

EFFECT OF MORINGA (*Moringa oleifera*) LEAF POWDER ON OXIDATIVE STABILITY OF COOKED AND RAW BROILER MEAT

*Adeyemi, K. D.¹, Olorunsanya, A. O.², Sola-Ojo, F. E.¹, Okukpe, K. M.¹, Malomo, G. A.¹,
Amira, O. J.³, Badmus, A. H. A.¹, Ahmed El-Imam, A. M.⁴, Shittu, R. M.¹ and O. W. Aboyeji¹

¹Department of Animal Production, University of Ilorin, Ilorin, Nigeria

²Department of Animal Science, Ibrahim Badamosi Babangida University,
Lapai, Niger state, Nigeria

³Department of Biochemistry, University of Ilorin, Ilorin, Nigeria

⁴Department of Microbiology, University of Ilorin, Ilorin, Nigeria

*kazyadeyemi@gmail.com; +2347034747954

ABSTRACT

Antioxidant effect of graded levels of moringa leaf powder on cooked and raw broiler meat was evaluated and compared with Butylated Hydroxyl Anisole (BHA), a synthetic antioxidant, using the Thiobarbituric acid (TBA) assay. The treatments consisted of a control without additive; moringa leaf powder was added separately at a rate of 0.1%, 0.2% and 0.3% of the weight of the minced meat while BHA was added at a rate of 0.01%. Each 700 g meat sample was divided into 56 parts of 12.5 g each. Twenty-eight of these were cooked in microwave oven for 1½ minutes while the other 28 samples were left raw. Both cooked and raw samples were stored in a refrigerator for 12 days at a temperature of 4°C. Oxidative stability of the cooked and raw samples was monitored at 2-day intervals. The result shows that all the additives and BHA were able to reduce lipid oxidation than the control in raw broiler meat. There was no significant difference ($P>0.05$) in the Thiobarbituric reactive substance (TBARS) values of 0.2% moringa, 0.3% moringa, and BHA treated samples in raw broiler meat. In the cooked samples, no level of moringa powder was effective in reducing lipid oxidation. BHA maintained its antioxidant potency in both cooked and raw meat samples. Addition of moringa leaf powder was effective in reducing lipid oxidation in raw broiler meat under refrigeration. Thus, oxidative stability of raw broiler meat can be prolonged for 12 days with moringa leaf powder under refrigeration storage.

Key words: antioxidant, moringa, BHA, broiler meat, TBA

INTRODUCTION

Lipid oxidation has long been recognized as a major problem in the storage of fatty foods (Olorunsanya *et al.*, 2009; Bali *et al.*, 2011). Oxidative changes can result in repugnant flavour, in the destruction of valuable nutrients and even in generation of toxic compounds (Olorunsanya *et al.*, 2009; Camo *et al.*, 2008; Carpenter *et al.*, 2007; Velioğlu *et al.*, 1998). These reactions occur by series of molecular mechanisms, which all channeled to the generation of oxygen rich precursors of reactive chain propagating free radicals

(Kanner and Rosenthal, 1992). The complexity of the chemical reaction defies the possibility of one universal, analytical test for unconditional evaluation of oxidation deterioration (Kanner and Rosenthal, 1992; Velasco and Williams, 2011). However, the better understanding of lipid oxidation achieved in recent years should assist in answering the questions of importance in food system (Kanner and Rosenthal, 1992). The reaction of molecular oxygen has long been a process of considerable interest.

Although wide varieties of organic molecules are susceptible to chemical attack by oxygen, a great deal of attention has recently been focused on lipids because of the remarkable implication of their oxidative damage. At the biological level, lipid oxidation cause damage to hormones, vitamins and membranes that are vital components for normal cell activity. At the nutritional level, lipid oxidation causes loss of food wholesomeness by deterioration of flavor and aroma as well as in the decay of nutritional and food safety qualities (Velasco and Williams, 2011; Kanner and Rosenthal, 1992). However, biological and nutritional aspects have merged; diets based on food containing peroxidized lipids have been related to far reaching effects such as carcinogenesis, premature aging and other diseases (Velasco and Williams, 2011; Kahl and Kappus, 1993). Irrespective of the amount of lipid present, lipid oxidation can occur in all fatty foods. It must, however, be borne in mind that unsaturated fats are readily susceptible to lipid oxidation than saturated fats. Practically, this process can affect all quality attributes of food. Thus aroma changes results from new volatile odorous compounds formed, flavor modification are caused by hydroxyl acids; the colour darkens as a result of condensation reaction between oxidation products and protein cross links. Unexpectedly, the safety and nutritive value of food are impaired (Kanner and Rosenthal, 1992).

Considering the possibility of undesirable influences of oxidized lipids on human health, it is of essential importance to minimize the hazardous effect of lipid oxidation in foods. The need to curb reduction in nutritional quality, incidence of off color, off odour and rancid taste or warmed over flavor caused by lipid oxidation necessitate the use of antioxidants in food (Adeyemi *et al.*, 2011a). In industrial processing, mainly synthetic antioxidants

such as Butylated hydroxyl anisole (BHA) and Butylated hydroxyl toluene (BHT) are used to prolong the oxidative stability of food (Olorunsanya *et al.*, 2009; Bali *et al.*, 2011; Adeyemi *et al.*, 2011b). However, synthetic antioxidants have been noted to be detrimental to human health. Synthetic antioxidants are carcinogenic (Cao *et al.*, 1997), cause impairment to blood clotting, lung damage and act as tumor promoters (Kahl and Kappus, 1993). Synthetic antioxidants are expensive and scarce (Adeyemi *et al.*, 2011a; Adeyemi *et al.*, 2011b). Because of these, consumers prefer natural ingredients and there is a growing interest in the use of antioxidants from natural sources (Adeyemi *et al.*, 2011a; Adeyemi *et al.*, 2011b; Olorunsanya *et al.*, 2009; Kingstone *et al.*, 1998).

Moringa, commonly known as the “Elixir Tree” is considered the most nutrient-rich plant ever known to mankind (Fahey, 2005). Moringa is rich in vitamin to the extent that it is one of the richest plant sources of vitamin (Fahey, 2005; Fuglie, 2001). The list of minerals present in moringa is abundant and few of the main minerals include calcium, copper, iron, potassium, magnesium, manganese and zinc (Fuglie, 2001). Moringa is the richest source of calcium from a plant material. It contains more calcium than that of milk (Fuglie, 1999; Fuglie, 2001).

Moringa has approximately 46 antioxidants and is one of the most powerful sources of natural anti-oxidants. Anti-oxidants supply the free atoms needed by the human body and mitigate the effect of free radicals. Moringa leaves are rich in flavonoids, a class of anti-oxidants (Fahey, 2005; Price, 2000). The major anti-oxidants present are Quercetin, Kaempferol, Beta-Sitosterol, Caffeoylquinic acid and Zeatin (Fahey, 2005). Antioxidants play a major role in controlling the symptoms of aging process and improve the cardiovascular health. Additionally,

Vitamin C and Vitamin E, present in moringa, also function as anti-oxidants. Researches confirm that the anti-oxidants deliver the desired result, if only taken with the combination of other essential vitamin and minerals, which makes health enthusiast to seek after moringa. Moringa leaves and fruits are loaded with Phytonutrients (Foidl *et al.*, 2001). The phytonutrients present in moringa include, Alpha-carotene, Beta-Carotene, Beta-cryptoxanthin, Lutein, Zeaxanthin and Chlorophyll. Phytonutrients flush toxins from the body, purify the liver, help to strengthen the immune system, help in rebuilding the red blood cells and the important of all, moringa phytonutrients rejuvenate the body at the cellular level (Foidl *et al.*, 2001; Fahey, 2005). The objective of this study was to evaluate the antioxidant effect of moringa leaf powder on cooked and raw broiler meat in comparison with Butylated hydroxyl anisole, a synthetic antioxidant.

MATERIALS AND METHODS

Source and preparation of meat

Twenty-five broiler birds of eight weeks old weighing 2 ± 0.3 kg were obtained from Animal Production Pavillion, University of Ilorin, Ilorin, Nigeria. The broiler birds were slaughtered by neck decapitation. They were scalded manually by dipping into boiled water for a minute, de-feathered, washed, eviscerated and de-skinned. The carcasses were cut into different parts. The breast, thigh and drumsticks were manually deboned using a sharp knife and minced together using a food processor (National MK-5080M). The minced meat was mixed thoroughly to form a homogenous mix.

Processing of moringa leaf

Fresh moringa leaves were obtained from Tanke area in Ilorin metropolis. The leaves were air-dried for 48 hours and ground into powder using mortar and pestle.

Treatments

The minced meat was weighed into four samples of 700 g each. These samples were treated as follows: no additive (Control), addition of 0.1%, 0.2% or 0.3% moringa powder or addition of 0.01% BHA. Each of the treated meat samples was divided into 56 parts of 12.5 g each. Twenty-eight of these were cooked for 1½ minutes using a microwave oven (National-NN-55WF) while the other parts were left raw. Both cooked and raw meat samples were wrapped in foil paper with labeling corresponding to the applied treatments and stored in a refrigerator (HR-170T) for 12 days at a temperature of 4°C. The oxidative stability was monitored at day 0, 2, 4, 6, 8, 10 and 12.

Lipid oxidation in meat

Lipid oxidation in the meat samples was evaluated using the 2-thiobarbituric acid (TBA) test. The thiobarbituric acid reactive substance (TBARS) values were measured on a duplicate 10 g samples at each storage day using the distillation method of Tarladgris *et al.* (1964). Ten (10) g of the meat sample was homogenized with 47.5 ml of distilled water in a specimen bottle using glass pestle. The homogenized mixture was rinsed with 50 ml of distilled water into a round bottom flask. Thereafter, 2.5 ml of diluted hydrochloric acid (1:2 solution) was added and the mixture was distilled through a condensing assembly to collect about 15 ml of the distillate. Five (5) ml of the distillate was mixed with 5 ml of thiobarbituric acid (TBA) (0.02M) and boiled for 35 minutes in boiled water. Then, the mixture was cooled for ten minutes under a running tap water for color development. The duplicate absorbance readings were measured at a wavelength of 538 nm against a blank that contained 5 ml of hydrochloric acid solution and 5 ml of thiobarbituric acid (TBA) reagent using a spectrophotometer (CECILL-2000). The absorbance values were multiplied by a

factor of 7.8 (Tarladgris *et al.*, 1964) to obtain the TBARS values in milligram per malonaldehyde per kilogram of sample (mg/MDA/kg). Each treatment was replicated four times.

Statistical analysis

Completely randomized design was used. The data obtained were analyzed using Analysis of Variance (ANOVA) model suitable for the design with the aid of a Genstat 5 program package (Payne, Lane and Genstat Committee, 1987). Duncan multiple range test was used to determine difference between means. Significance was defined at $P < 0.05$.

RESULTS AND DISCUSSION

In raw meat samples, there was a general increase in TBARS values as storage days advanced (Table 1). However, the increment in treated samples was lower than the

control samples. All additives and BHA reduced lipid oxidation in raw meat samples. This was shown by lower TBARS values observed for treated samples. The TBARS values observed on day 0 was significantly different ($P < 0.05$) from those observed on day 12 for all the treatments. The control samples had higher ($P < 0.05$) TBARS value than other treatments. On day 0, there was no significant difference ($P > 0.05$) among the treatments. On day 2, there was no significant difference among BHA, 0.2% and 3% moringa powder. The antioxidant properties of moringa leaf powder could be attributed to the presence of antioxidants such as Quercetin, Kaempferol, Beta-Sitosterol, Caffeoylquinic acid and Zeatin (Fahey, 2005). Moringa contains phenolic compounds such as flavonoids, which is also a potent antioxidant. Some authors have demonstrated the high antioxidant activity of phenolic compounds. They opined that phenolic compounds express their

Table 1: Effect of antioxidant treatments on oxidative stability of raw broiler meat

Treatment	TBARS (mg/MDA/kg)						
	Storage days for raw meat samples						
	0	2	4	6	8	10	12
Control	0.229 ^a	0.700 ^{b_y}	0.854 ^{b_z}	0.891 ^{b_z}	0.907 ^{b_z}	1.560 ^{c_y}	1.843 ^{c_z}
0.1%MOP	0.123 ^a	0.432 ^{a_y}	0.514 ^{b_y}	0.534 ^{b_y}	0.544 ^{b_y}	0.595 ^{b_x}	0.978 ^{c_y}
0.2%MOP	0.158 ^a	0.209 ^{a_x}	0.372 ^{a_x}	0.376 ^{a_x}	0.431 ^{a_x}	0.449 ^{a_x}	0.788 ^{b_x}
0.3%MOP	0.047 ^a	0.111 ^{a_x}	0.200 ^{a_x}	0.259 ^{a_x}	0.374 ^{b_x}	0.480 ^{b_x}	0.634 ^{b_x}
BHA	0.088 ^a	0.105 ^{a_x}	0.115 ^{a_x}	0.121 ^{a_x}	0.152 ^{a_x}	0.261 ^{a_x}	0.475 ^{b_x}
SEM	NS	0.096	0.096	0.096	0.096	0.096	0.096

a, b, c Means having different superscript along the same row are significantly different.

x, y, z Means having different subscripts along the same column are significantly different. NS= not significant

Table 2: Effect of antioxidant treatments on oxidative stability of cooked broiler meat

Treatment	TBARS (mg/MDA/kg)						
	Storage days for cooked samples						
	0	2	4	6	8	10	12
Control	0.379 ^{a_y}	0.811 ^{b_y}	1.100 ^{b_y}	1.230 ^{c_y}	1.254 ^{c_y}	1.539 ^{c_y}	1.638 ^{c_y}
0.1%MOP	0.675 ^{a_y}	0.757 ^{a_y}	1.100 ^{b_y}	1.223 ^{b_y}	1.318 ^{b_y}	1.478 ^{c_y}	1.910 ^{c_y}
0.2%MOP	0.932 ^{a_y}	0.967 ^{a_y}	1.125 ^{a_y}	1.229 ^{a_y}	1.287 ^{b_y}	1.429 ^{b_y}	1.804 ^{c_y}
0.3%MOP	0.803 ^{a_y}	0.942 ^{a_y}	1.138 ^{a_y}	1.280 ^{b_y}	1.322 ^{b_y}	1.640 ^{b_y}	1.878 ^{c_y}
BHA	0.043 ^{a_x}	0.144 ^{a_x}	0.195 ^{a_x}	0.256 ^{a_x}	0.322 ^{a_x}	0.783 ^{b_x}	0.811 ^{b_x}
SEM	0.087	0.087	0.087	0.087	0.087	0.087	0.087

a, b, c Means having different superscript along the same row are significantly different.

x, y, z Means having different subscripts along the same column are not significantly different.

antioxidant properties through three mechanisms: free radical scavenging activity (Zheng *et al.*, 2009), transition-metal-chelating activity (Andjekovic *et al.*, 2006), and/or singlet-oxygen-quenching capacity (Mukai *et al.*, 2005). *Moringa* is an ample source of various vitamins, some of which are antioxidant in nature. Examples are vitamins C, E and A. This observation agrees with the report of Pennington and Fisher (2009) that the total antioxidant property of fruits and vegetable extracts reflects the concentration of ascorbic acid (Vitamin C), alpha tocopherol (Vitamin E), beta-carotene (Vitamin A precursor), various flavonoids and other phenolic compounds. Furthermore, some synergistic effects among ascorbic acid, alpha tocopherol and beta-carotene have been reported against oxidation (Yeum *et al.*, 2009). There was no significant difference ($P>0.05$) in the antioxidant effect of 0.1% *Moringa* powder and the control samples. This could be attributed to the low concentration of the *moringa* powder. It was observed that as concentration of *moringa* leaf powder increased, there was a decrease in lipid oxidation shown by lower TBARS values in 0.2% and 0.3% *moringa* treated samples. On day 4, 6, 8 and 12, there was no significant difference ($P>0.05$) in the TBARS value of BHA, 0.2% and 0.3% *moringa* powder. On these storage days, 0.1% *moringa* treated samples had a lower TBARS value than the control samples. However, its antioxidant potency was significantly lower than BHA, 0.2% and 0.3% *moringa* powder. On day 10, control samples had the highest TBARS value that was significantly different ($P<0.05$) from other treatments. The results obtained for BHA is in line with the report of Branen (1975) who asserted the antioxidant potency of BHA.

In cooked meat samples, there was a general increase in TBARS values as storage day progressed (Table 2). On all storage days, there was no significant difference ($P>0.05$)

in the TBARS values of the control samples and all *moringa* treated samples. The higher TBARS value observed for *moringa* treated samples could be attributed to the destruction of antioxidant and phenolic compounds in *moringa* leaf powder in the course of boiling the meat samples. Aside this, heat can also denature most of the antioxidant phytochemicals to form pro-oxidant compounds. The TBARS value obtained for the cooked meat samples was observed to be higher than the raw meat samples. The reason might be that cooking, which is mostly associated with increase in temperature, activates some lypolytic enzymes such as lipase and phospholipase in the meat, which promote lipid oxidation (Krinsky, 1994). It was reported that increase in cooking temperature of meat, results in decrease in the moisture content and increase in the fat content of the cooked meat thus increasing the rate of oxidative rancidity (Smith *et al.*, 1982). Increase in lipid oxidation in the cooked samples may also be due to increase in ionic iron concentration from heat induced release of protein bound iron after cooking and the formation of hypervalent ferrylmyoglobin (or activated metmyoglobin) during cooking (Olorunsanya *et al.*, 2010). Other studies suggest that cooking disrupts the lipid membrane system (leading to loss of structural integrity) which caused the reaction of oxygen and molecular metal with unsaturated fatty acids resulting in the generation of oxidative reactions (Ashgar *et al.*, 1988).

CONCLUSION

All levels of *moringa* leaf powder and BHA were able to reduce lipid oxidation in raw meat samples. This was shown by their lower TBARS values, which was significantly different from control samples. Both 0.2% and 0.3% *moringa* leaf powder were as effective as BHA. In cooked meat samples, only BHA was able to reduce lipid

oxidation in meat samples. All moringa treated samples were not significantly different from control samples in cooked broiler meat. The cheap and commonly available moringa leaf powder could, therefore, be a good source of natural antioxidants for extending the shelf life of raw broiler meat.

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