% dried Ginger-Roselle [50:50], Treatment 6- Control diet+1% dried Ginger-Roselle [75:25]

Carcass characteristics of broiler chickens fed ginger, roselle and their blends is shown in Table 4. Significant differences (p<0.05) were observed in some of the parameters measured with Treatment 1 (Control) having higher live weight (2794.33), dressed weight (2571.83), eviscerated weight (2261.00) and abdominal fat (3.17). Treatment 4 (Ginger-Roselle [25:75]) had the lowest (P<0.05) abdominal fat (2.36), while treatment 6 (Ginger-Roselle [75:25]) had the lowest (P<0.05) live weight (2369.67) and dressed weight (2162.67).

Table 4: Carcass characteristics of broiler chickens fed ginger, roselle and their blends

Rel. Weights (g)	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Live weight	2794.33^a	2562.00^b	2430.67^c	2581.67^b	2399.83^c	2369.67^c	15.55
Bled weight	2672.83^a	2498.83^b	2308.83^d	2405.17^c	2305.50^d	2246.17^e	10.59
Dressed weight	2571.83^a	2359.00^b	2235.00^c	2331.83^b	2163.83^d	2162.67^d	10.54
Eviscerated Weight	2261.00^a	2071.50^b	1902.00^c	2038.33^b	1916.67^c	1890.17^c	8.09
Thigh	10.81	12.55	11.11	12.10	11.10	12.04	0.35
Drumstick	10.99	10.06	8.69	11.10	11.00	12.13	0.45
Breast	41.03	42.12	37.56	39.26	40.04	35.57	1.49
Back	32.77	35.09	33.28	29.89	31.93	32.27	0.76
Neck	8.41	8.63	8.75	9.51	8.29	9.01	0.32
Abdominal fat	3.17^a	2.98^b	2.51^b	2.36^c	2.67^b	2.93^b	0.24
Wings	9.18	8.18	8.85	8.79	8.85	9.22	0.23
Legs	3.63^c	3.25^c	4.17^b	4.39^a	4.43^a	4.59^a	0.12
Head	4.42	4.53	5.05	4.89	4.84	5.11	0.13
GIT	10.71	9.25	11.22	8.85	10.52	12.84	0.85
Liver	3.73	3.26	3.62	3.09	3.36	3.49	0.15
Heart	0.94	0.93	1.01	0.92	0.90	1.00	0.04
Gizzard	5.43^b	5.93^b	7.22^a	5.70^b	6.20^a	5.51^b	0.21
Lungs	1.00^c	0.89^c	1.16^b	1.31^a	1.25^a	1.10^b	0.04

^{abc}Means along the same row with different superscripts are significantly different (P<0.05)
SEM – Standard error of mean, GIT – gastro intestinal tract
T_1 - Control diet (no ginger no roselle), T_2 - Control diet+1% dried ginger (*Zingiber officinale*)
T_3 - Control diet+1% dried roselle *(Hibiscus sabdariffa*), T_4 - Control diet+1% dried ginger-roselle [25:75]
T_5 - Control diet+1% dried ginger-roselle [50:50], T_6 - Control diet+1% dried ginger-roselle [75:25]

Table 5 shows the lipid oxidation detected in meat from broiler chickens fed Ginger, Roselle and their blends, over a period of four weeks. Significant differences ($P<0.05$) were recorded across all the treatments at weekly evaluation intervals, with treatment 6 (Ginger-Roselle [75:25]) having the highest level of lipid oxidation at Weeks 1 (1.88) and 4 (3.13). Treatment 1 (Control) had the lowest lipid oxidation at Week 1 (0.82), while treatment 4 (Ginger-Roselle [25:75]) had the lowest level of lipid oxidation at Week 4 (2.25).

Table 5: Lipid oxidation(µg/g) in meat from broiler chickens fed ginger, roselle and their blends

Treatments / Weeks	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Week 1	0.82^{c}	1.21^{bc}	1.32^{bac}	1.10^{bc}	1.46^{ba}	1.88^{a}	0.10
Week 2	1.09^{b}	1.61^{ba}	1.42^{ba}	1.21^{b}	1.62^{ba}	2.21^{a}	0.16
Week 3	1.32^{b}	1.89^{ba}	1.69^{ba}	1.59^{ba}	2.35^{a}	2.39^{a}	0.15
Week 4	2.33^{ba}	3.08^{ba}	2.48^{ba}	2.25^{b}	2.58^{ba}	3.13^{a}	0.14

^{abc}Means along the same row with different superscripts are significantly different ($P<0.05$)

SEM – Standard error of mean, GIT – gastro intestinal tract

T_1 - Control diet (no ginger no roselle), T_2 - Control diet+1% dried ginger (*Zingiber officinale*)

T_3 - Control diet+1% dried roselle *(Hibiscus sabdariffa*), T_4 - Control diet+1% dried ginger-roselle [25:75]

T_5 - Control diet+1% dried ginger-roselle [50:50], T_6 - Control diet+1% dried ginger-roselle [75:25]

Discussion

One of the potential drawbacks of using medicinal plants and their derivatives as substitutes for antibiotics and synthetic chemicals in livestock and poultry production is reduction in liveweight, compared to when full complements of diets and antibiotics are used. This is probably due to marginal dilution of feed nutrients by these medicinal plants, and the difficulty of obtaining them in highly concentrated or pure forms unlike synthetic antibiotics (Aroche *et al.,* 2018). The same trend was observed in this study, where birds on the control diets had significantly higher final body weight (2533.20g) and better feed conversion ratio (2.88) compared to the diets supplemented with ginger, roselle and their blends. This is in consonance with previous observations by (Olagoke *et al.,* 2019; Adediran and Omojola 2022), where broiler chickens raised on diets with inclusion of different plant antioxidants had relatively lower weights regardless of non-significant feed intake relative to the control Similar trends to body weight were observed for organ weights and primal cuts, however, Treatment 4 (Ginger-Roselle [25:75]) had the lowest deposition of abdominal fat which is a pointer to the strong potential synergistic interaction of ginger with roselle to reduce fat deposition in broiler chickens. As consumer awareness continues to grow, these potentially health benefitting occurrence of lower fat deposition can be a trade off against the relatively lower weights of birds raised with supplementation of medicinal plants to earn producers more profits, when birds are marketed for their healthier carcass composition (Amein *et al.,* 2019; Atay, 2023).

Lipid oxidation is one of the major causes of quality losses in meat and meat products if not controlled soon after slaughter, due to loss of homeostasis (Parisi, 2016; Domínguez *et al.*, 2019; Secci and Wu *et al.*, 2022). In addition, to causing quality loss in meat, the end products of lipid oxidation in meat can trigger potential health hazards in consumers (Wazir *et al.*, 2019). In this study, lipid oxidation generally increased throughout the four weeks duration of storage as would normally be expected. roselle, ginger and their blends had varying effects on the levels of lipid oxidation recorded. However, it was noted that meat from Treatment 4 (ginger-roselle [25:75]) had the lowest level of lipid oxidation (2.25) by Week 4. This observation is likely linked to the lower level of fat deposition earlier pointed out in the same treatment, and reinforces the synergistic potentials of Ginger and Roselle at a combination of 25:75 in reducing fat deposition and simultaneously serving as potent antioxidant in reducing lipid oxidation from via ante mortem intervention and preserving meat quality. This observation corroborates earlier observations by Adediran *et al.* (2022) and

Akinwumi *et al.* (2022) where diets supplemented with ginger elicited substantial reductions in rate of lipid oxidation in broiler chicken meat.

Conclusion and recommendation

Inclusion of ginger, roselle and different combinations of their blends in broiler chicken diets generally reduced body weight. However, Treatment 4 (ginger-roselle [25:75]) reduced abdominal fat deposition and lipid oxidation up till four weeks of storage thereby promoting healthier carcass composition and preservation of meat quality. It is recommended that alternatives of exploring the beneficial synergy of ginger-roselle [25:75] combination like aqueous extraction in producing healthier and better quality meat be explored in future experiments.

References

Adediran, O. A., Awodoyin, O. R., Olusola, O. O.,and Omojola, A. B. 2022. Oxidative Stability and Quality of Meat from Broiler Chickens Fed Diets Supplemented with Plant Based Antioxidants. *Nigeria Agricultural Journal*, *53*(1), Article 1.

Adediran, O. A., and Omojola, A. B. 2022. Evaluation of the effects of feeding selected antioxidant plant supplements on the performance and carcass characteristics of broiler chickens. Nigerian Journal of Animal Production ,48(6),156–166. https://doi.org/10.51791/njap.v48i6.3288

Akinwumi, A. O., Oshodi, O. A., Olawuyi, B. S., Atandah, R. A., Olukade, B. C., Ogunsola, O. M., Ajani, R. A., Oyenekan, O. I.,and Olagoke, O. C. 2022. The Effect of Different Natural Antioxidants on Meat Quality of Broiler Chickens. *Annual Research*and *Review in Biology*, 96–107. https://doi.org/10.9734/arrb/2022/v37i930547

Akogou, F. U. G., den Besten, H. M. W., Kayodé, A. P. P., Fogliano, V.,and Linnemann, A. R. 2018. Antimicrobial evaluation of red, phytoalexin-rich sorghum food biocolorant. *PLoS ONE*, *13*(3), e0194657. https://doi.org/10.1371/journal.pone.0194657

Amein, S. M., Mosaad, G. M. M. and Hussein, M. K. 2019. Effect of Some Medicinal Plants as Feed Additives on Growth Performance, Blood Constituents and Carcass Characteristics of Broilers. *Journal of Advanced Veterinary Research*, *9*(4), Article 4.

Aslam, B., Wang, W., Arshad, M. I., Khurshid, M., Muzammil, S., Rasool, M. H., Nisar, M. A., Alvi, R. F., Aslam, M. A., Qamar, M. U., Salamat, M. K. F.,and Baloch, Z. 2018. Antibiotic resistance: A rundown of a global crisis. *Infection and Drug Resistance*, *Volume 11*, 1645–1658. https://doi.org/10.2147/IDR.S173867

Atay, A. 2023. The Effect Medicinal Plants on Performance, Carcass Parameters and Meat Quality in Broiler Chickens. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *13*(2), 1418–1428. https://doi.org/10.21597/jist.1229416

Atoyebi, O. E., Adetunji, V. O., Babalobi, O. O.,and Atoyebi, T. J. 2019. Prevalence and Antibiotics Sensitivity of Escherichia Coli O157:H7 In Table Eggs from Poultry Farms in Ibadan, Oyo State, Nigeria. *African Journal of Biomedical Research*, *22*(3), Article 3.

Biesalski, H. K. 2005. Meat as a component of a healthy diet – are there any risks or benefits if meat is avoided in the diet? *Meat Science*, *70*(3), 509–524. https://doi.org/10.1016/j.meatsci.2004.07.017

Christiana Cudjoe, D., Balali, G. I., Titus, O. O., Osafo, R.,and Taufiq, M. 2022. Food Safety in Sub-Sahara Africa, An insight into Ghana and Nigeria. *Environmental Health Insights*, *16*, 11786302221142484. https://doi.org/10.1177/11786302221142484

Davis, G. S., Waits, K., Nordstrom, L., Grande, H., Weaver, B., Papp, K., Horwinski, J., Koch, B., Hungate, B. A., Liu, C. M.,and Price, L. B. **2018**. Antibiotic-resistant Escherichia coli from retail poultry meat with different antibiotic use claims. *BMC Microbiology*, *18*(1), 174.

https://doi.org/10.1186/s12866-018-1322-5

Domínguez, R., Pateiro, M., Gagaoua, M., Barba, F. J., Zhang, W.,and Lorenzo, J. M. 2019. *A Comprehensive Review on Lipid Oxidation in Meat and Meat Products*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6827023/

Duncan, D. B. 1955. Multiple range and multiple F tests. biometrics, 11(1), 1-42.

Ederer, P.,and Leroy, F. 2023. The societal role of meat—What the science says. *Animal Frontiers*, *13*(2), 3–8. https://doi.org/10.1093/af/vfac098

Elmadfa, I.,and Meyer, A. L. 2017. Animal Proteins as Important Contributors to a Healthy Human Diet. *Annual Review of Animal Biosciences*, *5*(1), 111–131. https://doi.org/10.1146/annurev-animal-022516-022943

Emeje, M. O., Oloye, S., Bubakari, M.,and Adeyeye, M. 2022. Use of antibiotics in livestock in Nigeria: Curbing antimicrobial resistance and developing a national regulatory guideline towards monitoring antibiotic use in animal and animal foods. *International Research Journal of Public and Environmental Health*, *9*(2), 55–66. https://doi.org/10.15739/irjpeh.22.007

Ezirigwe, J. 2018. Much ado about food safety regulation in Nigeria. *Journal of Sustainable Development Law and Policy (The)*, *9*(1), 109–132. https://doi.org/10.4314/jsdlp.v9i1.6

Falowo, A., FAYEMI, P.,and Muchenje, V. 2014. Natural antioxidants against lipid-protein oxidative deterioration in meat and meat products: A review. *Food Research International*, *64*, 171–181. https://doi.org/10.1016/j.foodres.2014.06.022

Fukuda, K. 2015. Food safety in a globalized world. *Bulletin of the World Health Organization*, *93*(4), 212–212. https://doi.org/10.2471/BLT.15.154831

Gardzielewska, J., PudyszakK, Majewska, T., Jakubowska, M., and Pomianowski, J. 2003. Effect of plant supplemented feeding on fresh and frozen storage of broiler chicken meat. Animal Husbandry series of electronic J. Polish Agric. Univ.6(2).http:www.ejpau.media.pl/series/volume6/issue2/animal/art-12.html

Leroy, F., Smith, N. W., Adesogan, A. T., Beal, T., Iannotti, L., Moughan, P. J.,and Mann, N. 2023. The role of meat in the human diet: Evolutionary aspects and nutritional value. *Animal Frontiers*, *13*(2), 11–18. https://doi.org/10.1093/af/vfac093

National Research Council (NRC) 1994. Nutrient requirements of domestic animals No. 1 Nutrient requirement of poultry. 9th rev. ed. National Academy of Science, Washington DC

Olagoke, O. C., Akinwumi, A. O., and Emiola, I. A. 2019. *Growth Performance and Carcass Characteristics of Broiler Chicken Fed Diet Supplemented with Ginger (Zingiber Officinale), Garlic (Allium Sativum), Roselle (Hibiscus Sabdariffa) and their Combinations*. *6*(5), 143–152.

Olatoye, I. O., Daniel, O. F.,and Ishola, S. A. 2016. Screening of antibiotics and chemical analysis of penicillin residue in fresh milk and traditional dairy products in Oyo state, Nigeria. *Veterinary World*, *9*(9), 948–954. https://doi.org/10.14202/vetworld.2016.948-954

Olatoye,and Isaac, O. 2010. The incidence and antibiotics susceptibility of Escherichia coli O157:H7 from beef in Ibadan Municipal, Nigeria. *African Journal of Biotechnology*, *9*(8), 1196–1199. https://doi.org/10.5897/AJB09.1447

Omojola, A. B.,and Adediran, O. A. 2015. Effects of ethanolic extract of garlic, roselle and ginger on quality attributes of chicken patties. *African Journal of Biotechnology*, *14*(8), 688–694. https://doi.org/10.5897/AJB2014.14120

Onibi, G. E., Scaife, J. R., Murray, I., and Fowler, V. R. 2000. Supplementary á-tocopherol acetate in full fat rape-seed based diets for pigs. Influence on tissue á-tocopherol content, fatty acid profile and lipid oxidation.J.Sci.FoodAgric.80:1625-1632.

Pikul, J., Leszczynski, D. E., and Kummerow, F. A. 1989. Evaluation of three modified TBA methods for measuring lipid oxidation in chicken meat. Journal of Agricultural and Food Chemistry, 37(5), 1309–1313. https://doi.org/10.1021/jf00089a022

Parisi, G., Secci, G., Borgogno, M., Lupi, P., Rossi, S., Paci, G., Mancini, S., and Bonelli, A. 2016. Effect of mechanical separation process on lipid oxidation in European aquacultured sea bass, gilthead sea bream, and rainbow trout products. Food Control, 67, 75–81. https://doi.org/10.1016/j.foodcont.2016.02.033

SAS 1999 Statistical Analysis System, Statistical Methods. SAS Institute Inc., Cary, NC.

Sampaio, G. R., Saldanha, T., Soares, R. A. M., and Torres, E. A. F. S. 2012. Effect of natural antioxidant combinations on lipid oxidation in cooked chicken meat during refrigerated storage. *Food Chemistry*, *135*(3), 1383–1390. https://doi.org/10.1016/j.foodchem.2012.05.103

Secci, G.,and Parisi, G. 2016. From farm to fork: Lipid oxidation in fish products. A review. *Italian Journal of Animal Science*, *15*(1), 124–136. https://doi.org/10.1080/1828051X.2015.1128687

Soepranianondo, K., Wardhana, D. K., Budiarto, and Diyantoro. **2019**. Analysis of bacterial contamination and antibiotic residue of beef meat from city slaughterhouses in East Java Province, Indonesia. *Veterinary World*, *12*(2), 243–248. https://doi.org/10.14202/vetworld.2019.243-248

Wasowicz, E., Gramza, A., Hes, M., Jelen, H. H., Korczak, J., Malecka, M., Mildner-Szkudlarz, S., Rudzinska, M., Samotyja, U., and Zawirska-Wojtasiak, R. **2004**. *Oxidation of Lipids in Food*. *13*, 87–100.

Wazir, H., Chay, S. Y., Zarei, M., Hussin, F. S., Mustapha, N. A., Wan Ibadullah, W. Z., and Saari, N. 2019. Effects of Storage Time and Temperature on Lipid Oxidation and Protein Co-Oxidation of Low-Moisture Shredded Meat Products. *Antioxidants*, *8*(10), 486. https://doi.org/10.3390/antiox8100486

Wu, H., Richards, M. P., and Undeland, I. 2022. Lipid oxidation and antioxidant delivery systems in muscle food. *Comprehensive Reviews in Food Science and Food Safety*, *21*(2), 1275–1299. https://doi.org/10.1111/1541-4337.12890

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