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Research Article

Meat Quality Assessment of Broiler Chicken as Influenced by Dietary Antioxidant

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Abstract

Background and Objective: Some food spices and herbs with antioxidant properties have been identified, of which ginger (*Zingiber officinale*), garlic (*Allium sativum*) and roselle (*Hibiscus sabdariffa*) are important. The study aimed to assess meat quality of broiler chicken as influenced by dietary antioxidants. **Materials and Methods:** One hundred and fifty, 1 day old chicks were grouped into 5 treatments of three replicates each in a completely randomized design. Diets were formulated to have control (without antioxidant, T1), control with 1% garlic (T2), control with 1% ginger (T3), control with 1% roselle (T4) and T5 with 200 mg vitamin E. At the end of eight weeks, three birds per treatments were slaughtered, meat samples harvested and stored for 56 days. Data were collected on lipid oxidation, organoleptic properties and off-flavour properties on fresh and frozen meat samples. **Results:** There were significant differences across the treatment in parameters examined. At fresh meat state, T5 with reduced ($p < 0.05$) malondialdehyde (MDA) content (1.73) statistically compared with other treatments except T4. The MDA content of frozen meat was lowest ($p < 0.05$) in T3 which compared ($p < 0.05$) with T1, T2 and T5. Meat from birds on T4 showed highest ($p < 0.05$) perception of aroma and flavor, tendered, juiciest, bright coloured and generally acceptable. The natural antioxidants reduced ($p < 0.05$) off-flavour up to 6th week. Meat from ginger dietary supplement better reduced the rate of lipid oxidation and was generally accepted by the taste panelist. All the natural antioxidant reduced off-flavour up to 6th week period of storage. **Conclusion:** It, therefore, means from this study that, spice and herb of antioxidant properties could preserve quality of frozen meat. Dietary inclusion of ginger could inhibit lipid oxidation in frozen stored meat.

Key words: Natural antioxidant, lipid oxidation, off-flavour, meat quality, frozen meat

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Lipid oxidation in broiler meat is as a result of polyunsaturated fatty acids (PUFA), generation of cytotoxic and genotoxic compounds in tissues of animal. This consequently reduces nutritional qualities, organoleptic properties and consumer's acceptability of the meat and meat products¹. The chemical reactions that cause oxidative rancidity, auto-oxidation of lipids is carried out by a free-radical chain reaction². The generation of transitory hypoperoxides is the initial stage, which then degrades into malondialdehyde (MDA) and several other reactive compounds, and because of its unstable nature, it is further decomposed and form aldehydes, acids and ketones that produce undesirable rancid flavors³.

In raw meat, lipid oxidation could be observed within days or weeks. This proceeds into cooked meat where oxidized flavours are detectable within hours of cooking⁴. Thiobarbituric acid (TBA) is the most common chemical measurement of lipid oxidation in muscle foods. It is based on the reaction of malondialdehyde and thiobarbituric acid TBA generating TBA-MA complex. The adverse changes in flavor, color, texture and nutritive value and possible production of toxic compounds are the indicators of changes in meat quality⁵. High ambient temperature and erratic power supply in Nigeria, also induce lipid oxidation thereby preventing attainment of good quality meat and even deteriorate the quality of frozen meats.

Antioxidants plays vital role in preventing or delaying the oxidation of oxidizable substrates⁶. There are two ways of inhibiting oxidative rancidity/lipid oxidation in meat-Ante-mortem intervention and Post-mortem intervention. Ante-mortem intervention involves dietary supplementation of the particular antioxidants sources, while Post-mortem intervention involves addition of the particular antioxidants as spices or condiments. Ante-mortem intervention is, therefore, important because oxidation can be controlled by the amount of antioxidants compounds that is present in the muscle tissue. It, therefore, delays or prevents oxidation by inhibiting initiation or propagation of oxidizing chain reaction⁷.

Synthetic antioxidants used to slow or minimize oxidative deterioration in foods are carcinogenic and therefore rejected. Natural antioxidants are used to replace synthetic as they limits oxidative degradation of lipids and improve nutritional values of agrifoods⁷. Various researchers have reported the dietary inclusion of α -tocopherol at 200 IU kg⁻¹ to be effective in increasing oxidative stability of broiler meat and meat products^{8,9}.

Dried ginger consist of relatively large amounts of volatile oils camphene, zingiberene, alpha-terpineol, p-cineole and pentadecanoic acid¹⁰, with its extracts almost equivalent to that of synthetic antioxidants¹¹. Whole garlic constitute primarily sulphur containing constituents viz- S-alk(en)yl-L-cysteine sulfoxides (CSs, 1.8%) and γ -glutamyl-S-alk(en)yl-L-cysteine peptides (0.9%) and other odour free sulphur compounds¹². Anthocyanins present in roselle are delphinidin 3-sambubioside, cyaniding 3-sambubioside, delphinidin 3-glucoside and cyaniding 3-glucoside. Roselle is a good source of antioxidant as well as a natural food colourants¹². They are good source of lipid soluble antioxidants particularly γ -tocopherol¹³.

There is dearth of information on the use of roselle in broiler diet and as antioxidant including its comparison with garlic and ginger. The experiment was, therefore, designed to investigate the meat attributes of broiler chickens fed diets supplemented with ginger, garlic and roselle as natural antioxidant sources. This study is set to avail meat processors, the knowledge of reducing lipid oxidation in frozen meat.

MATERIALS AND METHODS

The research was carried out at the poultry unit of Teaching and Research Farms, University of Ibadan, Ibadan. Oyo state, Nigeria. The time duration of the experiment was April-July, 2011.

Experimental animals and management: A total number of one hundred and fifty, 1 day old chicks were purchased from a commercial hatchery. After seven days of brooding, birds were randomly allocated to five treatments with three replicate each consisting of ten birds. Brooding, according to Oluyemi and Roberts¹⁴ took 6-8 weeks, however, the experimental birds were brooded for 2 weeks taking into consideration environmental temperature. Prior to the arrival of the birds, pens were disinfected, wood shavings were spread and water and feeding trough were made available. The vaccination schedules for the birds were strictly adhered to during the experiment. Birds were provided free access to feed and water.

Experimental diets: Diets offered to birds were formulated to meet bird's requirement as recommended by NRC¹⁵. Diets were divided into five:

- T1 = Control diet (without antioxidant)
- T2 = Control diet with 1% dried garlic powder

- T3 = Control diet with 1% dried ginger powder
 T4 = Control diet with 1% dried roselle powder
 T5 = Control diet with 200 mg vitamin E (synthetic antioxidant)

Test ingredient preparation: The test ingredients- ginger, garlic and roselle were purchased from Bodija market, Ibadan. Fresh garlic bulbs and ginger rhizomes were purchased, while dried roselle calyces were purchased (because of the moisture content and the perishable ability of the fresh ones). Garlic and ginger were sliced, dried at 60°C in a drying oven for 48 h and then finely ground to powder.

Sample collection: At the end of the eight weeks experiment, a total of 45 broiler chicken of average body weight were selected for assessment of meat quality attributes. Birds were starved for 12 h prior to slaughtering. Selected birds were exsanguinated at the jugular vein of the neck, allowed to bleed through, defeathered, eviscerated and cut into different primal parts¹⁶. Breast meat samples were taken from each replicate and analyzed for MDA content, organoleptic properties and off-flavour after 24 h. Meat samples were also kept in the freezer (-18°C) for subsequent meat quality evaluation.

Thiobarbituric acid reactive substance was carried out according to the procedure of Pikul *et al.*¹⁷. Fresh and frozen meat samples (1 g) from breast muscle were taken for determination of MDA contents. The meat sample was homogenized with 2 mL of distilled water in a specimen bottle with glass pestle. A 2.5 mL of 20% of trichloroacetic acid (TCA) was added and then filtered. A 2 mL of filtrate was pipette and 2 mL of TBA was added. A blank was prepared containing TBA, TCA and distilled water. The absorbance reading was read at 532 nm by using spectrophotometer. The absorbance values were then multiplied with a constant 7.8 to obtain MDA mg kg⁻¹.

A total of ten trained individuals were used as the panelist using 9-point hedonic scale, (where, 1: dislike extremely and 2-like extremely)¹⁸. These panelists were randomly allocated to the control and other treatments. The panelist were made to rate each piece of the meat sample.

Meat was served in odorless plastic containers¹⁹. The panelist rated the samples for juiciness, flavor, aroma, tenderness, color and overall acceptability and off-flavor score.

Statistical analysis: The data generated were subjected to analysis of variance (ANOVA) at a significant level of 0.5%²⁰. Significant means were separated using Duncan's multiple range test of the same statistical package.

RESULTS

Determination of lipid oxidation: At fresh meat state, the Thiobarbituric Acid Reactive Substances (TBARS) significantly ($p < 0.05$) increased in groups of birds fed (Table 1), roselle dietary treatment and the least in the vitamin E dietary treatment. However, there were no significant difference ($p > 0.05$) in the TBARS values of roselle, ginger, garlic and control. Also, the least value obtained in the vitamin E treatment is not significantly different ($p > 0.05$) from garlic, ginger and control treatments. At the 14th day storage, TBARS values significantly ($p < 0.05$) reduced in meat of ginger dietary treatment. However, it was statistically ($p < 0.05$) the same with control and vitamin E. As the meat aged, the TBARS values had no significant difference ($p > 0.05$) across the treatment means.

Organoleptic properties and off-flavour perception: Meat from birds fed roselle dietary treatment had the highest ($p < 0.05$) score for organoleptic properties. It had the highest aroma and flavor perception, most tendered, juiciest, light coloured and generally acceptable by the panelist. However, meat from birds fed ginger dietary treatment had improved aroma and generally acceptable (Table 2).

The off-flavour score of freshly meat cooked from birds fed natural antioxidant sources on a nine point hedonic scale ranged from 2.1-3.1 (Table 3). Off-flavour was more perceived ($p < 0.05$) in meat of control and ginger dietary groups, while the least was observed in the vitamin E treatment. At week 2 (14th day storage), the off-flavour was more perceived ($p < 0.05$) in control and roselle groups, while the least ($p < 0.05$) perception was observed in meat on garlic treatment.

Table 1: Thiobarbituric acid reactive substance of broiler chicken meat as influenced by antioxidants (mg kg⁻¹ sample)

Storage periods (days)	Control	1% Garlic	1% Ginger	1% Roselle	Vitamin E (200 mg)	SEM
0	1.93 ^{ab}	1.83 ^{ab}	1.78 ^{ab}	2.04 ^a	1.73 ^b	0.10
14	1.97 ^{ab}	2.04 ^a	1.42 ^b	2.08 ^a	1.61 ^{ab}	0.21
28	2.20	2.15	2.37	2.42	2.39	0.16
42	2.38	2.10	2.59	2.68	2.66	0.22
56	2.61	2.68	2.83	3.03	2.93	0.16

^{ab}Means on the same row with similar superscripts are not significantly different ($p > 0.05$), SEM: Standard error of mean

Table 2: Organoleptic characteristics of chicken breast muscle as influenced by antioxidant sources

Parameters	Control	1% Garlic	1% Ginger	1% Roselle	Vitamin E (200 mg)	SEM
Aroma	4.2 ^a	2.9 ^c	4.4 ^a	4.6 ^a	3.1 ^b	0.01
Flavor	3.9 ^b	3.1 ^c	3.9 ^b	4.4 ^a	3.3 ^c	0.01
Tenderness	6.6 ^b	6.0 ^c	6.2 ^c	6.9 ^a	6.7 ^a	0.01
Juiciness	5.1 ^b	3.6 ^c	5.2 ^b	7.0 ^a	4.4 ^c	0.01
Colour	6.2 ^b	5.8 ^b	5.3 ^c	7.2 ^a	6.0 ^b	0.01
Overall acceptability	5.9 ^c	5.3 ^d	7.0 ^a	7.0 ^a	6.8 ^b	0.01

^{abcd}Means on the same row with similar superscripts are not significantly different ($p>0.05$), SEM: Standard error of mean

Table 3: Off-flavour score of breast muscle as influenced by dietary antioxidant

Storage periods(days)	Control	1% Garlic	1% Ginger	1% Roselle	Vitamin E (200 mg)	SEM
0	3.1 ^a	2.7 ^b	2.9 ^a	2.5 ^b	2.1 ^b	0.23
14	3.9 ^a	2.6 ^b	2.7 ^b	3.9 ^a	2.8 ^b	0.14
28	1.9 ^b	2.1 ^a	1.6 ^c	1.6 ^c	1.6 ^c	0.17
42	1.8 ^a	1.7 ^b	1.6 ^b	1.6 ^b	1.4 ^c	0.26
56	1.4	1.3	1.3	1.3	1.3	0.15

^{abc}Means on the same row with similar superscripts are not significantly different ($p>0.05$), SEM: Standard error of mean

Between week 4 and 8, the meat off-flavor score decrease as the meat aged with no significant differences ($p>0.05$) at week 8.

DISCUSSION

The result shown in Table 1, TBARS values of ginger and garlic dietary treatment had the same effect as the synthetic, vitamin E, on meat quality. However, as the meat aged, the antioxidant effect reduced, having no effect on meat quality. This is in the support of the results of Boler *et al.*⁹, Lahucky *et al.*¹⁰ and Kemin²¹ that 200 IU kg⁻¹ of α -tocopherol increased oxidative stability of broiler meat and pork. Meat from ginger treatment had reduced MDA value, which makes it the better among the antioxidants even at different storage period. This result is in consonance with the study of Sampaio *et al.*²², Adeyemi and Olorunsanya²³ and Taheri *et al.*²⁴, who opined that natural antioxidant protected cooked chicken meat and refrigerated turkey breast meat from lipid oxidation. Puvaca *et al.*²⁵ found out that dietary spice herbs had a positive effect on lipid oxidation process than in the control. Singh *et al.*²⁶ also observed significant reduction in TBA value by ginger than control and garlic.

It was observed that as the storage day progresses, the MDA value increases and was not significant starting from 28 days. This was also observed in the result of Adeyemi and Olorunsanya²³. Contrary to these results, Olagoke *et al.*²⁷ observed that reduced TBARS in meat from garlic compared to ginger and roselle after 28 days of storage. Researchers have found out that volatile compounds like sulfide and di-ally disulfide in garlic decreased after boiling process and resulted in detection of more compounds^{28,29}. It was also discovered that some compounds in garlic are unstable beyond 100°C,

whereby, boiling may have caused degradation of non-volatiles like thiosulfide to volatiles²⁹. On the other hand, despite boiling, terpenes were detected in soup of fish boiled with ginger and 2-propen-1-ol and sulfides in soup of fish boiled with garlic²⁹.

The flavor and aroma of the meat as perceived by the panelist showed the values fall below the intermediate as shown in Table 2. However, roselle dietary inclusion improved meat aroma and flavor, while ginger improve aroma of meat. The antioxidants effect on meat tenderness can be compared with the control treatments because all the values were above the intermediate value, with roselle treatment having the highest meat tenderness. Both the meat tenderness and juiciness most determined the consumers preference. The organoleptic properties are the attributes associated with meat palatability and acceptability showed whether the consumers are repeat buyers or not. Mastication break down the fibre matrix and release flavor-juices and the volatile aroma components into the mouth. The findings in this study also agreed with Taheri *et al.*²⁴, who discovered that chitosan+cumin used as natural antioxidant maintained turkey breast fillet shelf life until 15 days. Sampaio *et al.*²² reported pleasant flavor and great acceptability in cooked chicken meats with the use of sage, oregano and honey as natural antioxidant.

Meat juiciness is related to the intramuscular lipids and its moisture content. In combination with water, the melted lipids constitute a "broth" which when retained in the meat is released upon chewing. Roselle dietary treatment best improved the juiciness of meat followed by ginger dietary treatment which can be compared with the control. As much as the color will influence the consumers acceptance³⁰, so it is an important indicator of fresh or cooked meat.

All the antioxidant treatments positively affected the color, but roselle treatment most improves the color as perceived by the panelists. This can be due to the anthocyanin content of roselle calyces which makes it serve as good colorant as reported by Mohamed *et al.*¹³. Among the three natural antioxidants, meat from roselle and ginger dietary treatments are the most accepted.

From Table 3, the off-flavor of freshly cooked meat of garlic and roselle supplementation can be compared with the lowest value in vitamin E treatment. The result at 14th day storage implied ginger, garlic and vitamin E could keep the meat fat from going rancid. However, as the meat aged, the influence of the antioxidant might not be significant on the rancidity of meat fat. Off-flavor score is an indicator of rancidity in meat. The development of oxidative rancidity is enhanced by some lipolytic bacteria and yeast³¹. Lipolysis, thus result into a chalky flavor.

CONCLUSION

It, therefore, means from this study that, spice and herb of antioxidant properties could preserve quality of frozen meat. Dietary inclusion of ginger could inhibit lipid oxidation in frozen stored meat. It could be observed that roselle dietary treatment of broiler chicken will improve its eating quality, but increased the off-flavour perception till 14 days before reducing it again till 42 days. Ginger and garlic dietary inclusion minimized the off-flavour along with the storage periods just like the synthetic counterpart.

SIGNIFICANCE STATEMENT

This study discovered ginger, garlic and roselle have antioxidant properties with which to delay/prevent lipid oxidation, which can be beneficial for the meat processors and frozen food sellers. This study will help the researcher to uncover the critical areas of herbs (Roselle calyces) with antioxidant properties and as meat colourant that many researchers were not able to explore. Thus, a new theory on herbs and spices combinations may be arrived at.

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