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Research Article
Quality Assessment of Suya (Tsire) as Affected by *Moringa oleifera* Leaf Powder

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Abstract

Background and Objective: The development of lipid peroxidation also called oxidative rancidity as being one of the problem faced in the meat industry. This study was carried out to evaluate the physicochemical properties of Suya (tsire) processed with *Moringa oleifera* leaf powder (MOLP) as antioxidant and anti-microbial. **Materials and Methods:** Semi membranous muscle from a mature bull was sliced into thin sheets. Fresh green *Moringa* leaves were prepared to obtain its leaf powder (MOLP). The study comprised of five treatments with 10 replicates in three batches in a completely randomized design. Suya prepared was analyzed for Water Holding Capacity (WHC), shear force, pH, lipid oxidation and microbial load at days 0, 3 and 6 of storage at 4°C. **Results:** Treatment five had the highest WHC while treatment one had the least WHC. The pH value ranged from 6.00-6.36. Treatment one had the highest oxidative rancidity while the least oxidative rancidity in treatment five. Microbial load was lower in treatment five. **Conclusion:** The result of this study showed that the use of MOLP up to 10% could use in suya production due to its ability to reduce the rate of lipid oxidation and microbial load of suya. Also result showed that physico-chemical properties were not adversely affected.

Key words: Tsire, physicochemical, leaf powder, microbial load, *Moringa oleifera*, leaf powder, suya production

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The technical term for food products with reduced water activity is intermediate moisture foods. Most of meat prevention methods based on the drying of meat fall into this category. Meat drying technique have been used for centuries and can be considered the oldest meat preservation method[1]. In other words, intermediate moisture meat are partially dehydrated products that have a suitable concentration of dissolved solute to bind the remaining water sufficiently to inhibit the growth of bacteria, mold and yeasts[1]. Examples of such are kilishi, kundi, suya etc. Usually in Nigeria, skinless, boneless flesh of cattle or chicken is used for commercial preparation of suya. Finely grounded roasted groundnut cake, red pepper, salt, ground ginger, ground garlic, chunked fresh tomatoes and minced fresh onions are required to give a quality Suya meat product[2]. Lipid peroxidation has been one of the primary mechanisms of quality deterioration in displayed or stored foods especially muscle food[3]. Synthetic antioxidants such as butylatedhydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tertiary butyl hydroquinone-BHQ have been used to retard or minimize oxidative deterioration of foods[4]. Recently, consumers have rejected synthetic antioxidants because of their carcinogenicity[5]. This has given much attention to the use of natural antioxidants to stabilize meat as they are considered safer than synthetic antioxidants[6]. It has also been reported that these natural antioxidants, especially of plant source, have greater application potential for consumer's acceptability, palatability, stability and shelf life of meat products[6].

According to Moyo *et al.*[7], there is quite a lot of literature on the nutritional value of *Moringa oleifera* Lam. leaves with varying nutritional content. *Moringa oleifera* has been reported to posses several nutrients, including: Calcium, Magnesium, Potassium, Iron, Vitamin A and Vitamin C and a crude protein content that varies[8-10] from 16-40%. Therefore, *Moringa oleifera* leaves could be highly digestible because of its immense nutritional qualities *Moringa oleifera* is an important source of naturally occurring antioxidant[11]. The presence of these substances in *Moringa* leaves make it an important dietary supplement[12].

A survey conducted by Yang *et al.*[13] and Jang *et al.*[6] on 120 edible plant species showed that *Moringa oleifera* was among the most promising species based on their high antioxidant activity, high contents of micro-nutrients and phyto-chemicals processing properties, ease of growing etc. The objective of this study was therefore to evaluate the physiochemical, lipid oxidation and microbial quality of suya (tsire) as affected by *Moringa oleifera* leaf powder.

MATERIALS AND METHODS

Experimental site: The experiment was carried out at the Meat Science Laboratory of the Department of Animal Science University of Ibadan, Ibadan. This experiment was carried out in three batches with time interval of one month in May, 2015.

Preparation of *Moringa* leaf powder: Fresh green M*oringa* leaves were harvested thoroughly washed with distilled water and oven dried at 50°C for 48 h to maintain its greenish colour and nutritive value. The dried leaves were shredded and sieved with 0.2 mm fine mesh to obtain the *Moringa* leaf powder.

Meat preparation: Raw beef was purchased from the slaughter house of the Department of Animal Science in the University of Ibadan. The cut of beef used in this experiment was taken from a portion of the semi membranous muscle of a mature bull. The meat was trimmed of all visible bones and connective tissue. It was cut into chunks of 12 cm long and 6 mm wide. The chunks were sliced into 0.15-0.30 mm thickness in the same direction of the muscle fibre using a long knife with a very sharp blade. Weight was taken, recorded and labelled after which the meat was staked on the slender wooden stick. The weighed sheets of meat with sticks were randomly allotted into five treatments with ten replicates each.

Preparation of Suya ingredients: Spices are obtained from Bodija market in Ibadan, Oyo state. The spices were mixed together as shown in Table 1.

Table 1: Composition of Suya ingredients

	Moringa leaf powder treatment				
Ingredients	1	2	3	4	5
Groundnut cake powder	52.00	49.50	47.00	44.5	42.00
Moringa leaf powder	0.00	2.50	5.00	7.50	10.00
Ginger	5.00	5.00	5.00	5.00	5.00
Garlic	5.00	5.00	5.00	5.00	5.00
Red dried pepper	10.00	10.00	10.00	10.00	10.00
White pepper	5.00	5.00	5.00	5.00	5.00
Salt	8.50	8.50	8.50	8.50	8.50
Curry	5.00	5.00	5.00	5.00	5.00
Maggi	7.50	7.50	7.50	7.50	7.50
Groundnut oil	2.00	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.0	100.00	100.00

Preparation of Suya: Meat pieces on sticks were properly coated with the formulated ingredients and each treatment was labelled for easy identification. The labelled sticks of meat were then arranged on a glowing, smokeless fire made from grilling machine that was medium hot (about 65.5°C). The stick meats were allowed to stay on the fire for 20 min with regular turning and additional groundnut oil was sprinkled on the meat while roasting continued. Treatment 1, which is the control had no *Moringa* leaf powder while treatments 2, 3,4 and 5 contained *Moringa* leaf powder at 2.5, 5, 7.5 and 10%, respectively

Thiobarbituric acid value: Thiobarbituric acid value (TBA) was estimated by modified methods of Buege and Aust[14], 3 mL each of glacial acid and 1% TBA solution were added to test tubes appropriately labelled blank and tests. About 0.6 mL of distilled water was added to the blank, while 0.6 mL of the homogenised sample was added to each of the tests tubes. These were thoroughly mixed, incubated in a boiling water bath for 15 min, 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 532 nm) 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:

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

Where:

O.D = Absorbance of test at 532 nm
V = Total volume of the reaction mixture = 6.6 mL
A = Molar extinction coefficient of the product and according to Buege and Aust[14] is equal to 1.56×10^5
I = Length of light path = 1 cm
Y = Milligram of tissue in the volume of the sample used
v = Volume of tissue extract used = 0.6 mL

Determination of microbial load of suya: Suya samples (lg) were aseptically transferred into 9 mL of 0.1% sterile peptone water. Serial dilutions were made. From each dilution, 0.1 mL was plated into sterile Petri-dishes. Nutrient agar, MacConkey agar and potato dextrose agar was poured in duplicates using the spread plate method. Nutrient agar and MacConkey agar plates were incubated at 37°C for 24 h, while the potato dextrose agar plates were incubated at 25°C for 72 h. Developed colonies were counted and expressed in log CFU g^{-1} of samples.

Determination of physical properties of Suya

Shear force: Shear force was determined by the procedures described by Honikel[15].

Water Holding Capacity (WHC): This was determined with press method according to Suzuki *et al.*[16]. An intact sample was pressed between 2 filter papers with a plexiglass for over 1 min using a table device. The amount of juice released from the sample was measured indirectly by measuring the area of the filter paper wetted relative to the area of pressed sample. A pencil was used to trace out the area covered by the compressed meat sample and the area covered by the water let out onto a piece of tracing paper and then it was transferred onto a graph sheet. The area calculated was used to determine the water holding capacity.

pH: The pH was determined using a digital pH meter model PHS-25 Microfield England according to the method described by AOAC[17]. The pH value of cooked sausage samples were determined by weighing 10 g of sample into a blender with 90 mL of distilled water and homogenised until smooth slurry was formed. The digital pH meter was placed in a buffer solution in order to allow equilibrium for 2 min before placing it into prepared slurry.

Storage of Suya: Suya was properly wrapped with foil paper to prevent moisture loss and placed inside the refrigerator for 6 days. Parameters were taken for 0, 3 and 6 days of storage.

Statistical analysis: Completely Randomized Design (CRD) was used for this study. Data obtained were analyzed using the general linear model (GLM) of Statistical Analysis System's Procedures Institute Inc., Cary, NC[18] with a 5% level of significance. Means were separated using the Duncan's new multiple range test.

RESULTS AND DISCUSSION

Physic-chemical properties of Suya as affected by *Moringa* leaf powder over the storage period: The data in Table 2 showed the physic-chemical properties of Suya as affected by *Moringa* leaf powder over the storage period. There was significant difference ($p<0.05$) in Water Holding Capacity (WHC) among the treatments on day 0 with T5 having the highest value of 37.95% while T1 had the least value of 34.26%. On day 3 WHC varied significantly ($p<0.05$) among treatments with T5 having the highest value of 36.49 while T1 had the least value of 33.12%. Same trend was observed

for day 6 with T5 having the highest value of 34.95% while T1 had the least value of 31.85%. Significant difference ($p<0.05$) was also observed in all treatments among storage days. The water holding capacity, which is the ability of the meat to retain its water during application of external force, is important in meat processing. This is because the overall eating quality of the product revolves around this by Omojola *et al.*[19]. Apata *et al.*[20] recorded similar range of values (24.52-34.24%) for suya prepared in the laboratory and those collected from various zones. This suggested that *Moringa* leaf powder inhibit denaturation of sarcoplasmic proteins, which plays an important role in determining water holding capacity.

Shear force (Table 2) measured the degree of toughness of meat and the higher the value, the tougher the meat. On day 0, significant ($p<0.05$) decrease was observed in shear force values among the treatments as the inclusion level of *Moringa* leaf powder increased. The same trend was observed on day 3 and day 6. Apata *et al.*[20] recorded similar result from suya prepared in the laboratory. When compared among days, significant difference ($p<0.05$) was also observed in all the treatments. Aduku and Olukosi[21] reported that when moisture and water holding capacity of meat or meat product are lowered, shear force value of the meat or meat product is raised as observed in T1. This result indicated that *Moringa* leaf powder influences meat tenderness.

pH of Suya as affected by *Moringa* leaf powder over the storage period: The pH of meat is the measure of the degree of acidity or alkalinity of the meat and meat products. On day 0 (Table 2), there was no significant difference ($p>0.05$) among treatments, with a range of 6.00-6.15. Almost same trend was observed for day 3 and 6 among all treatments. Significant deference ($p<0.05$) was however observed among days in all the treatments. The pH of suya increased with length of storage as shown in Table 2.

Lipid oxidation of Suya as affected by *Moringa* leaf powder over the storage period: The Thiobarbituric acid (TBARS) value determines the extent of lipid oxidation. On day 0 (Table 3), TBARS among the treatments with T4 and T5 having the least value of 0.09 mg Malonaldehyde kg^{-1}, while the T1 had the highest value of 0.13 mg Malonaldehyde kg^{-1}. Same trend of significance ($p<0.05$) was observed on day 3 and 6. When compared among days, there was an increasing trend in TBARS among days in all the treatments. T5 recorded the least value. It could be inferred that, the antioxidant components of MOLP preserved the suya (especially in T5 which had highest inclusion rate) against lipid oxidation over the duration of storage.

Table 2: Physico-chemical properties of fresh and stored suya (Tsire) as affected by *Moringa oleifera* leaf powder

		Days of treatments					
Parameters	Storage	1	2	3	4	5	SEM
WHC	0	34.26^{ei}	35.56^{di}	35.95^{ci}	36.83^{bi}	37.95^{ai}	0.33
	3	33.12^{cj}	33.62^{cj}	34.86^{bj}	35.65^{abj}	36.49^{aj}	0.35
	6	31.85^{dk}	32.79^{cj}	33.59^{bk}	33.72^{bk}	34.95^{ak}	0.27
SEM		0.34	0.44	0.46	0.53	0.43	
SF	0	6.33^{a}	6.10^{abj}	6.00^{b}	5.60^{cj}	5.53^{c}	0.08
	3	6.40a	6.20^{bij}	6.16c	6.20^{bi}	5.80d	0.09
	6	6.43^{a}	6.25^{abi}	6.20^{bc}	6.20^{bci}	6.00^{c}	0.04
SEM		0.02	0.03	0.05	0.12	0.12	
pH	0	6.00^{j}	6.15^{j}	6.15^{j}	6.13^{j}	6.00^{j}	0.03
	3	6.12^{j}	6.35^{i}	6.20^{j}	6.15^{j}	6.15^{ij}	0.02
	6	6.30^{i}	6.30^{i}	6.35^{i}	6.36^{i}	6.35^{i}	0.03
SEM		0.04	0.03	0.03	0.04	0.06	

^{abcde}Means on the same row with similar superscript are not significantly different ($p>0.05$), ^{ijk}Means on the same column with similar superscript are not significantly different ($p>0.05$), inclusion level of *Moringa* leaf powder: Treatment 1: 0%, Treatment 2: 2.5%, Treatment 3: 5%, Treatment 4: 7.5%, Treatment 5: 10%. WHC: Water holding capacity, SF: Shear force, SEM: Standard error mean

Table 3: Effect of *Moringa oleifera* leaf powder on TBARS (mg Malonaldehyde kg^{-1}) of fresh and stored Suya (Tsire)

	Days of treatments					
Storage	1	2	3	4	5	SEM
0	0.13^{ak}	0.11^{abk}	0.10^{bj}	0.09^{bj}	0.09^{bk}	0.00
3	0.21^{aj}	0.19^{abj}	0.19^{bi}	0.15^{bi}	0.11^{bj}	0.01
6	0.25^{ai}	0.21^{bi}	0.20^{bi}	0.16^{ci}	0.13^{ci}	0.11
SEM	0.01	0.01	0.01	0.01	0.01	

^{abcde}Means on the same row with similar superscript are not significantly different ($p>0.05$), ^{ijk}Means on the same column with similar superscript are not significantly different ($p>0.05$), inclusion level of *Moringa* leaf powder: Treatment 1: 0%, Treatment 2: 2.5%, Treatment 3: 5%, Treatment 4: 7.5%, Treatment 5: 10%, SEM: Standard error mean

Total aerobic count of Suya as affected by *Moringa* leaf powder over the storage period: Total aerobic count (TAC) significantly ($p<0.05$) differed among the treatments means on day 0 (Table 4). T1 had the highest value (2.00) while T5 had the least value (0.90). The same trend was observed for TAC on day 3 and 6. Previous studies[22] recorded similar range of 0.07×10^5-2.22×10^5 CFU g^{-1} and stated that the values placed the Suya samples consumed in Nigeria within satisfactory limit according to the International Commission of Microbiological Standards for Foods[23]. The result obtained in this study fall within the acceptable range of 2.5×10^5-1.0×10^8 CFU g^{-1} recorded by Pearson[24]. The result suggested that *Moringa* leaf powder significantly ($p<0.05$) reduced aerobic bacteria load of suva (tsire), it also showed

Table 4: Effect of *Moringa oleifera* leaf powder on microbial count (log_{10} CFU g^{-1}) of fresh and stored suya (Tsire)

		Days of treatments					
Parameters	Storage	1	2	3	4	5	SEM
TAC	0	2.00^{a}	1.30^{b}	1.05^{b}	1.00^{b}	0.90^{bc}	0.11
	3	2.15^{a}	1.45^{b}	1.35^{b}	1.30^{b}	0.90^{c}	0.11
	6	2.30^{a}	1.80^{ab}	1.60^{ab}	1.40^{ab}	1.00^{bc}	0.12
SEM		0.09	0.1	0.12	0.11	0.04	
TCC	0	1.00^{a}	0.87^{ab}	0.75^{ab}	0.70^{ab}	0.50^{bc}	0.06
	3	1.15^{a}	1.05^{ab}	0.95^{ab}	0.90^{b}	0.45^{c}	0.08
	6	1.25^{a}	1.00^{ab}	1.05^{ab}	1.05^{ab}	0.55^{c}	0.07
SEM		0.05	0.07	0.07	0.07	0.03	
TFC	0	1.00^{a}	0.67^{b}	0.52^{bc}	0.35^{cji}	0.25^{bc}	0.08
	3	1.05^{a}	0.75^{ab}	0.72^{ab}	0.50^{bcij}	0.22^{b}	0.09
	6	1.10^{a}	0.77^{ab}	0.75^{ab}	0.72^{abi}	0.35^{b}	0.09
SEM		0.04	0.04	0.09	0.04	0.03	

^{abcde}Means on the same row with similar superscript are not significantly different (p>0.05), ^{ijk}Means on the same column with similar superscript are not significantly different (p>0.05), inclusion level of *Moringa* leaf powder: Treatment 1: 0%, Treatment 2: 2.5%, Treatment 3: 5%, Treatment 4: 7.5%, Treatment 5: 10%, TAC: Total aerobic count, TCC: Total coliform counts, TFC: Total fungi counts, SEM: Standard error mean

that a high level of hygiene of the meat and ingredient used in preparing the Suya was observed. The total aerobic count among days showed no significant difference (p>0.05) in all the treatments. It was expected that as the storage days increased, there would be a significant (p<0.05) increase in total aerobic count of suya but this was not so, this suggested that *Moringa* leaf powder contain antimicrobial properties, which inhibits microbial growth. It could also be due to the lowered storage temperature as obtained in the refrigerator, as against the high ambient temperature. Similar trend was obtained in total coliform and fungi count. Bacterial count exceeding 10^5/g or coliform counts higher than 10^2/g in delicate food products are indicative of dangerous contamination[25]. Results obtained in this study revealed that *Moringa* leaf powder significantly (p<0.05) decreased fungi load of suya (tsire). Edema *et al.*[22] reported similar results.

CONCLUSION

This study has shown that TBARS and microbial counts were reduced as the inclusion level of *Moringa oleifera* leaf powder increased. Therefore, the use of *Moringa oleifera* leaf powder up to 10% reduced the rate of lipid oxidation and microbial load of suya (Tsire). The result of this study showed that physico-chemical properties were not adversely affected; TBARS and microbial load were reduced as the inclusion level of *Moringa oleifera* leaf powder increased. Therefore, *Moringa oleifera* leaf powder up to 10% can be used in Suya production to increase its overall quality.

SIGNIFICANCE STATEMENT

This study discovered M*oringa oleifera* leaf powder contained anti-microbial growth and antioxidant activities that can be beneficial to reduces the microbial load and inhibit the onset of oxidative rancidity. This study will help the researchers to uncover the critical areas of M*oringa oleifera* leaf powder as anti-microbial growth and antioxidant.

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