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OXIDATIVE STABILITY OF BROILER CHICKEN MEAT COOKED WITH SELECTED NIGERIAN SPICES AS AFFECTED BY DURATION OF STORAGE

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ABSTRACT

The primary factor responsible for quality deterioration in meat is oxidation, which includes all the biochemical reactions leading to changes in colour pigments and lipids. Consequently, when lipids and colour quality in meat deteriorates, undesirable flavour and rancidity develop thereby impacting on consumer's taste and satisfaction. Oxidative stability status of broiler chicken meat, cooked with selected spices used as pepper soup ingredients in the form of singly or individual, un-informed and informed usage were assessed using standard procedures in a CRD design, The selected spices (*Allium sativum, Monodora myristica, Zingiber officinale, Tetrapleura tetraptera, Xylopia aethiopica, Aframomum melegueta, Piper guineense, Ocimum gratissimum and Ocimum basilicum*) were singly used in cooking meat from broiler chickens, after which the oxidative stability was determined. Broiler chicken meat was also cooked with mixtures of selected spices as prepared by the pepper soup makers (Un-informed mixtures) and analyzed for oxidative stability. The three spices conferring the best meat quality attributes in terms of oxidative stability (*T. tetraptera, Z. officinale and M. myristica*) in phases 1 and 2 were used to formulate the mixture of spices in different proportions in phase 3 hereby referred to as Informed mixtures. These spice mixtures were used in cooking broiler chicken meat and thereafter exposed to refrigeration. The extent of oxidation was measured at day 1 and day 6. The use of the selected spices (Singly, un-informed and informed mixtures) significantly ($p < 0.05$) reduced the extent of oxidation of the refrigerated meat, which could impact on consumer's appeal and satisfaction.

Keywords: Spices, Broiler chicken, Storage, Oxidation, Malonaldehyde.

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INTRODUCTION

Poultry, especially Chickens have the potentials to bridge the gap between supply and demand of animal protein in developing countries like Nigeria (Bashar, 2010). This is not without many challenges of which oxidative stability of meat plays a significant role. Biochemical changes in meat leading to deterioration in its quality have been a consequential factor in meat general acceptability especially in Nigeria. Lateef (2005) considered quality as the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs of which oxidation plays a prominent role in determining the

quality of a product. Oxidation in meat includes all the biochemical reactions leading to changes in colour pigments and lipids. Consequentially, when color quality in meat deteriorates, undesirable flavour and rancidity develops thereby impacting on consumer's appeal and satisfaction. Gray and Pearson (1994), reported that oxidation of fatty acids in animal tissues start to occur almost instantly after slaughter. Onibi and Osho (2007) also reported that lipids oxidation in meat increases with increasing periods of refrigeration irrespective of meat condition and dietary treatments. Therefore, the need to scientifically probe into possible ways of inhibiting biochemical changes which could lead to quality deterioration in meat, using available plant materials with proven records of anti-oxidative activities would be a noble course, hence this study. The use of suitable plant materials possessing anti-oxidant properties as ingredients used in pepper soup preparation can be adopted to be useful in maintaining meat quality, extending shelf life and enhancing consumer's acceptability of meat products.

MATERIALS AND METHODS

The experiment was conducted in phases:

Phase 1: Individual use of the selected spices used in Nigerian pepper soup as anti-oxidative agents.

Phase 2: Anti-oxidative activities of un-informed mixture of spices (mixtures as prepared by pepper soup makers) used as Nigerian pepper soup on broiler chicken meat.

Phase 3: Anti- oxidative activities of informed mixture of spices (proportionate mixture) used as pepper soup on broiler chicken meat.

Phase 1: Individual use of the selected spices used in Nigerian pepper soup as anti-oxidative agents.

Preparation of Individual Spices and Meat Samples: The selected spices were *Xylopia aethiopica, Ocimum gratissimum, Ocimum basilicum, Zingiber officinale, Allium sativum, Tetrapleura tetraptera, Piper gueneense, Aframomum melegueta and Monodora myristica.* They were sourced from the local herbal market, Arakale road, Akure, Ondo State, Nigeria. Akure is located in the rain forest zone, South-West, Nigeria which lies between latitude 7º 15^1 North and Longitude 5º 12^1 East with about 1200 – 1500mm of average rainfall per annum (NIMET, 2014). The climatic condition followed the pattern of South-West Nigeria where the climate is usually influenced by the rain-bearing South-West monsoon winds from Atlantic Ocean and dry North-East winds from the Sahara desert. The rainy season usually last for about seven months (April-October). The atmospheric temperature usually ranges between 28ºC and 33ºC and the mean annual relative humidity is usually about 80% (Ajibefun, 2011). The spices were identified at the Department of Crop, Soil and Pest Management of the Federal University of Technology, Akure (FUTA), Nigera. The processing of the spices for analysis was done by properly washing the spices in clean water and thereafter rinsed in distilled water to guide against contamination. The spices were later air dried at room temperature for two weeks, after which they were pulverized using electric blender and stored in labeled air tight containers away from sunlight until required for analysis. The powdered spices were analyzed for their various phytochemical contents (tannins, saponin, flavonoids, terpenoids, alkaloids, oxalate and cardiac glycosides) at Julius Okojie

Central Research Laboratory in the University (FUTA).

Experimental procedures:

Five (5) grams of each blended spices was added to 1 kg of broiler chicken meat (thigh) from broiler chicken raised under the same environmental condition. Thereafter, 50 Cl of water was added and the meat cooked for 25 minutes as described by Fakolade *et al,* (2014). At the end of the cooking, the meat samples were removed from the broth and allowed to cool for 20 minutes. Thereafter, the extent of oxidation were determined on the meat samples on days 1 and 6 of refrigerated storage, using the thiobarbituric acid (TBA) assay method as described by Pikul *et al.* (1989). The meat sample (50g each) was blended with 170ml of 4% perchloric acid and 5ml of 0.02% butylated hydroxytoluene (BHT in 100ml ethanol). After blending for 1 minute, the mixture was filtered through a Whatman No. 1 (110 mm diameter) filter paper using a vacuum pump. The filtrate (30 ml) was stored in covered bottles and frozen. On the day of analysis, the frozen samples were allowed to thaw at room temperature for 1 hour. The filtrate (5 ml) was transferred into screwed cap tubes and 5 ml of 0.2882M TBA solution was added to each sample. The tubes were arranged in racks and incubated in boiling water for 30 minutes. They were later removed from the water and allowed to cool in cold water after which the absorbance of color formed was read against the blank using a Spectrumlab 23A spectrophotometer at 532nm. TBA value was measured as (mg) malonaldehyde (MDA) per kg muscle. TBA (mg/MDA/kg muscle) = MDA concentration.

$$\text{TBA}(mg\ MDA/kg\ muscle) = (Absorbance\ value - 0.016)/0.628$$

Phase 2: Anti-oxidative activities of un-informed mixture of spices (mixtures as prepared by pepper soup makers) used as Nigerian pepper soup on broiler chicken meat.

Preparation of Un-Informed Spices: The un-informed spices could be described as the mixtures of individual spices formulated by the local pepper soup ingredients sellers in Akure metropolis, based on their desired interest. The individual spices in the expected mixture of pepper soup ingredients were purchased from the local herbal market, Arakale road, Akure, Ondo State. The dried products of the edible portions of the different spices in each group of the spice mixture was pulverized as a mixture and kept in air tight containers for adequate preservation. The different spice mixtures identified as groups in this case were purchased from different sellers and tagged A, B, C, D and E. Thereafter, the percentage weight of individual spice in the un-informed mixture was calculated to determine the ratios of individual spices in each mixture of un-informed spices, as described in Table 1.

$$\text{Percentage inclusion level of spices} = \frac{weight\ of\ individual\ spices}{Weight\ of\ un-informed\ spices} \times 100$$

Table 1: Percentage inclusion level of individual spice in un-informed mixture of Spices in Nigerian pepper soup

		Un-informed Mixtures				
	Spices	A	B	C	D	E
1	*Tetrapleura tetraptera*	18.84	39.00	26.00	10.00	28.15
2	*Zingiber officinale*	31.88	12.00	16.00	14.00	11.65
3	*Allium sativum*	6.28	9.00	8.00	34.00	10.68
4	*Monodora myristica*	14.50	10.00	14.00	10.00	7.77
5	*Piper guineense*	8.69	6.00	9.00	9.00	10.68
6	*Xylopia aethiopica*	9.18	13.00	12.00	7.00	12.62
7	*Aframomum melequeta*	2.42	1.00	2.00	2.00	1.94
8	*Ocimum gratissimum*	3.86	5.00	6.00	8.00	6.80
9	*Ocimum basilicum*	4.35	5.00	7.00	6.00	9.71

Phase 3: Anti- oxidative activities of informed mixture of spices (proportionate mixture) used as pepper soup on broiler chicken meat.

The experimental procedures were as described above in phase 1 and 2

Preparation of informed spices: Based on the positive attributes of the spices, in relation to oxidative stability of the meat especially when used as individual and as un-informed spices. Three (3) of the pepper soup spices were selected (*T. tetraptera, Z. officinale and M. myristica*) and used in different combinations in the informed mixtures. The spices were used in ratio to formulate the informed spices as described in table 2. .

Table 2: Proportion of spices in the informed spice mixture of Nigerian pepper soup

	Spices		
Treatments	***T. tetraptera***	***Z. officinale***	***M. myristical***
I (Control)	0	0	0
II	50	25	25
III	25	50	25
IV	25	25	50
	Spice mixtures		
	II	III	IV
V	50	25	25
VI	25	50	25
VII	25	25	50

Experimental procedures.

Similar to the experimental procedures in phases 2 and 3, three chickens carcasses were assigned to a treatment and tagged treatments I, II, III, IV, V, VI and VII. Treatment VII was the control. Thighs from the three carcasses were carefully separated and cooked with the informed

spice mixtures as described. 5g from the informed mixture of spices was added to 1kg of meat, along with 500 ml of water and cooked for 25 minutes. Thereafter, the oxidative stability measurement of the chicken meat was carried out.

Statistical analysis: Data obtained were subjected to one way analysis of variance (ANOVA) using the Statistical Analysis System (2008). Where significant different were found, the means were separated using the Duncan's multiple range test of the same statistical package.

RESULTS

The results of the extent of oxidation, which was measured as the concentration of Malondialdehyde (MDA) in cooked meat with different spices during refrigerated storage was shown in table 3. The chicken meat cooked with various spices on days 1 and 6 showed significant (P< 0.05) differences. On day 1, the control (meat without spices) had the highest MDA concentration (2.78 ± 0.08 mgMDA/kg) while meat cooked with *T. tetraptera* had the least value (1.6 ± 0.24mgMDA/kg; P < 0.05). The control, had the highest value of MDA concentration on day 6 (3.82 ± 0.16 mgMDA/kg) followed by meat cooked with *A. melegueta* (3.48 ± 0.09mgMDA/kg). Generally, the control trial had highest MDA concentration compared with those cooked with the spices and MDA concentration in the cooked meat was higher in day 6 than day 1 of refrigerated storage.

Table 3: Oxidative stability (mgMDA/kg meat) of broiler meat cooked with some spices used in Nigerian pepper soup (n= 3)

Spices	Lenght of Refrigeration	
	Day 1	Day 6
Control	2.78 ± 0.08^{a}	3.82 ± 0.16^{a}
Tetrapleura tetraptera	1.65 ± 0.24^{b}	2.98 ± 0.10^{bc}
Zingiber officinale	2.11 ± 0.21^{ab}	2.56±0.06^{cd}
Allium sativum	2.18 ± 0.12^{ab}	3.07±0.05^{bc}
Monodora myristica	2.18 ± 0.34^{ab}	3.11±0.14^{bc}
Piper gueneense	2.19 ± 0.12^{ab}	3.00±0.08^{bc}
Xylopia aethiopica	2.15 ± 0.46^{ab}	2.68±0.30^{cd}
Aframomum melegueta	2.44 ± 0.39^{ab}	3.48±0.09^{ab}
Ocimum gratissimum	2.10 ± 0.45^{ab}	2.84±0.15^{b}
Ocimum basilicum	1.91 ± 0.08^{ab}	2.53±0.3^{cd}

$^{a-c}$Means ±SE with different superscripts within the same column are significant (P<0.05).
SE = Standard error.

The result of oxidative stability (mgMDA/kg) of broiler chicken meat cooked with un-informed mixture of spices is as presented in table 4. The result as expressed in days 1 and 6 showed the spices in the cooked meat samples significantly (P < 0.05) reduced the extent of oxidation across the treatments. However, the control had the highest MDA concentration (P < 0.05) on both days 1 and 6 of refrigeration storage (3.87 ± 0.08 and 4.07 ± 0.11 mgMDA/kg respectively). Meat from treatment "B" had the least MDA concentration in day 1 (2.32 ± 0.03 mgMDA/kg) and treatment "A" (2.44 ± 0.21 mgMDA/kg) in day 6. Generally, there was an increase in MDA concentration between days 1 and 6 in all the samples.

Oxidative stability of broiler meat cooked with informed mixture of spices (mgMDA/kg meat) on days 1 and 6 of refrigerated storage (4-6^{0}C) is presented in table 5. There was a significant (P< 0.05) influence of the spice mixtures on the cooked meat samples particularly on the extent of oxidation. The meat cooked without the spice mixture (control) had significantly (P<0.05) higher concentration of MDA (1.23 ± 0.08 mgMDA/kg) on day 6 than the rest of the meat samples cooked with other spices, while the remaining treatments had lower MDA concentration (0.76 ± 0.02 to 1.15 ± 0.05 mgMDA/kg). Treatment IV, which had the combinations of 25% *T. tetraptera*, 25% *Z. officinale* and 50% *M. myristica* had the least MDA concentration.

Table 4: Oxidative stability (mgMDA/kg meat) of broiler meat cooked with un-informed mmixture of Nigerian spices (n= 3)

Un-informed Spice mixture	Length of refrigeration	
	Day 1	Day 6
Control	3.87±0.08^{a}	4.07±0.11^{a}
A	2.40±0.13^{d}	2.44±0.21^{d}
B	2.32±0.03^{d}	3.40±0.13^{bc}
C	2.83±0.11^{c}	2.91±0.14^{cd}
D	3.32±0.05^{b}	3.80±0.14^{ab}
E	3.08±0.17^{bc}	2.77±0.26^{cd}

$^{a-c}$Means ±SE with different superscripts within the same column are significant (P<0.05).
SE = Standard error.

Table 5: Oxidative stability (mgMDA/kg meat) of broiler chicken meat cooked with informed mixture of Nigerian spices (n= 3)

Informed Spice mixture	Length of refrigeration	
	Day 1	Day 6
I (Control)	0.44±0.02^{bc}	1.23±0.08^{a}
II	0.41±0.04^{bc}	1.15±0.02^{ab}
III	0.46±0.07^{bc}	0.99±0.02^{abc}
IV	0.69±0.05^{a}	0.76±0.02^{c}
V	0.54±0.02^{b}	1.11±0.23^{ab}
VI	0.35±0.01^{c}	0.86±0.07^{bc}
VII	0.70±0.06^{a}	1.02±0.03^{abc}

$^{a-c}$Means ±SE with different superscripts within the same column are significant (p < 0.05).
SE = Standard error.

DISCUSSION

The extent of oxidation of the chicken meat samples in days 1 and 6, upon the usage of individual spices showed that the control (Treatment without spices) had the highest MDA concentration (2.78 ± 0.08 and 3.82 mgMDA/kg meat respectively), which confirms a report by Gray and Pearson (1994) that spices inhibit oxidative rancidity and retard the development of off-flavour in some products such as meat. This was again corroborated by Peter (2004), that aqueous extracts of spices possesses anti-oxidative properties. This showed noticeable

increase in MDA concentration from day 1 to day 6, which corroborates the findings of Onibi and Osho (2007), who reported that lipid oxidation in meat increases with increasing period of refrigeration irrespective of meat condition and dietary treatments. This was again supported by Gray and Pearson (1994) who reported that oxidation of fatty acids in animal tissues starts to occur almost instantly after slaughter. Similar to what was reported when the spices were used singly, the extent of oxidation (mgMDA/kg) of broiler meat cooked with un-informed mixture of spices as pepper soup ingredients in days 1 and 6 of refrigerated storage showed that meat sample without spice mixture (control) in both days had highest MDA concentrations (3.87 ± 0.08 and 4.07 ± 0.11 mgMDA/kg respectively) which could be as a result of the anti-oxidative influence of the spice mixtures on the cooked meat as supported by Peter (2004). According to the Author, anti-oxidants are added to foods to preserve the components from quality deterioration. Results on day 6 of refrigeration storage agrees with the reports of Pikul *et al*. (1989) and Onibi *et al*. (1998) that deterioration changes due to oxidation and continues during refrigeration storage of meat. The reduction in the extent of oxidation of meat samples in both days 1 and 6 of refrigerated storage, showed that the informed spices had positive effects on oxidative stability, as meat without spices (control) had higher MDA concentration especially on day 6 which is a measure of the degree of deterioration. The reduced MDA concentration in meat samples with spices shows the positive influence of the spice mixtures on the meat samples. *Zingiber officinale* for example, has been identified in several studies as a plant with high anti-oxidant content (Shobana and Zaidu, 2000).

The reduction in the extent of oxidation of the meat samples in both days 1 and 6 of refrigerated storage showed that the informed spices had positive effects on oxidative stability, as meat without spices (control) had higher MDA concentration especially on day 6, which shows the influence of the spice mixtures on the meat samples.

CONCLUSION

- *Tetrapleura tetraptera, Zingiber officinale, Allium sativum, Monodora myristica, Piper guineense, Xylopia aethiopica, Aframomum melegueta, Ocimum gratissimum* and *Ocimum basilicum* which are spices used in Nigerian pepper soup possess anti-oxidative properties due to the phytochemicals present in them as they elicited lower concentration of Malondialdehyde on cooked chicken meat.
- The use of the selected spices (singly, un-informed and informed mixtures) suggest reduction in the extent of oxidation of the meat, which could further enhance Consumer's acceptability of meat products.

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