Nig. J. Anim. Prod. 2020, 47(3):99 - 109
©Nigerian Society for Animal Production
Nigerian Journal of Animal Production

Quality and stability of meat obtained from broiler chickens fed diets containing tonic root (M*ondia whitei*) as supplement

*[1]Sanwo, K. A., [1]Adegoke A. V., [1]Ayo – Ajasa, O. Y., [1]Elegbede, [1]Fagbohun, A. O. and [1]Adeyanju, T. M.

[1]*Department of Animal Production and Health, Federal University of Agriculture, Abeokuta P.M.B. 2240, Abeokuta, Nigeria.*

***Corresponding author:** bumogardens@yahoo.com

Abstract

Tonic root has been speculated to improve Libido and this could have effect on performance and carcass traits of the animal. A fifty-six days experiment was conducted to determine meat quality of Abor acre Strain of broiler chickens fed graded dietary inclusion of supplemental white ginger (Mondia whitei). One hundred and eighty, one day-old broiler chicks were assigned to five treatment groups with three replicates per group. Birds on treatment one were fed concentrate with no supplements, those on treatment two had concentrate + 0.5g Mondia whitei per kg feed, treatment three had concentrate + 1g Mondia whitei per kg feed; Treatment 4 had concentrate with 1.5g Mondia whitei per kg feed and treatment five had concentrate + 2g Mondia whitei per kg feed. At the end of the eight weeks feeding trial, three birds each from each replicate of five treatment groups were randomly selected, deprived of food for 12 hours prior to slaughtering. After the traditional slaughtering method, feather plucking and evisceration were done and breast muscles were excised from the carcasses for quality parameters evaluation. The results showed significance (P< 0.05) in some measured parameters such as colour, yellowness (b) and Lightness (L*). Highest (P<0.05) triglyceride content of meat (145.33 mg/dL) was recorded in the meat of birds fed inclusion level at 0.5g/kg and the lowest value (91.67mg/dL) in the meat of birds fed inclusion level of 1g/kg. Breast muscles had the highest (P<0.05) pH score 6.72 at 1g/kg inclusion level and least value of 6.51 was in the control group. Dietary inclusion of Mondia whitei showed no significant (P>0.05) effect on cholesterol, high density lipoprotein (HDL) and low-density lipoprotein (LDL). Although superoxide dismutase (SOD) and water absorptive power were not significantly (P>0.05) influenced, cooking and refrigeration loss as well as thiobarbituric acid reactive substance (TBARS) in meat were significantly (P<0.05) lowest in birds fed 1g/kg dietary inclusion level of Mondia whitei. Some phytochemicals and overall sensory acceptability were statistically influenced by the dietary treatments.*

Keywords: *Mondia whitei*, carcass traits, water absorptive power, thiobarbituric acid reactive substance (TBARS)

Introduction

Chicken meat has been recognized to have high susceptibility to lipid oxidation due to the high content of polyunsaturated fatty acids which brings about the disintegration of flavour, colour, aroma, quality, and nutritive value. Hence, the broiler industry is constantly searching for ways to improve its product and quality in order to meet the demands of the consuming public. In this regard, several researchers are still on going on how best to increase poultry meat yields and improving carcass quality (Volpato *et al*., 2007) and Daffallaa et al., 2016), without decreasing sensory quality or consumer's acceptability. One of such is the addition of natural feed supplements, mainly herbs in animal feed (Gardzielewska *et al.*, 2003). Several herbs and spices have been specified as good antioxidants such as rosemary (*Rosmarinus officinalis)* (RO), garden thyme (*Thymus vulgaris)*, oregano (*Origanum vulgare)*, olive leaves (*Olea europea) L*., sage (*Salvia officinalis*) and

similar herbs (Rahal et al., 2014). Others includes ginger, garlic, turmeric, perper etc. The positive effects of herbs and spices as supplements on broiler performance, carcass quality and quality traits of meat have been demonstrated (Schleicher et al., 1998). Capsaicinoids are Capsaicin that have also been proven to possess the potential to decrease lipid peroxidation (Kentaro et al., 2002; Oboh et al., 2006; Conforti et al., 2007). Emadi and Kermanshahi (2006) supplemented 0.75% of turmeric rhizome powder in broiler rations and reported improved carcass quality, lean meat and significant decrease in abdominal fat up to 57% level and heart weights to live body weight., Turmeric powder supplementation in broiler feed caused higher dressing percentage up to 57% level, increased the liver weight, spleen weight and whole giblets weight (Kurkure et al., 2002; Al-Sultan, 2003). Oleforuh-Okoleh et al. (2014) reported that feeding ginger and garlic improved final body weight gain, carcass weight and dressing percentage and reduced abdominal fat of the broiler birds. Karangiya et al. (2016), also reported that supplementation of garlic improved the performance of broilers when added at the rate of 1% of broiler ration and can be a viable alternative to antibiotic growth promoter in the feeding of broiler chicken. Furthermore, Garlic extracts have been shown to exhibit: antiatherosclerotic, antimicrobial, hypolipidemic, antithrombotic, antihypertensive, antidiabetic effects and reduces anti oxidative stress. (Ide and Lau 2001; Mansoub, 2011)

Mondia whitei otherwise called tonic root, is an aromatic plant of the Periplocacea family (Watcho et al., 2005), and commonly known as Isirigun among the Yoruba ethnic group of Nigeria. The in vitro antioxidant and antimicrobial activities of the extracts of the root of Mondia whitei have been earlier reported (Gbadamosi and Erinoso, 2015). It contains vitamins A, D, E and K as well as magnesium, zinc, iron, calcium and protein. (Youkeu, 2008). In addition, an in vivo study to determine the effect of M. whitei extracts on the endurance of rats subjected to intense physical activity was performed. The author discovered that rats fed meal supplemented with 0.61% M. whitei were better adapted to the physical effort with a performance of approximately 6% with respect to the control group. However, there is paucity of information on the effect of Mondia whitei on physiochemical parameters and stability of broiler chicken. This study therefore, is intended to determine the effect of supplementing Mondia whitei in broiler feed and to see the effect on physiochemical characteristics on the broiler chicken.

Materials and methods

The experiment was carried out at the Poultry unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Alabata, Abeokuta, Ogun state, Nigeria.

A total of one hundred and eighty (180), one day-old broiler chicks were used for the experiment. The poultry house and equipment were cleaned with disinfectant, wood shavings were used on the floor and on arrival, clean water and anti-stress was administered and medications giving at the appropriate time.

Processing of Mondia whitei

The roots of the plant material (Mondia whitei) were obtained from a local market in Abeokuta, Ogun state, Nigeria. The roots were cut into pieces sun-dried until constant weight was obtained. The dried roots were subsequently milled.

Experimental management and layout

The birds were brooded collectively for two weeks. At the end of the second week, birds were weighed individually and randomly allotted to five dietary treatment groups.

The treatments contained different inclusion levels of milled Mondia whitei added to the control diet in the following proportion; 0g (control diet), 0.5g, 1g, 1.5g and 2g per kg feed. Table 1 shows the composition of the experimental diets.

Table 1: Composition of the experimental diet at starter and finisher phase of broiler chicken

Ingredients	starter phase	finisher phase
Maize	52.00	58.40
Wheat bran	4.30	10.60
Soyabean meal	18.50	10.00
Groundnut cake	17.00	14.00
Fishmeal	2.20	1.00
Bone meal	3.00	3.00
Limestone	2.00	2.00
Salt	0.25	0.25
Mineral and Vitamin	0.25	0.25
Methionine	0.25	0.25
Lysine	0.25	0.25
Total	100.00	100.00

Data collection

At the end of the eight weeks of experiment, two birds from each replicate in the five treatment groups were randomly selected, deprived of food but not water for 12hours. They were slaughtered; each carcass was plucked and eviscerated and needed muscles were excised for meat quality and sensory analysis.

Muscle pH

The raw muscle pH was measured using a digital pH meter. GLP 21 (Crison Instruments, S.A., Barcelona, Spain)

Colour measurements

Raw and cooked meat color were measured for thigh muscle using a Minolta colorimeter (model CR300, Konica Minolta, Ramsey, NJ) that was standardized with a white calibration plate (illuminate C readings of Y= 92.8; x = 0.3134; y= 0.3197). Color was Measured using the C.I.E. L*a*b* color scale, the colour values were expressed as L* (lightness), a* (redness/greenness) and b* (yellowness/blueness) according to Hunt (1991).

Nutrient composition

The Moisture, Crude Protein, crude ash and crude fat contents of thigh muscle were analysed according to AOAC (1990). The contents of calcium and iron were measured using flame atomic spectrophotometry. Calcium was determined at λ = 442.7 nm and iron was determined at λ = 248.3nm using the method described by AOAC (1990).

Cooking loss

The weight of each sample was taken before and after cooking to determine cooking loss, which is defined as the cooked weight divided by uncooked weight multiply by 100. The following formula was used:

Cooking loss (g) =

Weight of raw meat – Weight of cooked meat

Cooking loss (%) =

$$\frac{\text{Weight of raw meat} - \text{Weight of cooked meat}}{\text{Weight of raw meat}} \times 100$$

Refrigeration loss

Meat samples weighing 50g was obtained from the breast muscles before refrigeration and re-weighed after 48 hours to determine the refrigeration loss.

Refrigeration Loss (g) = Weight of sample before refrigeration - weight after refrigeration

Water absorptive power

3g of meat samples from breast muscles was collected and placed in clean labelled

test tubes, 10mL of distilled water was added to each test tube, each sample was totally submerged in distilled water and left for an hour. After which samples were removed and reweighed. The increase in weight of the sample indicates the volume of water absorbed.

Cholesterol level, triglyceride, high- and low-density lipoprotein

Composite paste of the thigh muscle was prepared with a known amount of chloroform and methanol mixture 1: 1 (v/v) for each replicate. The resulting paste solvent mixture was filtered and rinsed with an additional volume of the combined homogenate and allowed to stand for five minutes. The filtered homogenate was equilibrated to remove non lipid material, 2% (0.32M) w/v KCl. Solution was added to the aqueous layer after it was gravimetrically measured (Folch *et al*., 1957). The filtrate was centrifuged and lipid extract was decanted. The extract made up to a final volume by adding chloroform, which was decanted, and the mixture obtained was used for the determination of meat cholesterol, triglycerol and high and low density lipoprotein values respectively.

MDA determination using 2-Thiobarbituric Acid Reactive substance

Each meat sample (5 g) from the thigh muscles of each replicate was homogenized in 15 ml of distilled water. Sample homogenate (5 ml) was transferred to a test tube and lipid oxidation was determined as the 2-thiobarbituric acid-reactive substance (TBARS) value by method described by Ahn and Maurer (1990). Lipid oxidation was reported as milligrams of malondialdehyde per kilogram of meat (Jang *et al*., 2007).

Superoxide dismutase (SOD)

The activity of SOD was measured by the xanthine oxidase method (ELISA Kit: Cayman Chemical Company, USA, Catalog No. 706002), which monitors the inhibition of nitro blue tetrazolium reduction by the breast meat sample as described by Sun *et al*. (1988). The protein concentrations in breast muscle were quantitated by the bicinchonibate (BCA) method, using a protein assay kit (Bio-Rad, Hercules, CA, USA).

Sensory evaluation

Samples from the breast muscle were collected and washed in clean water, packed in a transparent polythene bag and labelled for identification. They were boiled at 70^0c in water for 15minutes (Sanwo et al., 2011) and were allowed to cool under room temperature and served to panelist. Eight experienced panelists were used for the sensory evaluation. Bite size portions of boiled meat samples from the breast meat weighing about 10g was served at room temperature to the trained panelists. Each panelist was required to masticate one sample per treatment and ranked preferences in the following categories: color, juiciness, meaty, flavor, tenderness, saltiness, overall flavor and overall acceptability and then awarded scores using a 9-point Hedonic scale (1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Intermediate, 6 = Like slightly, 7 = Like moderately, 8 = Like very much, 9 = Like extremely as described by (Sanwo *et al*., 2013).

Statistical design and model

Data obtained were subjected to one-way analysis of variance and analyzed using the general linear model procedure of SPSS (2011) version 20. Treatment means with significant difference at $p<0.05$ were compared using Duncan Multiple Range Test (DMRT) of the statistical package.

Results and discussion

The effect of *Mondia whitei* on the moisture determination and colour evaluation of broiler chicken is shown in Table 2. Moisture showed no significance ($P>0.05$).

The b* yellowness of raw meat sample and L* of cooked meat samples were the only parameters that showed significance (P<0.05). The L * was recorded in bird fed 2g/kg of *Mondia whitei* and the highest value of 62.20 was recorded for birds fed 1.5g/kg of *Mondia whitei.* b* (yellowness) of raw sample, least value was obtained from bird fed 0.5g/kg *Mondia whitei*) while the highest value of 5.44 for L* (Lightness) was recorded in birds fed the control diet for cooked meat sample. The present research corroborates the findings of Gardzielewska *et al.* (2003) that supplementation of broiler chicken feed with echinacea (*Echinacea purpurea*), garlic (*Allium sativum*) and ginger (*Zingiber officinale*) had no significant effect on meat moisture content. Colour is known to be influenced by breed, age or diet. The differences in the yellowness of the muscle across treatment could be as the result of pigment contained in yellow maize which is one of the ingredients in the test diets. This finding corroborates the report of Bett (1993). Bert-Marco (2012) also reported that the root of *Mondia whitei* contains 1.2 % of a yellow liquid with a strong coumarin-odor. The results obtained for colour indices of fresh meat sample did not corroborate the research of Park *et al*. (2013) who observed significant differences in *L and a* after inclusion of Cinnamon powder in the diet of a broiler chicken. There is high correlation between muscle pH, meat colour, and particularly for lightness. It is also well known that dark coloured muscle is associated with high muscle pH (Livingston and Brown, 1981). The L* (Lightness) value for cooked muscle was higher in the *Mondia whitei* groups compared to the control group High pH of muscles has darker colour than those of a low-pH (Allen *et al*., 1997; Fletcher *et al*., 2000). As pH increased the L* value decreased, i.e. while darkness of meat increased the lightness declined. Qi ao *et al*. (2001) separated meat colour into three groups according to meat lightness (L*) as follows: lighter than normal (light, L* > 53), normal (48 < L* < 53), and darker than normal (dark, L* < 46). The result obtained in this study is also in accordance with Barbut (1993) who reported that lightness (L*) had the highest correlation of the L*, a*, b* colour values and dietary addition of garlic, black pepper and hot red pepper had an influence on broiler chicken meat colour.

Table 2: Physiochemical characteristics of raw and cooked broiler chickens fed diet containing *Mondia whitei*

	Inclusion of *Mondia whitei* (g/kg Diet)					
Parameters	**0**	**0.5**	**1**	**1.5**	**2**	**SEM**
Raw Muscle pH	6.51^{b}	6.68^{a}	6.72^{a}	6.66^{a}	6.72^{a}	0.26
Raw Meat Moisture (%)	66.77	68.83	67.37	66.82	70.43	0.64
Cooked Meat Moisture (%)	53.95	53.65	55.95	49.48	54.35	2.74
Uncooked muscle						
L* (Lightness)	61.10	60.35	62.12	62.20	60.00	0.45
a * (Redness)	12.24	11.58	11.29	12.28	11.83	0.42
b* (Yellowness)	5.44^{a}	2.59^{b}	3.54^{ab}	4.54^{ab}	4.16^{ab}	0.35
Cooked muscle(meat)						
L* (Lightness)	47.82^{b}	62.60^{a}	55.94^{ab}	56.04^{ab}	56.12^{ab}	2.52
a* (Redness)	0.80	-0.12	-0.05	0.43	0.57	0.20
b*(Yellowness)	5.48	6.22	5.91	7.31	6.71	0.52

$^{a, b,}$ Means within rows with different superscripts differ significantly (p <0.05)
SEM: Standard error of Mean

The nutrient composition of muscles is an important quality measurement of broiler meat (Grashorn, 2012). Dietary supplementation of *Mondia whitei* shows no significant (P>0.05) effect on the nutrient composition of breast meat of the broiler chickens except in Iron. Dietary supplementation of *Mondia whitei* numerically increased the crude protein content and decreased fat content in breast meat. Although there are no investigations concerning the potential application of *Mondia whitei* in animal production, laboratory analysis proved that *Mondia whitei* and its extract can have a significant effect on lipid metabolism in animals. Tests carried out on rats have revealed a positive impact on the use of this type of supplementation (Kuo *et al*., 2006). Tissue mineral concentration data are usually used to evaluate mineral status of animals and humans (Feng *et al*., 2009). This result is in line with several other studies who reported increase in breast muscle for calcium and iron concentration with increase in dietary iron. Ma et *al*. (2012). Cao *et al.* (1996) also reported an average iron concentration between 8.54 – 11.34 mg/kg.

Table 3: Nutrient composition of breast meat from broiler chickens fed diets containing *Mondia whitei*

	Inclusion of *Mondia whitei* (g/kg Diet)							
Parameters	Control	0.5	1	1.5	2	SEM	P-value	Mondia Whitei
Ash (%)	10.09	10.55	10.95	12.09	9.71	0.356	0.352	4.35
Crude Fat (%)	7.14	6.46	6.02	6.64	6.38	0.498	0.190	2.12
Crude Fibre (%)	0.02	0.00	0.01	0.02	0.00	0.295	0.121	18.50
Crude Protein (%)	21.59	21.91	21.74	21.59	22.29	0.173	0.701	7.51
Moisture (%)	75.60	76.34	75.84	75.43	77.47	0.289	0.147	67.52
Calcium (mg/dl)	3.10	3.40	4.03	3.57	4.37	0.233	0.487	
Iron (mg/dl)	1.67^{b}	1.69^{b}	1.70^{b}	1.80^{ab}	2.07^{a}	0.069	0.010	

^{a,b}Means within rows with different superscripts differ significantly (p <0.05)
SEM: Standard error of mean.

Dietary supplementation of *Mondia whitei* shows no significant (P > 0.05) effect on the lipid profile parameters of breast muscle considered, except triglyceride which shows significant (P < 0.05) increase as shown in Table 4. The increase in triglyceride is strongly considered a good and healthy sign as most often high triglyceride are associated with an increase in LDL cholesterol and a decrease in HDL cholesterol. *Mondia whitei* has beneficial effects on the cholesterol and triglyceride levels related to the improvement of the liver function, which can result in reduction of cholesterol biosynthesis and stimulation of transformation of cholesterol into bile acids, and also potential therapeutic and dietary applications in humans, for example, in the treatment of diabetes and obesity (Gill, 1992; Burkill, 1997).

Table 4: Lipoprotein profile of broiler chickens fed diets containing *Mondia whitei*

Inclusion levels of *Mondia whitei* (g/kg Diet)							
Parameter	Control	0.5	1	1.5	2	SEM	P-value
T. Cholesterol(mg/dl)	72.00	69.00	81.00	84.67	80.33	3.729	0.707
T.glyc.(mg/dl)	79.67^{b}	145.33^{a}	91.67^{b}	92.00^{b}	111.00^{ab}	6.872	0.002
HDL (mg/dl)	40.83	48.80	47.37	54.77	43.10	3.398	0.163
LDL (mg/dl)	15.23	11.10	12.50	11.73	13.20	0.789	0.299

$^{a, b,}$ Means with different superscript along the same rows are significantly different P<0.05)
T. Chol. - Total Cholesterol, Tglyc. – Triglyceride, HDL - High Density Lipoprotein
LDL - Low Density Lipoprotein, SEM – Standard Error of Mean

Dietary supplementation of *Mondia whitei* shows significant ($P < 0.05$) effect on all meat quality parameters measured, except Superoxide Dismutase (SOD) and water absorptive power which were not significantly ($P > 0.05$) influenced as shown in Table 5. There was a significant ($P < 0.05$) increase in muscle pH of the broiler chickens as compared to the control group. The least ($P<0.05$) values of cooking loss, refrigeration loss, and TBARS were all obtained in birds fed diets supplemented with *mondia whitei* at 1g/kg level. Differences in pH values of breast meats investigated may be attributed to the pre-slaughter stress, which changes muscle glycogen content and eventually had an effect on the rate and extent of pH decline (Berri *et al*., 2007) in which the ultimate pH is considered to be the main factor that affects all quality attributes, including color as equally reported by Dadgar *et al*. (2011), who observed changes in pH values affected some meat quality attributes. The thiobarbituric acid assay is a practical method for the determination of food lipid peroxidation. Where high oxidative deterioration in broiler meat is due to high concentration of polyunsaturated fatty acids (Luna *et al.*, 2010). However, the reverse is the case in this study since decrease in TBARS of broiler breast muscle at inclusion of 1g/kg *Mondia whitei* was observed. Delles *et al.* (2011) corroborated this studies by reporting that samples from birds fed anti-oxidant supplemented diet, showed lower TBARS formation compared with basal dietary regimes. Other studies focusing on natural antioxidants have also shown that feeding broilers high levels of α-tocopherol (De Winnie and Dirinck, 1996) and Se (Ryu *et al*., 2005) delayed the onset of oxidative off flavour formation in chicken meat during storage.

Table 5: Meat quality and stability parameters of breast meat from broiler chickens fed diets containing *Mondia whitei*

	Inclusion levels of *Mondia whitei* (g/kg Diet)						
Parameter	**Control**	**0.5**	**1**	**1.5**	**2**	**SEM**	**P-value**
Muscle pH	6.51^{b}	6.68^{a}	6.72^{a}	6.66^{a}	6.71^{a}	0.026	0.037
Cook Loss (%)	20.67^{ab}	20.00^{ab}	18.00^{b}	32.67^{a}	33.33^{a}	2.108	0.031
WAP (%)	0.90	0.63	1.07	0.73	1.10	0.125	0.770
Ref.Loss(%)	9.10^{b}	10.97^{ab}	8.57^{b}	13.43^{a}	13.93^{a}	0.730	0.026
TBARS(mg/kg)	5.70^{a}	3.50^{ab}	3.43^{b}	4.70^{a}	4.87^{a}	0.230	0.016
SOD(IU ML-1)	6.06	7.44	6.02	6.80	5.96	0.121	0.514

[a, b,] Means with different superscript along the same rows are significantly different ($P < 0.05$)
WAP – Water Absorptive Power, TBARS – Thiobarbituric acid reactive substance

Cooking loss is known to be one of the main factors affecting meat quality, because some nutrients may be lost in the exudates by water loss, and affect juiciness and tenderness. In this study, the observed decrease in cooking loss in meat obtained from broiler birds fed up to 1g/kg inclusion level agrees with the findings of Symeon *et al*. (2009) that dietary supplementation of curry plant extracts decreased cooking loss of broiler meat at 0.5% inclusion level. Kolodzej-Skalaska *et al*. (2011) reports also corroborated observation from this study. Most of the parameters measured were not significant ($P>0.05$) except for the overall acceptability as shown in Table 6. The result indicates lesser acceptability of the meat. This may be due to high cooking loss of meat samples (Table 5) in which most of the meat nutrients were not retained during cooking, hence reducing overall acceptability. This result disagreed with the study of Waskar *et al*. (2011) that supplementation with herbal products in poultry diets was effective in improving overall meat quality attributes such as tender yield, sensory characteristics, overall palatability and consumer acceptability of meat.

Table 6. Sensory Evaluation of Broiler Chickens fed diet containing *Mondia whitei*

	Inclusion of *Mondia whitei* (g/kg Diet)					
Parameter	**0**	**0.5**	**1**	**1.5**	**2**	**SEM**
Colour	5.46	5.58	6.12	6.00	5.54	0.11
Juiciness	5.50	5.46	5.63	6.00	5.38	0.12
Meaty Flavour	6.38	6.50	6.17	6.42	6.58	0.11
Tenderness	6.34	5.88	5.92	6.17	5.42	0.11
Saltiness	5.17	5.59	5.75	5.58	5.38	0.10
Overall Flavour	6.13	6.17	5.92	6.17	5.42	0.11
Overall Acceptability	6.25^{a}	6.21^{ab}	6.09^{ab}	6.21^{ab}	5.75^{b}	0.07

[a, b] Means within rows with different superscripts differ significantly (p <0.05)
SEM: Standard error of mean.

Conclusion

In conclusion *Mondia whitei* had effect on some physiochemical parameters such as meat colour (Lightness and Yellowness) and overall acceptability for sensory evaluation of broiler chicken.

References

Ahn, D. U. and Maurer, A. J. 1990. Poultry meat color: Kinds of haem pigments and concentrations of the ligands. *Journal of Poultry Science*. **69**:157–165.

Allen, C. D., Russell, S. M. and Fletcher, D. L. 1997. The Relationship of broiler breast meat colour and pH to shelf-line and odor development. *Poultry Science Journal,* 76:1042-1046.

Al-Sultan, S. I. 2003. The effect of *Curcuma longa* (Tumeric) on overall performance of broiler chickens. *International Journal of Poultry Science*, 2: 351-353

AOAC. 1990. Method 960.39. Fat or ether extract in meat. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, DC

Barbut, S. 1993. Colour measurements for evaluating the pale soft exudative (PSE) occurrence in turkey meat. *Food Research Journal,* 26: 39-43.

Berri, C., LeBihan-Duval, E., Debut, M., Sante-Lhoutellier, V., Baeza, E., Gigaud, V., Jego, Y. and Duclos, M. J. 2007. Consequence of muscle hypertrophy on characteristics of pectoralis major muscle and breast meat quality of broiler chickens. *Journal of Animal Science*. 85:2005–2011.

Bert-Marco, S. 2012. *Mondia whitei*-Mondi. http://psychotropicon.info/mondia-whitei-mondi-whites-ginger.

Bett, K. L. 1993. Measuring sensory properties of meat in the laboratory. *Food Technology Journal*, 47: 121-126,134.

Burkill, H. M. 1997. The useful plants of West Tropical Africa. 2nd edition volume 4, Families M–R. Royal Botanic Gardens, Kew, Richmond, United Kingdom. P. 969.

Conforti, F., Statti, G. A. and Menichini, F. 2007. Chemical and biological variability of hot pepper fruits (*Capsicum annuum var. acuminatum L.*) in relation to maturity stage. *Food Chemistry* 102:1096-1104.

Dadgar, S., Lee, E. S., Leer, T. L. V., Crowe, T. G., Classen, H. L. and Shand, P. J. 2011. Effect of acute cold exposure, age, sex, and lairage on broiler breast meat quality. *Poultry Science Journal*. 90:444–457.

Daffallaa, B. M. M. and Mukhtar, A. M.

2016. Effect of mixture of three herbal essential oils on performance, carcass yield and blood serum constituents of broiler chicks. *World Journal of pharmacy and pharmaceutical sciences* Volume 5, Issue 2, 63-72.

De Winne, A., Dirinck, P. 1996. Studies on vitamin E and meat quality; Effect of feeding high vitamin E levels on chicken meat quality. *Journal of Agricultural and Food Chemistry,* 44:1691–1696.

Delles, R. M., Xiong, Y. L., True, A. D. 2011. Mild protein oxidation enhanced hydration and myofibril swelling capacity of fresh ground pork muscle packaged in high-oxygen atmospheres. *Journal of Food Science.* 76: C760 – C767.

Duncan, D. B. 1955. Multiple ranges and multiple F- test. Biometrics, 11:1-42.

Emadi, M. and Kermanshahi, H. 2006. Effect of turmeric rhizome powder on performance and carcass characteristics of broiler chickens. *International Journal of Poultry Science*, 5: 1069-1072.

Feng, J., Ma, W. Q., Xu, Z. R., He, J. X., Wang, Y. Z. and Liu, J. X. 2009. The effect of iron glycine chelates on tissue mineral levels, fecal mineral concentration, and liver antioxidant enzyme activity in weanling pigs. *Animal Feed Science and Technology,* 150, 106-113.

Fletcher, D. L., Qiao M. and Smith D. P. 2000. The relationship of raw broiler breast meat colour and pH to cooked meat colour and pH. *Poultry Science Journal*, 79:784-788.

Folch, J., Lees, M. and Sloane-Stanley, G. H. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biology Chemistry* 233: 311- 320.

Gardzielewska, J., Pudyszak, K., Majewska, T., Jakubowska, M. and Pomianowski, J. 2003. Effect of plant-supplemented feeding on fresh and frozen storage quality of broiler chicken meat. *Animal Husbandry volume 6.*

Gbadamosi, I. T. and Erinoso, S. M. 2015. *In vitro* antioxidant and antimicrobial activities of *Mondia whitei* (Hook.f.) Skeels. *Journal of Basic Applied Science* 11:428-433.

Gill, L. S. 1992. Ethnomedical uses of plants in Nigeria. Uniben Press, Benin City, Nigeria.

Grashorn, M. A. 2012. Fattening performance, carcass and meat quality of slow and fast growing broiler strains under intensive and extensive feeding conditions. Page 249 in XII *European Poultry Conference*, Verona, Italy. (Ed. I. Romboli, D. Flock, and A. Franchini). *World's Poultry Science Association*, Italian Branch, Bologna, Italy.

Ide, N. and Lau, B. H. 2001. Garlic compounds minimize intracellular oxidative stress and inhibit nuclear factor-κB activation. *The Journal of nutrition* 131: 1020-1026.

Jiang, Z., Y. Lin, G. Zhou, L. Luo, S. Jiang, and F. Chen. 2009. Effects of dietary selenomethionine supplementation on growth performance, meat quality and antioxidant property in yellow broilers. *Journal of Agricultural and Food Chemistry*, 57:9769–9772.

Karangiya V. K., Savsani, H. H., Patil, S. S., Garg, D. D., Murthy, K. S., Ribadiya, N. K. and Vekariya, S. J. 2016. Effect of dietary

supplementation of garlic, ginger and their combination in feed intake, growth performance and economics in commercial broilers.. *Veterinary World* vol; 9(3):245-50.

Kentaro, K., Satoru, G., Miki, N., Mina, Y., Kazutoyo, A., Chie, O., Hironori, S., Takenori, K. and Hiroshi, T. 2002. Mechanism of potent antiperoxidative effect of capsaicin.. *Biochimica et Biophysica Acta* 1573: 84-92.

Kołodziej-Skalska, A., Rybarczyk, A., Matysiak, B., Jacyno, E., Pietruszka, A. and Kawęcka, M. 2011. Effect of dietary plant extracts mixture on pork meat quality. Acta Agriculture Scand. Section A, *Journal of Animal Science.* 6:80–85.

Kuo, X. K., Chang, L. Z., Chen, Y. W. and Liao, J. W. 2006. Safety evaluation of feeding a newly introduced medicinal plant Vuka (*Mondia whitei*) to mice. Bull. Taichung Dist. *Agriculture Improvement Standard* 91:21-29.

Kurkure, N. V., Kalorey, D. R. and Ali, M. H. 2002. Herbal nutraceuticals: An alternative to antibiotic growth promoters. Poultry Fortune, August 2002, pp: 31-32.

Livingston, D. J. and Brown, W. D. 1981. The chemistry of myoglobin and its reactions. *Food Technology Journal*, 35:244-252.

Ma, W. Q., Sun, H., Zhou, Y., Wu, J. and Feng, J. 2012. Effects of Iron Glycine Chelate on Growth, Tissue Mineral Concentrations, Fecal Mineral Excretion, and Liver Antioxidant Enzyme Activities in Broilers. *Biological Trace Element Research,* 149, 41 204-211.

Mansoub, N. H. 2011. Comparative effects of using garlic as probiotic on performance and serum composition of broiler chickens.2011. *Annals of Biological Research* 2: 486-490.

Oboh, G., Puntel, R. L. and Rocha, J. B. T. 2006. Hot pepper (Capsicum annuum, Tepin and Capsicum Chinese, Habanero) prevents Fe2+-induced lipid peroxidation in brain in vitro. *Food Chemistry* 102: 178-185.

Oleforuh-Okoleh, V. U., Chukwu, G. C. and. Adeolu, A. I. 2014. Effect of ground ginger and garlic on the growth performance, carcass quality and economics of production of broiler chickens. *Global Journal of Bio – science and Bio technology.* vol.3 (3): 225-229.

Park, S. O., Ryu, C. M., Park, B. S. and Hwangbo, J. 2013. The meat quality and performance of broiler chicken fed diet with Cinnanom powder. *Journal of Environmental Biology*, Volume 34, 127-133.

Qiao, M., Fletcher, D. L., Smith, D. P., and Northcutt, J. K. 2001. The effect of broiler breast meat color on pH, moisture, waterholding capacity, and emulsification capacity. *Poultry Science Journal*, 80:676–680.

Rahal, A., Kumar, A., Singh, V., Yadav B., Tiwari, R.,:Chakraborty, S. and Dhama, K. 2014. Oxidative stress, prooxidants and antioxidants The interplay. *Biomedication Resistance International,* 2014:761264.

Sanwo, K. A., Iposu, S. O., Oladoyin, F. O. and Adegbite, J. A. 2011. Quality characteristics of sausages prepared from local and exotic cockerels. Nig. *Poultry Science Journal*, 8:26-30.

Schleicher, A., Fritz, Z. and Kinal, S.

1998. Zastosowanie wybranych ziół w mieszankach tre_ciwych dla kurcz_t rze_nych [The use of some herbs in concentrates for broiler chickens]. Rocz. Nauk. Zootech. 25(3): 213-244 (in Polish).

Smith, A. J. 1990. The tropical Agriculturalist Poultry, The Macmillan Press Ltd. London United Kingdom. Pp.106

Sumalatha, K., Kumar, S. A. and Lakshmi, S. M. 2010. Review on Natural Aphrodisiac potentials to treat Sexual dysfunction. *International Journal of Pharmacy & Therapeutics*. 1, 2010, 10-18.

Symeon, G. K., Zintilas, C., Ayoutanti, A., Bizelis, J. A. S. and Deligeorgis, G. 2009. Effect of dietary oregano essential oil supplementation for an extensive fattening period on growth performance and breast meat quality of female medium-growing broilers. *Cambridge Journal of Animal Science,* 89:331–334.

Tshabalala, P. A., Strydom, P. E., Webb, E. C. and de Kock, H. L. 2003. Meat quality of designated South African indigenous goat and sheep breeds. *Meat Science Journal,* 65(1): 563-570.

Venter, H. J. T., Verhoeven, R. L. and Bruyns, P. V. 2009. Morphology and taxonomy of *Mondia* (*Apocynaceae: Periplocoideae*), *South African Journal of Botany* 75, 2009, 456–465.

Volpato, G., Michielin, E. M. Z., Ferreira, S. R. S. and Petrus, J. C. C. 2007. Kinetics of the diffusion of sodium chloride in chicken breast (pectoralis major) during curing. *Journal of Food Engineering* 79: 779-785.

Waskar, V. S., Ravikanth, K. and Maini, S. 2011. Effect of polyherbal feed supplement and antimycotic product on meat quality attributes of chicken. *Journal of Indian Veterinary Association* 9:39-45.

Watcho, P., Donfack, M. M., Zelefack, F., Nguelefack, B. T., Wansi, S., Ngoula, F., Kamtchouing, P., Tsamo, E. and Kamanyi, A. 2005. Effects of the hexane extract of *mondiawhitei*on the reproductive organs of male rat. *Afr. J. Trad.CAM;* 2 (3): 302– 311.

Youkeu, N. J. 2008. Natural substances and sport performance. In: Mbopi-Kéou, F.-X. (Ed.), Health and Sports in Africa: A Challenge for Development. John Libbey Eurotext, Montrouge, France, pp. 73–83.

Received: 10th November, 2019
Accepted: 22nd February, 2020