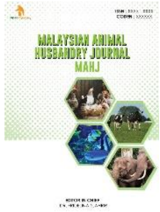
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2805-5500 (Online)
CODEN: MAHJAQ

Malaysian Animal Husbandry Journal (MAHJ)

DOI: http://doi.org/10.26480/mahj.01.2024.36.42



CrossMark

RESEARCH ARTICLE

MEAT CHOLESTEROL CONTENT AND OXIDATIVE STABILITY OF BROILER CHICKENS FED DIETS SUPPLEMENTED WITH MEXICAN-TEA AND FIREWEED LEAVE MEAL

Andrew B. Falowo

Department of Animal Science, Faculty of Agriculture, Adekunle Ajasin University, Akungba-Akoko, Nigeria.
****Corresponding author email: andrew.falowo@aaua.edu.ng; anddele2013@gmail.com***

ARTICLE DETAILS

Article History:

Received 15 April 2024
Revised 23 May 2024
Accepted 28 June 2024
Available online 01 July 2024

ABSTRACT

This study assessed the antioxidant constituent of Mexican-tea (MT) and Fireweed (FW) leave meal (LM) and its dietary effect on meat cholesterol content, and lipid and protein oxidation of broiler chickens during cold storage (0, 7 and 21days) at -21^{0}C. A total of 120 day-old Cobb 500 broiler chicks were assigned to four treatments and designated as Diet 1 (no supplementation), Diet 2 (0.02% Vit C), Diet 3 (0.25% FWLM) and Diet 4 (0.25% MTLM). The results revealed that FWLM contained higher antioxidant contents ($p < 0.05$) than MTLM. The extract of FWLM exhibited higher free radical scavenging activity than MTLM extract ($p < 0.05$). Supplementation of FWLM and MTLM significantly ($p < 0.05$) lowered the cholesterol content of chicken breast muscle compared to control group. No significant effect ($p <0.05$) of FWLM and MTLM on meat lipid oxidation was observed throughout the storage period (0, 7 and 21d). At day 21 birds fed diet supplemented with FWLM (Diet 2) had the lowest meat protein oxidation ($p < 0.05$) compared to other treatments. This study showed that FWLM and MTLM could be used as feed supplements to improve quality of broiler meat.

KEYWORDS

Antioxidant, breast meat, cholesterol, lipid and protein oxidation, leaf meal,

1. INTRODUCTION

The poultry meat industry has advanced tremendously over the last 30 years with an annual growth rate of over 5% when compared to the beef, mutton and pork industries, which grew at 1.6, 1.7 and 3.1%, respectively (Alexandratos and Bruinsma, 2012; Fathima et al., 2022). With this it has been forecast that by 2029, poultry will be the fastest-growing meat producer in world with production increase of 16% (OECD/FAO, 2020; Cabrol et al., 2022). This substantial increase may be attributed to its fast production cycle, high prolificacy, high feed conversion ratio and simplicity of production which can be easily replicated in almost every inhabited region of the world (Cabrol et al., 2022). In addition, poultry meats are mostly preferred by consumers because they are easily affordable, healthy and ease to prepare without any religious or ethical constraints to its consumption when compared to other meat types (Cabrol et al., 2022). More so, the discovery and application of antibiotic growth promoters as feed additives in conjunction with strict biosecurity and hygiene measures has helped in the expansion of poultry meat production across the globe. Traditionally, antibiotic growth promoters are used to improve health/welfare and enhance growth performance of poultry by increasing feed conversion ratio, growth rate and disease prevention (Mehdi et al., 2018; Abdelli et al., 2021). However, evidence has shown that the continuous usage of these compounds in poultry nutrition in recent times can lead to antibiotic resistance to pathogenic bacteria and the deposition of antimicrobial residues in meat products, which are detrimental to consumer health (Mehdi et al., 2018; Lipiński et al., 2019). This has resulted in the ban or removal of antibiotic growth promoters as feed additives and as well caused a tremendous growth in research focusing on use of natural substances such as phytogenic feed additives (Abdelli et al., 2021).

Phytogenic feed additives are plant-derived products, such as herbs, spices and their extracts that possess growth-promoting potential, huge nutraceuticals and antioxidant capacity, and high immune-modulatory properties (Van der Aar et al., 2017; Abdelli et al., 2021). The potential of these phytogenic feed additives has been attributed to the concentration of inherent bioactive and phytochemical substances (flavonoids, tannins, carotenoids, phenol, saponin, terpenes etc), protein content (amino acids), minerals and vitamins (E, C, and A) (Abdelli et al., 2021; Falowo et al., 2022). Many studies have reported the dietary application of different phytogenic feed additives such as *Syzygium aromaticum* leaf meal, *Myristica fragrans* seed meal, moringa leaf meal, garlic rhizome meal, *Ocimum gratissimum* leaf meal, *Irvingia gabonensis* seed meal could reduce the rate of fat deposition, lower cholesterol content and limit the extent of lipid oxidation production in muscle of broiler chicken (Adu et al., 2020; Gbore et al., 2021; Oloruntola et al., 2022; Adeyeye et al., 2021; Falowo, 2022).

High production of lipid oxidation can cause meat quality deterioration that could negatively affect nutritional content and lower market value during processing and storage (Falowo et al., 2014). Other study has also shown that lipid oxidation can increase the formation of toxic compounds which are detrimental to human health (Addis and Park, 1989; Falowo, 2014). Excessive intake of meat products high in cholesterol and fat content has also been implicated in causing in major chronic diseases and other related health challenges (Al-Shaar et al., 2020). The ability of phytogenic feed additives to act as cholesterol-reducing agents and antioxidants in meat products have been reported with remarkable results in literature (Falowo et al., 2014; Falowo, 2022). Among such phytogenic feed additives which has not been exploited in broiler nutrition are Mexican-tea and firewood leave meal.

Quick Response Code	Access this article online	
	Website: www.mahj.org.my	**DOI:** 10.26480/mahj.01.2024.36.42

Cite The Article: Andrew B. Falowo (2024). Meat Cholesterol Content and Oxidative Stability of Broiler Chickens Fed Diets Supplemented with Mexican-Tea and Fireweed Leave Meal. *Malaysian Animal Husbandry Journal, 4(1): 36-42.*

Mexican-tea (*Chenopodium ambrosioides L.*) plant is an aromatic herbaceous medicinal/vegetable plant that belong to the family of *Chenopodiaceae* and the genus *Chenopodium*. The plant is widely distributed in Nigeria and other West Africa countries (Kasali et al., 2021). The plant is used in traditional medicine to treat different infections such as uterine fibroids (Kumar et al., 2007; Diroff, 2008). The inclusion of Mexican-tea leave meal in fish diet has been reported to induce higher immune cells and endogenous antioxidants such as superoxide dismutase and catalase activities when compared to control group (Reyes-Becerril et al., 2019). Fireweed (*Crassocephalum crepidioides*) plant is a succulent edible vegetable and herb that belongs to the family Asteraceae (Compositae).

The plant is widely distributed in Africa, Asia and Australia (Can and Thao, 2020). Nutritionally, the plants is known to contain rich protein, crude fibre, minerals and other phytochemical compounds with ability to elicit antibacterial and antioxidant activities (Nupo et al., 2013; Can and Thao, 2020; Falowo et al., 2023). The dietary supplementation of leaf meal of these plants has been reported to boost red blood cell and reduce oxidative stress in mouse and chicken during production (Can and Thao, 2020). Hence, the aim of this study was to examine the antioxidant constituent of Mexican-tea and fireweed leave meal and its effect on meat quality of broiler chicken.

2. Materials And Methods

1.1 Plant collection and extract preparation

Fresh leaf of Mexican-tea and fireweed leave meal were purchased from the town markets in South-West, Nigeria. The leaves were cleaned and allowed to air-dry in an open shade. The dried leaves were pulverized using electric blending machine and the powdered samples were packed into a polyethene bag for further analysis. Five cleaned and dried reagent bottles were filled with ten grams of each sample, 100 milliliters of ethanol-water solvent (7:3), and each bottle was left for 72 hours while being periodically shaken on a shaking orbit machine. A 0.45 m Nylon membrane filter was then used to filter the mixture. The extracts were evaporated to dryness under reduced pressure at 40^{0}C by a rotary evaporator. The collected hydro-ethanol extracts were used for the determination of antioxidant content and activity.

1.2 Experimental site

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Federal College of Agriculture, Akure, Nigeria. The experimental site is located at 7°25' N and 5°19' E with average annual temperature and annual rainfall of 25.3°C and 1455 mm, respectively. The entire study was carried out for six weeks following the research ethics and guidelines of the Animal Science Department of the institution.

1.3 Determination of total phenol content

The total phenol content of each extract was determined by the method outlined (Singleton et al., 1999). Briefly, 2.5ml of 10% Folinciocalteau's reagent and 2ml of 7.5% Sodium carbonate were combined with 0.2ml of each extract. After, the reaction mixture was incubated at 45^{0}C for 40mins, and the spectrophotometer was used to measure the absorbance at 700 nm. The amount of phenol was given as mg of garlic acid equivalent and compared with that of the tannin acid as reference standards.

1.4 Determination of total flavonoid content

Using a colorimeter technique developed by Bao (2005), the total flavonoid concentration of each extract was measured. Briefly, 0.3ml of 5% $NaNO_3$ was added at zero time along with 0.2ml of each extract. 0.6ml of 10% $AlCl_3$ was added after 5 minutes, and after 6 minutes, 2ml of 1M NaOH and 2.1ml of distilled water were added to the mixture. Flavonoid concentration was quantified as mg rutin equivalent and absorbance was measured at 510 nm against the reagent blank. The flavonoid content of the extract was compared with that of the quercetin as reference standards.

1.5 Determination of DPPH free radical scavenging ability

Using the method, the free radical scavenging ability of the extracts against DPPH (1, 1- diphenyl-2-picryhydrazyl) was assessed (Gyamfi et al., 1999). In order to measure the absorbance at 516 nm, 1 ml of the extract was combined with 1 ml of the 0.4 mM methanolic solution of the DPPH. The mixture was then left in the dark for 30 minutes. The DPPH scavenging ability of the extracts was compared with that of trolex as reference standards.

1.6 Determination ABTS radical scavenging activities

ABTS free radical scavenging activity of plant extracts was determined as described by (Re et al., 1999). The ABTS was generated by reacting ABST solution (7nmol/l) with $K_2S_2O_8$ (2.45mmol/l, final concentration) in the dark for 16h and adjusting the absorbance at 734nm to 0.700 with ethanol. The extracts were diluted in ratio 1:10 for the assay. An aliquot of 0.2ml from each extract was added to 2.0 ml ABTS solution and absorbance was measured after 15mins at 734nm using the UV-Visible spectrophotometer. The ABTS radical scavenging ability of the extracts was compared with that of trolex as reference standards.

1.7 Experimental diets and animals

Two basal diets [starter (0-21 days) and finisher phase (22-42days)] were formulated to meet the broiler's nutritional requirement (Table 1). At each phase, the experimental diets were divided into four treatments and designated as Diet 1 (Control/no supplementation), Diet 2 (0.02% Vitamin C), Diet 3 (0.25%MTLM) and Diet 4 (0.25% FWLM). One hundred and twenty 1-day-old Cobb 500 broiler chicks were randomly distributed to four dietary treatments. Each treatment was replicated three times. Thirty birds were assigned to each treatment (10 birds/replicate) in a completely randomized design (CRD). The birds were raised in their respective pen (200 x 100 cm) with the floor covered with wood shavings. The temperature of the pen was maintained within 31^{o}C ± 2 for the first seven days, then it was lowered by 2^{o}C every subsequent week until it reached 26 ± 2 ^{o}C. Over the course of the six-week feeding trial, light was provided 23 hours each day, and food and water were given *ad libtum.*

1.8 Determination of meat lipid and protein oxidation

At 42 weeks of age, three birds per treatment were randomly selected and humanely slaughtered. Before slaughter, feed was withdrawn for the birds overnight. After slaughtering, birds were allowed to bleed for 5 min, scalded and eviscerated. About 100g of fresh meat samples from breast muscle were excised for determination of level of cholesterol content, lipid and protein oxidation. The lipid oxidation of the breast meat samples was assessed (at 0, 7 and 21 d during cold storage at -21^{0}C) by analysis of Thiobarbituric acid reaction (TBARS) based on the method described by (Xia et al., 2012; Rashid and Khidhir, 2021). TBARS values was measured and expressed as mg of malondialdehyde (MDA) per kg broiler breast muscle and then calculated as follows:

TBARS (mg/kg) = A532/Ws × 9.48

where A532 represent the absorbance of the solution measured at 532 nm, Ws is the sample weight (g), and "9.48" is a constant originating from the dilution factor and the molar extinction coefficient (1.52 × 105 M^{-1} cm^{-1}) of the Thiobarbituric acid (TBA) reaction product.

The protein oxidation of the breast meat samples was determined at 0, 7 and 21d during cold storage of -21^{0}C) by measuring protein carbonyl content according to the method described by (Berardo et al., 2016). The protein carbonyl content of the meat sample was detected with 2, 4-dinitrophenylhydrazine (DNPH) and calculated according to the absorbance of the solution at 280 and 370 nm as follows:

Carbonyl content (nmol/mgprotein) = $(A_{370})/\ (\varepsilon\text{hydrazone } 370 \times (A_{280} - A_{370} \times 0.43) \times 10^6$

Where εhydrazone370 = 22,000 $M^{-1}cm^{-1}$

1.9 Statistical analysis

Data obtained on antioxidant contents of the plant extracts and meat quality of broiler chicken were analyzed using PROC GLM procedures of SAS (version 9.1.3 of 2007). Differences in mean values were computed using Duncan's Multiple Range Test for multiple comparisons. For all statistical tests, significance was determined at $p < 0.05$.

Table 1: The Experimental Basal Diets' Composition

Ingredients	Starter diet	Finisher diet
Maize	52.33	59.32
Maize bran	7.02	0.00
Rice bran	0.00	6.03
Fish meal	3.00	3
Soybean meal	30	24
Premix	0.30	0.30
Bone meal	3.00	3.00
Soy oil	3.00	3.00
Methionine	0.30	0.30
Limestone	0.50	0.50
Salt	0.30	0.30
Lysine	0.25	0.25
Analyzed composition (%)		
Crude fibre	3.55	3.63
Crude fat	4.47	3.94
Crude protein	22.19	20.09
Calculated composition (%)		
Calcium	1.02	0.97
Available phosphorus	0.44	0.41
Methionine	0.68	0.65
Lysine	1.36	1.24
Metabolizable energy (Kcal/kg)	3018.93	3108.16

2. Results And Discussion

2.1 Antioxidant status of the plant leaf meals

Nutritionally, utilization of medicinal plants are considered as important source of antioxidant to boost animal endogenous antioxidants, inhibit oxidation and hypercholesterolemia and lower cholesterol level in meat and meat products during production (Falowo et al., 2014; Adu et al., 2020; Falowo, 2022). The results of the antioxidant content of hydroethenolic extract of Fireweed leave meal (FWLM) and Mexican-tea leave meal (MTLM) showed that both plants are very rich in phenol and flavonoid content (Figure 1, 2, 3 and 4). The leaf meal of FW revealed higher ($p < 0.05$) amount of phenol content (125.3 mg GAE/g DW) than leaf meal of MT (109.3GAE/g DW), although lower than standard tannic acid value (134.9 mg GAE/g DW). Similarly, the flavonoid content of FWLM (5.114.73 mg Ru/g DW) was significantly higher ($p < 0.05$) than that of MTLM (4.73 mg Ru/g DW) but lower compared to the standard quercertin (7.96 mg Ru/g DW). The phenol content of plant leaf has been reported to possess redox properties that help to absorb and neutralize free radicals (such as superoxide anions, lipid peroxy radicals and hydroxyl radicals), quench singlet and triplet oxygen, or activate antioxidant enzymes, and inhibit oxidases to protect biological systems against peroxidations (Okwu and Josiah, 2006; Moyo et al., 2012; Udedi et al., 2020).

Also, flavonoids have been implicated in helping the body to regulate cellular activity, fight off free radicals, and prevent diseases that are related to oxidative stress (Kumar and Pandey, 2013; Jovana et al., 2018). The phenol and flavonoid content of MTLM recorded in this study was slightly higher than those reported by Tchani et al. (2021) and Ouadja et al. (2021) but lower than those reported Awang-Kanak et al. (2019) and Wijaya et al. (2011). These differences could be as a result of the method and solvent of extraction, georgraphical location and method of analysis (Sevindik et al., 2017; Anees Ali Jafr et al., 2023). However, in comparison to the standard tannic acid and Quertecin, the observed low phenol and flavonoid content of extract of FWLM and MTLM could be as a result of low concentration of extract used in the analysis.

The result of antioxidant activity showed that the leaf meal of FW (71.63%) possessed higher ($p < 0.05$) 2-Diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging ability than the leaf meal of MT (60.46%) although lower than the standard trolex at 97.38%. The value of the ABTS radical were significantly similar in leaf meal of FWLM (0.02 mMol/g) and MTLM (0.02 mMol/g) but lower than the standard trolex (0.03 mMol/g). This is implying that MTLM had higher antioxidant potential to scavenge free radicals and other reactive species compared to MTLM. This could be attributed to the higher phenolic and flavonoid content earlier recorded in FWLM compared to MTLM (Figure 1 and 2). Study has revealed that plants that possessed high phenol and flavonoid content has hydroxyl groups that are responsible for scavenging free radicals (Anees Ali Jafr et al., 2023). The decrease in DPPH and ABTS fee radical scavenging activity of FWLM and MTLM recorded in this study compared to the standard trolex may be a result of low concentration of phenol and flavonoid inherent in the plants due to the concentration used. Studies shown that the level of free radical inhibition and destruction of free radical in system is dependent on the amount or concentration of plant extract used (Afolayan et al., 2008; Bahar et al., 2016).

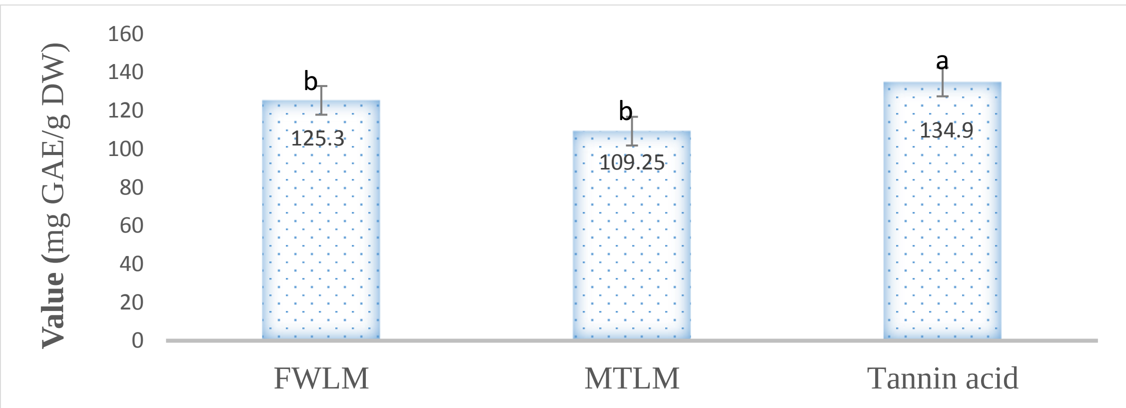


Figure 1: Phenolic content of the plant leaf extracts

FWLM = Extract of Fireweed leave meal. MTLM= Extract of Mexican-tea leave meal

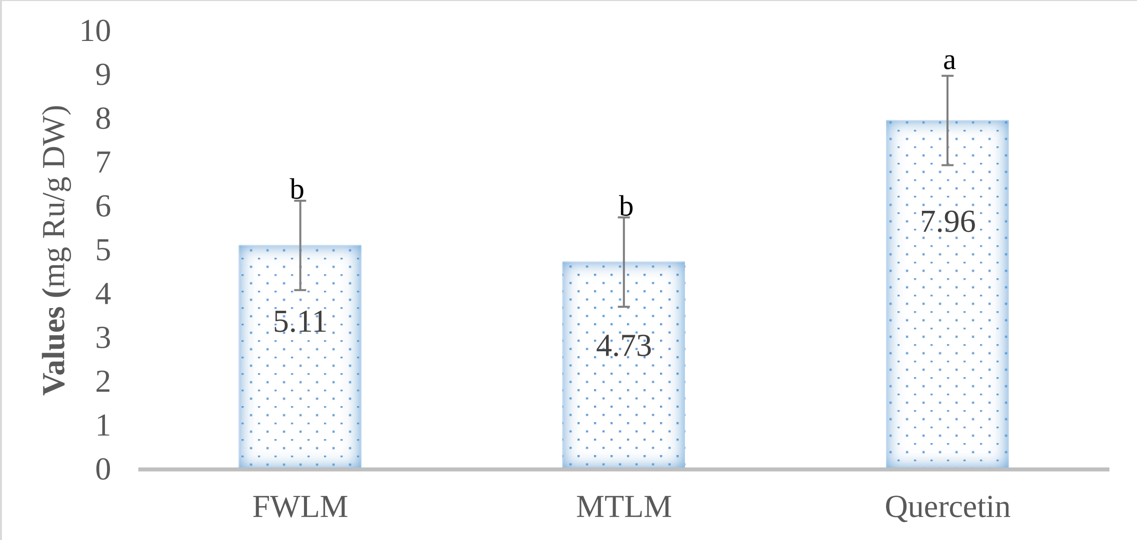


Figure 2: Flavonoid content of the plant leaf extracts

FWLM = Extract of Fireweed leave meal. MTLM= Extract of Mexican-tea leave meal

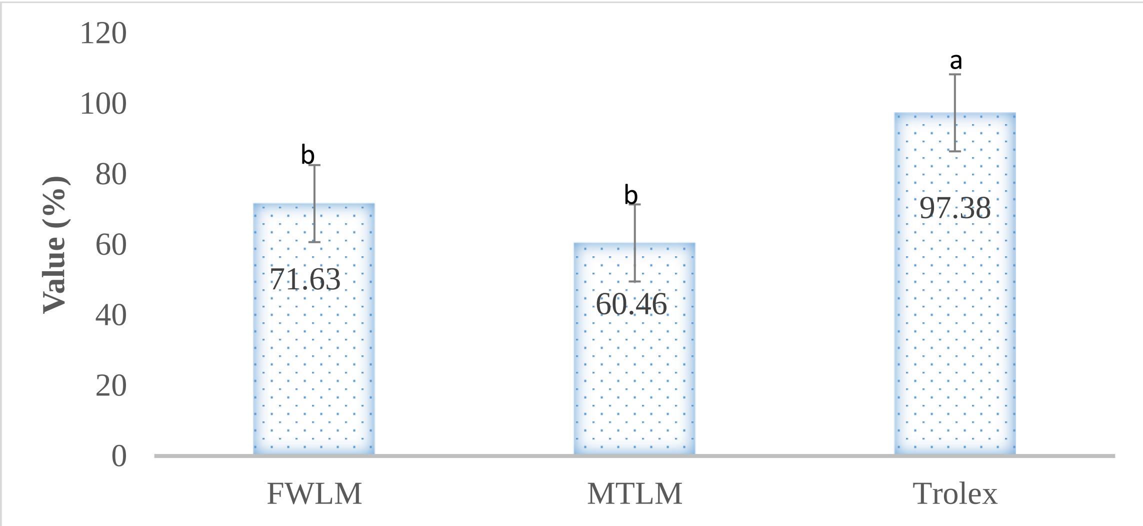


Figure 3: Antioxidant activity (2, 2-Diphenyl-2-picrylhydrazyl, DPPH) of the plant leaf extract

FWLM = Extract of Fireweed leave meal. MTLM= Extract of Mexican-tea leave meal

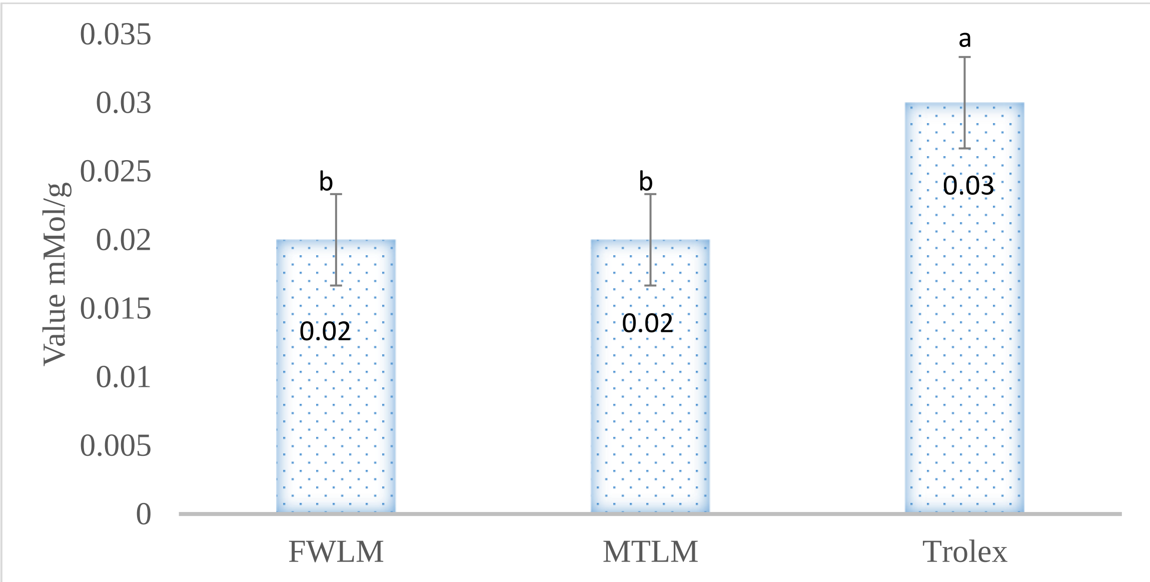


Figure 4: Antioxidant activity (ABST) of the plant leaf extracts

FWLM = Extract of Fireweed leave meal. MTLM= Extract of Mexican-tea leave meal

2.2 Meat quality

The measure of meat quality could be related to its antioxidant capacity to inhibit deterioration caused by oxidations. The result of the breast meat lipid and protein oxidation of broiler chickens fed diets supplemented with MT leaf meal during 0, 7- and 21-days cold storage at -21⁰C is presented in Table 2. The result showed that dietary supplementation of FWLM and MTLM could protects breast meat against lipid oxidation during the cold storage period. At day 0, 7 and 21 of storage, the overall TBARS values of the FWLM and MTLM meat samples were numerically lowered compared with the control and Vit C treatments. The decrease in TBARS formation in breast meat could be attributed to the capacity of inherent antioxidant content (phenol and flavonoid, Figure 1 and 2) and activity of FWLM and MTLM as mentioned above. This result is consistent with some previous studies who reported a decline in lipid oxidation of breast muscle of broiler chicken fed diet supplemented leaf meal during cold storage (Nkukwana et al., 2014; Cui et al., 2018).

The result of protein oxidation showed that that dietary supplementation of FWLM and MTLM did not affect the carbonyl value of the breast meat at day 0 and 7d cold storage. However, at day 21, a significant decrease in the carbonyl value was observed in breast meat of broiler chicken fed diet containing FWLM compared to MTLM and control treatments. This is suggesting that FWLM possessed anti-oxidation capacity to inhibit the protein oxidation compared to MTLM. This result is in contrast with findings of da Silva et al. (2018) who found that dietary inclusion of olive leaf meal significantly influence the protein oxidation of breast muscle of broiler chicken during storage. The observed higher carbonyl value in breast meat of broiler fed diet 4 could mean that dietary inclusion of MTLM at 0.25% was not effective enough to inhibit the production of protein oxidation during storage.

The amount of total cholesterol in the breast muscle was significantly lowered by supplementation of FWLM, MTLM and Vit C compared to control (Figure 5). This is suggesting that both FWLM and MTLM contained anti-cholesterolemic agent. The anti-cholesterolemic activity of plant leaf meal has been associated to their phytochemicals and high fiber content (Falowo, 2022). This result is in agreement with other studies that have showed that inclusion of herbal plants in broiler diets can significantly inhibit hypercholesterolemia and lower cholesterol level in muscle food due to the inherent bioactive compounds (Abbas, 2013; Adu et al., 2020; Falowo, 2022).

Table 2: Lipid oxidation of broiler chickens fed diets supplemented with Fireweed (FW) and Mexican-tea (MT) leave meal during cold storage

Parameters	Day	Diet 1 Control	Diet 2 0.02% Vit C	Diet 3 0.25% FWLM	Diet 3 0.25% MTLM	SEM	*P value*
	0	1.25	0.86	0.83	0.77	0.17	0.18
Lipid oxidation (mgMDA/g)	7	2.61	1.43	1.09	1.26	0.36	0.07
	21	2.71	1.55	1.16	1.50	0.49	0.21
	0	100.05	104.05	99.89	100.43	1.03	0.06
Protein Oxidation (nmol/mg protein)	7	108.26	107.27	106.85	104.74	1.08	0.21
	21	114.85^{b}	114.56^{b}	111.95^{b}	119.48^{a}	1.05	0.01

Means within a row with different letters and significantly different ($p < 0.05$). SEM Standard error. FWLM = breast meat of broiler chicken fed diet supplemented with Fireweed leave meal. MTLM= breast meat of broiler chicken fed diet supplemented with Mexican-tea leave meal

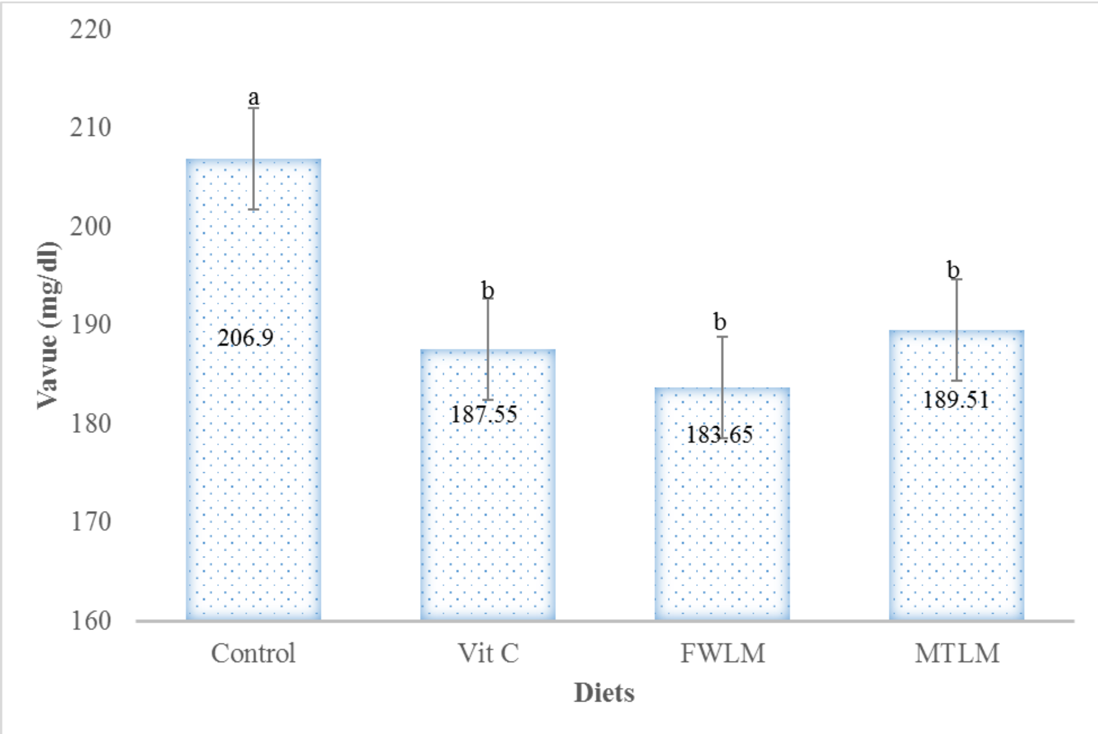


Figure 5: Cholesterol content of breast meat of broiler chicken fed diet supplemented with Fireweed (FW) and Mexican-tea leave meal

3. Conclusion

Findings from this study have revealed that fireweed (FW) and Mexican-tea (MT) leave meal contained moderate amount of phenol and flavonoid content and could be used to inhibit or quench free radical in biological system. The dietary application of the FWLM and MTLM have showed that they could be used as effective feed supplement in poultry nutrition to inhibit oxidation production and reduce cholesterol content in breast muscle during storage. Further research should be conducted on utilization of FWLM and MTLM on colour and organoleptic properties of meat from boiler chicken

References

Abbas, T.E., 2013. The use of Moringa oleifera in poultry diets. Turkish Journal of Veterinary and Animal Sciences, 37 (5), Pp. 492-496.

Abdelli, N., Solà-Oriol, D., and Pérez, J.F., 2021. Phytogenic Feed Additives in Poultry: Achievements, Prospective and Challenges. Animals, 11, Pp. 3471. https://doi.org/ 10.3390/ani11123471ski

Addis, P.B., and Park, S.W., 1989. Role of lipid oxidation products in artherosclerosis. In S. L. Taylor, & R. A. Scanlan (Eds.), Food toxicology.

A perspective on the relative risks (pp. 297–330). New York: Marcel Dekker.

Adeyeye, S.A., Oloruntola, O.D., Ayodele, S.O., Falowo, A.B., and Agbede, J.O., 2020. Wild sunflower and goat weed leaf meals composite-mix supplementation in broiler chickens: effects on performance, health status and meat. Acta fytotechn zootechn, 23 (4), Pp. 205–212. DOI: 10.15414/afz.2020.23.04.205-212

Adu, O.A., Gbore, F.A., Oloruntola, O.D., Falowo, A.B., and Olarotimi, O.J., 2020. The effects of Myristica fragrans seed meal and Syzygium aromaticum leaf meal dietary supplementation on growth performance and oxidative status of broiler chicken. Bulletin of the National Research Centre, 44 (1), Pp. 1-10.

Afolayan, A.J., Aboyade, O.M., and Sofidiya, M.O., 2008. Total Phenolic Content and Free Radical Scavenging Activity of Malva parviflora L. (Malvaceae). Journal of Biological Sciences, 8, Pp. 945-949.

Alexandratos, N., and Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No. 12-03. Rome, FAO.

Al-Shaar, L., Satija, A., Wang, D.D., Rimm, E.B., Smith-Warner, S.A., Stampfer, M.J., Hu, F.B., and Willett, W.C., 2020. Red meat intake and risk of coronary heart disease among US men: prospective cohort study. BMJ, Pp. 371.

Awang-Kanak, F., Bakar, M.F.A., and Mohamed, M., 2019. Ethnobotanical note, total phenolic content, total flavonoid content, and antioxidative activities of wild edible vegetable, Crassocephalum crepidioides from Kota Belud, Sabah. IOP Conference Series Earth and Environmental Science, 269 (1), Pp. 012012.

Bahar, E., Siddika, M.S., Nath, B., and Yoon, H., 2016. Evaluation of in vitro antioxidant and in vivo antihyperlipidemic activities of methanol extract of aerial part of Crassocephalum crepidioides (Asteraceae) Benth S Moore. Tropical Journal of Pharmaceutical Research, 15 (3), Pp. 481-488.

Berardo, A., De Maere, H., Stavropoulou, D.A., Rysman, T., Leroy, F., and De Smet, S., 2016. effect of sodium ascorbate and sodium nitrite on protein and lipid oxidation in dry fermented sausages. Meat Science, 121, Pp. 359-364. doi: 10.1016/j. meatsci.2016.07.003.

Cabrol, M.B., Martins, J.C., Malhão, L.P., Alves, S.P., Bessa, R.J., Almeida, A.M., Raymundo, A., and Lordelo, M., 2022. Partial replacement of soybean meal with Chlorella vulgaris in broiler diets influences performance and improves breast meat quality and fatty acid composition. Poultry Science, 101 (8), Pp. 101955.

Can, N.M., and Thao, D.T.P., 2020. Wound Healing Activity of Crassocephalum crepidioides (Benth.) S. Moore. Leaf Hydroethanolic Extract. Oxidative medicine and cellular longevity, Pp. 1-10.

Cui, Y.M., Wang, J., Lu, W., Zhang, H.J., Wu, S.G., and Qi, G.H., 2018. Effect of dietary supplementation with Moringa oleifera leaf on performance, meat quality, and oxidative stability of meat in broilers. Poultry Science, 97 (8), Pp. 2836-2844.

Da Silva, S.L., Marangoni, C., Brum, D.S., Vendruscolo, R.G., Silva, M.S., de Moura, H.C., Rampelotto, C., Wagner, R., de Menezes, C.R., Barin, J.S., and Campagnol, P.C.B., 2018. Effect of dietary olive leaves on the lipid and protein oxidation and bacterial safety of chicken hamburgers during frozen storage. International Food Research Journal, 25 (1), Pp 383-391.

Diroff, T., 2008. Epazote and Holistic Health in Mexico, Senior Thesis Projects, University of Tennessee. Available at: http://trace.tennessee.edu/utk_interstp5/9

Falowo, A.B., 2021. A comprehensive review of nutritional benefits of minerals in meat and meat products. Science Letter, 9 (2), Pp. 55-64. doi:10.47262/SL/9.2.132021010.

Falowo, A.B., 2022. Potential of medicinal plants as Hypocholesterolemic agents in chicken meat production. Science Letter, 10 (1), Pp. 24-31. doi:10.47262/SL/10.1/.132021028

Falowo, A.B., Fayemi, P.O., and Muchenje, V., 2014. Natural antioxidants against lipid–protein oxidative deterioration in meat and meat products: A review. Food Research International, 64, Pp. 171–181. doi:10.1016/j.foodres.2014.06.022

FAO, R., 2020. Prospects for food, nutrition, agriculture and major commodity groups. World Agric. Towards 2030–2050 2006, 2030, 2050.

Fathima, S., Shanmugasundaram, R., Adams, D., and Selvaraj, R.K., 2022. Gastrointestinal Microbiota and Their Manipulation for Improved Growth and Performance in Chickens. Foods, 11, Pp. 1401. https://doi.org/10.3390/ foods11101401

Gbore, F.A., Oloruntola, O.D., Adu, O.A., Olarotimi, O.J., Falowo, A.B., and Afolayan, E.O., 2021. Serum and meat antioxidative status of broiler chickens fed diets supplemented with garlic rhizome meal, moringa leaf meal and their composite. Tropical Animal Health and Production, 53, Pp. 1-10.

Gyamfi, M.A., Yonamine, M., and Aaniya, Y., 1999. Free radical scavenging action of medicinal herbs from Ghana: thonningia sanguine on experimentally induced liver injuries. General Pharmacology, 32, Pp. 661 – 667.

Jafri, S.A.A., Khalid, Z.M., Khan, M.R., Ashraf, S., Ahmad, N., Karami, A.M., Rafique, E., Ouladsmane, M., Al Suliman, N.M.S., and Aslam, S., 2023. Evaluation of some essential traditional medicinal plants for their potential free scavenging and antioxidant properties. Journal of King Saud University-Science, Pp. 102562.

Kasali, F.M., Tusiimire, J., Kadima, J.N., and Agaba, A.G., 2021. Ethnomedical uses, chemical constituents, and evidence-based pharmacological properties of Chenopodium ambrosioides L.: extensive overview. Future Journal of Pharmaceutical Sciences, 7, Pp. 1-36.

Kumar, R., Mishra, A.K., Dubey, N.K., and Tripathi, Y.B., 2007. Evaluation of Chenopodium ambrosioides oil as a potential source of antifungal, antiaflatoxigenic and antioxidant activity. International Journal of Food Microbiology, 115, Pp. 159–164. doi: 10.1016/j.ijfoodmicro.2006.10.017

Kumar, S., and Pandey, A.K., 2013. Chemistry and Biological Activities of Flavonoids: An Overview. Science World Journal, 2013 |Article ID 162750 | doi:10.1155/2013/162750

Lipinski, K., Antoszkiewicz, Z., Kotlarczyk, S., Mazur-Kuśnirek, M., Kaliniewicz, J., and Makowski, Z., 2019. The effect of herbal feed additive on the growth performance, carcass characteristics and meat quality of broiler chickens fed low-energy diets. Archives Animal Breeding, 62 (1), Pp. 33-40.

Mehdi, Y., Létourneau-Montminy, M.P., Gaucher, M.L., Chorfi, Y., Suresh, G., Rouissi, T., Brar, S.K., Côté, C., Ramirez, A.A., and Godbout, S., 2018. Use of antibiotics in broiler production: Global impacts and alternatives. Animal nutrition, 4 (2), Pp. 170-178.

Moyo, B., Oyedemi, S., Masika, P.J., and Muchenje, V., 2012. Polyphenolic content and antioxidant properties of Moringa oleifera leaf extracts and enzymatic activity of liver from goats supplemented with Moringa oleifera leaves/sunflower seed cake. Meat Science, 91, Pp. 441–447. doi:10.1016/j. meatsci.2012.02.029

Nkukwana, T.T., Muchenje, V., Masika, P. J., Hoffman, L. C., Dzama, K., and Descalzo, A. M., 2014. Fatty acid composition and oxidative stability of breast meat from broiler chickens supplemented with Moringa oleifera leaf meal over a period of refrigeration. Food Chemitry, 142, Pp. 255-261.

Nupo, S.S, Onigbogi, I.O., Akinlotan, J.V., and Ilori, O.A., 2013. Effect of different processing methods on the nutrients and antinutrient composition of senecio biafrae, crassocephalum crepidiodes and solanum nigrum consumed in south west Nigeria. American Journal Food Nutrition, 3 (3), Pp. 147-154.

Okwu, D.E., and Josiah, C., 2006. Evaluation of the chemical composition of two Nigerian medicinal plants. African Journal of Biotechnology, 4, Pp. 357-361.

Oloruntola, O.D., Ayodele, S.O., Adeyeye, S.A., Oloruntola, D.A., Osowe, C.O., and Fasuhami, O.A., 2022. Broiler Chickens' Growth, Haematological Indices, Guts Microbiota, Carcass and Meat Analysis in Response to Dietary Supplementation with Anacardium occidentale Leaf Powder and A Mix of Prebiotic, Probiotic and Acidifier. Journal of Poultry Research, 19 (2), Pp. 52-59.

Ouadja, B., Katawa, G., Toudji, G.A., Layland, L., Gbekley, E.H., Ritter, M., Anani, K., Ameyapoh, Y., and Karou, S.D., 2021. Anti-inflammatory, antibacterial and antioxidant activities of Chenopodium ambrosioides L. (*Chenopodiaceae*) extracts. Journal of Applied Biosciences, 162 (1), Pp. 16764-16794.

Rashid, N.J., and Khidhir, Z.K., 2021. Impact of different storage temperatures on canned meat Characteristics. Euphrates Journal of Agriculture Science, 13 (3), Pp. 28-37.

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M., and Rice-Evans, C.A., 1999. Antioxidant activity applying an improved ABTS radical cation decolourising assay. Free Radical Biology and Medicine, 26, Pp. 1231–1237.

Reyes-Becerril, M., Angulo, C., Sanchez, V., Vázquez-Martínez, J., and López, M.G., 2019. Antioxidant, intestinal immune status and anti-inflammatory potential of *Chenopodium ambrosioides L.* in fish: In vitro and in vivo studies. Fish Shellfish Immunology, 1 (86), Pp. 420-428. doi: 10.1016/j.fsi.2018.11.059

Sevindik, M., Akgul, H., Pehlivan, M., and Selamoglu, Z., 2017. Determination of therapeutic potential of Mentha longifolia ssp. longifolia. Fresen Environ Bull, 26 (7), Pp. 4757-4763.

Soyer, A., Özalp, B., Dalmiş, Ü., and Bilgin, V., 2010. Effects of freezing temperature and duration of frozen storage on lipid and protein oxidation in chicken meat. Food Chemistry, 120 (4), Pp. 1025–1030.

Tchani, G.W., Agbeme, K.S., Agbodan, K.A., Baba, G., and Kpegba, K., 2021. Phytochemical Study and Comparative Antioxidant Activity of Extracts from Aerial Parts of Chenopodium ambrosioides Linn. (*Chenopodiaceae*). Advances in Biological Chemistry, 11 (5), Pp. 220-233.

Udedi, S.C., Ani, O.N., Asogwa, K.K., Maduji, F.C., and Okafor, C.N., 2020. In-vitro and in-vivo Antioxidant Activity of Ethanol Leaf Extract of Justicia carnea. International Journal of Biochemistry Research and Review, 29 (4), Pp. 48-60.

Van der Aar, P.J., Molist, F.V., and Van Der Klis, J.D., 2017. The central role of intestinal health on the effect of feed additives on feed intake in swine and poultry. *Animal* Feed Science and Technology, 233, Pp. 64-75.

Wijaya, S., Nee, T.K., Jin, K.T., Din, W.M., and Wiart, C., 2011. Antioxidant, anti-inflammatory, cytotoxicity and cytoprotection activities of Crassocephalum crepidioides (Benth.) S. Moore. Extracts and its phytochemical composition. European Journal of Scientific Research, 67 (1), Pp. 1-10.

Xia, X., Kong, B., Liu, J., Diao, X., and Liu, Q., 2012. Influence of different thawing methods on physicochemical changes and protein oxidation of porcine longissimus muscle. LWT-Food Science and Technology, 46 (1), Pp. 280-286