EFFECT OF LEMON (*CITRUS LIMON*) ON LIPID OXIDATION IN CHICKEN CRUMBS

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ABSTRACT
The study was aimed at evaluating the influence of lemon juice on lipid oxidation in chicken crumbs. In a completely randomized design, hygienically harvested fresh chicken muscle, was deboned, cut into smaller pieces (±100g) and marinated inside freshly squeezed lemon juice at the concentrations of 0, 10, 20, 30, 40, and 50% in 100mL of water, respectively. The marinated chicken samples were dried in an electric oven for 1hour at 1050C to achieve uniformly dried crumbs. The chicken samples were removed from the oven and allowed to cool at room temperature (26ºC) before packing each treatment in Ziploc bags and stored for 90 days at room temperature (26ºC). Samples were evaluated for oxidative rancidity at days 30, 60 and 90 using standard procedures. Data obtained were analysed using ANOVA at α0.05. The highest oxidative rancidity (mg/g) was observed in Control (5.07) at 90 days, which was significantly higher (p<0.05) than for all other treatments and evaluation intervals. Whereas the lowest oxidative rancidity at day 90 were 1.39 and 2.00 for crumbs marinated in 30% and 40% lemon juice. From this study it can be concluded that marinating chicken crumbs in lemon juice of concentrations between 30% to 40% before drying can reduce lipid oxidation for up to three months.
Keywords: Lemon juice, Lipid Oxidation, Chicken muscle, Chicken crumbs, Oxidative rancidity

INTRODUCTION

Meat constitutes a crucial component of the majority of human diets, providing essential amino acids, highly bioavailable iron, zinc, selenium, and B vitamins, notably vitamin B_{12}. Many of these nutrients are globally deficient and can be addressed by consuming just a few ounces of beef per week (Neufingerl and Eilande, 2021). However, meat is highly perishable, susceptible to microbial growth, chemical changes, and breakdown by endogenous enzymes, rendering it unfit for consumption and potentially hazardous to health (Ronald *et al.,* 2024). Various measures can be taken to mitigate these processes, including reducing temperatures to slow microbial growth, cooking or canning to destroy organisms and enzymes, or employing methods like drying or osmotic control to remove water. Additionally, chemicals or, more recently, ionising radiation (though restricted in some countries) can be used to inhibit microbial growth (Ronald *et al.,* 2024).

During the cooking of meat, hydro-peroxides are formed, which can break down into volatile organic compounds, impacting sensory quality and leading to oxidative flavours, pigment and vitamin loss in meat products (Macho-González *et al.,* 2020). The heating process disrupts muscle cell structure, deactivates anti-oxidative enzymes, and generates catalytic iron from myoglobin, creating a pro-oxidant environment affecting both lipids and proteins (Huang *et al.,* 2019). Grinding of meat has been reported to further exacerbate lipid oxidation by disrupting muscle cell membranes (Huang *et al.,* 2019).

Meat is a complex food with a vulnerable composition prone to oxidation (Amaral *et al.,* 2018). The oxidative stability of meat hinges on the interaction between endogenous anti-oxidant and pro-oxidant substances, as well as the composition of substrates prone to oxidation, including polyunsaturated fatty acids (PUFA), cholesterol, proteins, and pigments (Macho-González *et al.,* 2020). Lipid oxidation leads to the formation of reactive oxygen species (ROS), affecting both lipids and proteins and resulting in changes to sensory attributes and nutritional quality (Macho-González *et al.,* 2020).

Antioxidants, whether synthetic or natural, can be added to meat and meat products during processing to delay lipid oxidation (Domínguez *et al.,* 2019; Bellucci *et al.,* 2022). Natural antioxidants, such as

plant polyphenols and essential oils (EOs), are increasingly favoured over synthetic options due to safety concerns (Bellucci *et al.,* 2022; Petcu *et al.,* 2023).
This study sought to evaluate the efficacy of lemon as a natural antioxidant in reducing lipid oxidation and enhancing quality of meat products throughout processing till consumption.

MATERIALS AND METHODS

Experimental Site

This experiment was carried out at Animal Products Laboratory of Animal Production Department Faculty of Agricultural Science University of Jos, Jos, Plateau State Nigeria located between latitude 9^0 E55' North of the Greenwich meridian and longitude 8^0 E54' East of the Equator (Haruna *et al.,* 2007).

Experimental Design

6×3 arrangement in a completely randomized design.
6= 6 lemon juice concentrations 0, 10%, 20%, 30%, 40%, 50%, in 100mls of water
3= 3 evaluation intervals, 30days (First month), 60days (Second month), and 90days (Third month).

Lemon Juice Preparation

Fresh lemons were harvested, washed thoroughly, and then juiced with the aid of juice squeezer. The juice was then added to 100ml of water at different concentrations thus; 0, 10%, 20%, 30%, 40%, and 50% respectively.

Crumbing Process

Hygienically harvested chicken muscles were cut into smaller pieces averaging 100g, washed thoroughly with distilled water and marinating with the different concentrations of lemon juice. The marination was allowed to stand for one hour before drying the samples to constant weight in the oven at 105^0C.

Storage procedure

The chicken samples were removed from the oven and allowed to cool at room temperature before packing each treatment in Ziploc bags and stored for 90 days. Evaluations were done at days 30, 60 and 90.

Oxidative Rancidity

Thiobarbituric acid value (TBA) was estimated by modified methods of Buege and Aust (1978). 3mls each of glacial acid and 1% TBA solution were added to test tubes appropriately labelled blank and tests. 0.6mL of distilled water was added to the blank, while 0.6mL of the homogenised sample was added to each of the tests tubes. These were thoroughly mixed, incubated in a boiling water bath for 15 minutes, then allowed to cool, after which they were centrifuged and their supernatants collected. The supernatant from the blank was used to zero the spectrophotometer (preset at 532nm) before reading the absorbance of the supernatant from the test solutions.
The amount of TBARS was expressed as milligrams of malondialdehyde per gram of sample.

$$TBA = \frac{O.D \times V \times 1000}{A \times V \times I \times Y}$$

Where:
O.D = Absorbance of test at 532nm.
V= Total volume of the reaction mixture = 6.6mL
A= Molar extinction coefficient of the product, and according Buege and Aust (1978) is equal to 1.56x105
I= Length of light path =1cm.
Y= mg of tissue in the volume of the sample used.
v= volume of tissue juice used =0.6mL

Statistical Analysis

The collected data were statistically analysed using one-way ANOVA and two-way ANOVA. A 95% confidence interval was used to determine the statistical difference between the control and the treatments and between groups.

Results

Table 1 displays the interaction effect of storage duration and lemon juice on the oxidative rancidity of chicken crumbs. The results indicate significant differences ($p<0.05$) among the treatments. Specifically, in the control group, the chicken crumbs at the third month exhibited the highest oxidative rancidity value at 5.07 (mg/g). On the other hand, the chicken crumbs marinated in 10% lemon juice showed the lowest oxidative rancidity value at 1.15 (mg/g) in the second month.

Table 1: Effect of storage duration and lemon juice on oxidative rancidity of chicken crumbs

Parameters	Months	Control	10% LJ	20%LJ	30% LJ	40% LJ	50% LJ	SEM	P-value
Oxidative rancidity (mg/g)	1st month	1.95^{cij}	1.65^{bjk}	1.93^{bij}	2.05^{aij}	2.35^{bi}	1.17^{bk}	0.09	0.000
	2nd month	4.30^{bi}	1.15^{cm}	2.78^{ak}	1.77^{abl}	3.57^{aj}	1.50^{blm}	0.28	0.000
	3rd month	5.07^{ai}	2.96^{aj}	2.59^{ajk}	1.39^{bm}	2.00^{bm}	2.21^{akl}	0.29	0.000
	SEM	0.47	0.27	0.13	0.10	0.24	0.20		

[a, b, c, d] means with different superscripts on the same column differ significantly ($P<0.05$)
[I, j, k, l] means along the same row with different superscripts differ significantly ($P<0.05$)
LJ - Lemon juice, SEM - Standard error of mean.

Discussion

The results obtained in this study showed that there was significant ($p<0.05$) difference and interaction between the storage time and lemon juice concentration. A trend was observed as the lemon juice inclusion levels increase, there was a decrease in oxidative rancidity. Similarly, as the storage duration increases, there was an increase in the oxidative rancidity. The result obtained shows that lemon juice has antioxidant activities which caused a reduction in the oxidative rancidity as the concentration levels increased. The result obtained in this study was in agreement with the finding of (Chidanandaiah *et al.,* 2009) who reported TBARS values increased significantly ($p<0.05$) during refrigerated storage period. Similar findings were stated by Yadav *et al*. (2018) who found a significant increase in TBARS value of control and fiber enriched sausage with an increase in storage period. (Disha *et al.,* 2020) also obtained similar results obtained in this study where different level of lemon juice on quality and shelf life of chicken meatballs during frozen storage. The results obtained could be due to the presence of bioactive compounds found in lemon juice that is ascorbate acid which has antioxidant activity and oxygen barrier properties that contributed to lipid oxidation-reduction. The oxidative rancidity value in lemon treated crumbs was significantly lower than in control without lemon juice, which could be due to the inhibition of oxygen permeation and synergistic effects of lemon juice (Chytiri *et al.,* 2004).

CONCLUSION

From this study it can be concluded that marinating chicken crumbs in lemon juice of concentrations between 30% to 40% before drying can reduce lipid oxidation for up to three months.

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