Effect of Different Marinades and Marination Methods on Beef Quality

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Abstract:
There is consumer’s preference for tender meat. The use of tenderizers and antioxidants to soften meat helps to reduce nutrient losses due to prolonged cooking. This study was conducted to compare the effects of four marinades (redwine, Tumeric, Leamon-juice, and distilled water)using different marination method on the quality of beef. One thousand five hundred grams (1500 g) of beef excised from the thigh muscle was cut into twelve whole pieces of similar sizes of 150g and were randomly distributed into replicates in a Factorial design). Treatment groups were randomly allotted to experimental marinades measuring 300mL with each marinade containing 100mL of tenderizers.
Marination spanned for a period of 24 hours at a temperature of 4 °C. Data collected were:proximate composition, oxidative stability, pH of unmarinated and marinated beef, cook losses and percentage cook loss, sensory scores. Results showed that marinades used significantly influenced (P>0.05) moisture content, crude protein,DM, crude fibre, ash. Fat content and NFE were not significantly influenced by marinades used,pH from beef and marinades varied significantly (P<0.05) after marination. Tumeric-based marinades and control produced more (P<0.05) tender beef; and had significantly (P<0.05) better flavour and overall acceptability. It is therefore concluded that distilled water and turmeric based marinads produced beef with the best quality.

Keywords: Redwine, tumeric, lemon juice, beef, marinades, meat quality

1. Introduction
Meat and meat products constitute important sources of protein in man’s diet. Intake of meat and meat products depends on several factors such as socio-economic conditions, ethical issues, religious beliefs and tradition (Font-I-Furnols and Guerrero, 2014). Among all, beef plays an important role in human nutrition providing a source of high quality protein, vitamins and minerals especially iron and zinc (Jensen et al., 2014).

One of the ways to improve the tenderness, juiciness and flavor of cooked meat is by marination. Typically, marinated beef is bathed in a solution or sauce containing ingredients known to increase tenderness and juiciness, and enrich flavor. This often a slow process which involves the passive transport of marinade into meat products by absorption or osmosis. Marination is commonly used to improve the functional and sensory properties of meat by immersion, injecting or tumbling with an aqueous solutions composed of different ingredients (Latif, 2001).

Tenderness of meat products together with juiciness, flavor and color are the main eating quality characteristics that do influence the consumer’s overall judgment of quality (Young 1992).They can be influenced by several production factors (Genetics, feeding system, etc.) and processing techniques (chilling, marination, and cooking) (Palka, 1999). Marination is a traditional culinary technique that is used to tenderize and to improve flavor, juiciness of meat (Lemos et al., 1999).

Meat marination has been known for many years. The selection of marinade ingredients and marinating techniques are constantly improved so that the product obtained meets the expectation of the consumers. Consumers are increasingly aware of diet-related problems and therefore demanding natural ingredients which are expected to be safe and healthy promoting (Fernandez-Lopez et al.,2004).

However, there is a knowledge gap in terms of common antioxidants and tenderizers available for meat processing in Nigeria. Meat processors use plant part and extract that has tenderizing properties for the softening of beef. Some of such
are Redwine, Tumeric and lemon juice. Therefore, this research will be evaluating the effects of these locally utilized tenderizers in marinade solutions using different marination methods on beef quality.

2. Materials and Methods

The experiment was conducted, to compare the effects of four marinades using different marination method injection and immersion made of different locally available tenderizers at the meat processing laboratory of the Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Muscle from the thigh of a freshly slaughtered cattle was harvested and conveyed in a cold container to the laboratory. Also, each marinade was constituted as follows: 100mL of seasoned water, 100mL canola oil and 100mL of marinades. Marinades in respective treatments are as follows: treatment 1, 100mL of distilled water, treatment 2 contained 100mL of lemon juice extract. Collected data includes the Proximate compositions of fresh beef and marinated beef, weights of fresh beef and marinated beef, pH of fresh and marinated beef, percentage loss from beef after refrigeration and cooking, and sensory scores of beef after cooking.

2.1. Cooking Losses and Percentage Cooking Loss of Marinated Beef

The marinated meat samples from each replicates across the experimental treatments were labelled and weighed on a sensitive scale. Samples were cooked in a uniscope laboratory water bath at 70°C for 20min. Cooked weight of samples were taken after allowing samples to cool at room temperature for 2mins. cooking loss percentage was determined as the difference between pre-cooked and post-cooked weights and divided by pre-cooked weights of meat multiplied by 100 (Sanwo et al., 2011).

Cooking Weight Loss = weight before cooking – weight after cooking
Percentage Cook Loss = weight before cooking (g) – weight after cooking (g) X 100
Weight before cooking (g)

2.2. Proximate Composition of Raw and Marinated Meat

Proximate composition will be determined using the method described by (AOAC, 2005)

- Moisture content: moisture content will be determined in triplicate by placing an accurately 5g amount of marinated sample in a pre-weighed porcelain crucible thermostat oven at 105°C for 24hrs until constant weight is obtained. Moisture content will be calculated using the following equation

Moisture content (%) = (initial weight - final weight)/weight of sample X 100

- Ash content: The sample will be subjected to a temperature of 600°C + C in a muffle furnace for 4hrs (AOAC, 2005) after which samples will be removed and kept in a desiccator to cool. Then ash content will be weighed using an electronic balance

- Crude protein content: Kjeldahl method of analysis AOAC, 2005 will be used to determine crude nitrogen present in the marinated beef sample. Then resulting nitrogen will be multiplied by 6.25 to obtain crude protein

- Fat content: fat content will be determined according to the method outlined by Gheisari et al. (2010) and Lee 1996. The following equation will be used to calculate fat content

Fat content (%) = amount of fat extracted from samples (g) X 100
Weight of sample (g)

2.3. Oxidative Stability of Marinated Meat

The lipid oxidation was determined using Thiobarbituric Acid Reactive substances (TBARS) method described by Pensel (1990). Two (2) grams of marinated meat samples from all replicates in the treatment groups were blended separately in 20ml of distilled water using a mortar and a pestile. The slurry was filtered into a conical flask through a Whatman No 1 filter. Then 20ml of 5% trichloroacetic acid in 1.6% m-phosphoric acid solution was added to 5ml of freshly prepared 0.02M Thiobarbituric Acid in each tube and mixed for 4-5seconds. Tubes were stored in the dark for 1hr to develop the colour. The colour intensity was measured using Spectrophotometer at a wavelength of 530nm.

TBA mg (MA) = K x O.D.530nm

where K= 9.242
MA= Malonaldehyde
O.D= Optical Density

2.4. Sensory Score

Panelists converge in the laboratory for a total of three sessions for testing three replications of each treatment. A preliminary briefing session was held with the panelists to explain the meaning of each descriptive term.

Prepared beef meat samples was cut into 3 cm long slices. The slices will then be distributed in white plates and presented to the panelist in random order for evaluation. Bottled water was supplied to the panelist for rinsing between samples. The panelist was asked to score several sensory parameters of the product using 9-point hedonic scales. Panelists asked to indicate how much they like or dislike each product on a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) according to texture, taste, flavour, overall acceptability characteristic as described by
Sanwo et al. (2011). The sensory evaluation was conducted in an appropriately designed and lighted room and a mean score was estimated for each product.

2.5. Statistical Analysis

All data taken after marination of beef were subjected to a 4 × 2 factorial arrangement using SPSS statistical package. Differences was considered to be significant at P<0.05 and significant differences among treatment means, and their interactions was separated by Duncan multiple range test.

3. Results and Discussion

3.1. Chemical Composition and Oxidative Stability of Marinated and Unmarinated Beef

Table 1 shows the chemical composition of unmarinated beef. Table 2 shows Effect of marinades on chemical composition and oxidative stability of marinated beef. Marinade has significant differences (p< 0.05) on moisture, dry matter, Ash, crude fibre and crude protein of marinated beef while Table 3 shows that Marination method had no significant effect (p>0.05) on proximate composition and oxidative stability (Tbars) of marinated beef. Table 4 shows the Interaction effect of treatment and method of marination showed no significant difference p>0.05 in the proximate composition of marinated beef however mean values across treatment tends to be statistically similar.

TBARS were significantly influenced p<0.05 by the interaction of treatment and method of marination. Moisture content in present study showed a decrease after marination in beef marinated with red wine and lemon juice these finding agrees with Leygonie (2012) who also reviewed that the moisture content of meat was decreased during freezing and refrigeration. marinades has significant differences on protein, The increase of protein might be due to synthesis of protein from non-protein nitrogenous substances by resident microorganisms in marinades (Agunbiade et al., 2010).

The TBARS has been widely used to determine the degree of lipid oxidation. (Klangpetch et al., 2016) and used as an index of lipid oxidation in meat products during storage (Fernández-López et al., 1997 and Pearson, 1991). However marinades and marination method had no significant influence on oxidative stability (TBARS) of meat.

| Sample       | Moisture | Dry matter | Fat content | Ash content | Crude fibre | Crude protein | NFE  |
|--------------|----------|------------|-------------|-------------|-------------|---------------|------|
| Raw beef     | 78.4     | 21.6       | 0.10        | 2.01        | 0.4         | 13.98         | 5.11 |

Table 1: Mean Values of Chemical Composition for Beef Meat

| Parameter (%) | Injection | Immersion | SEM |
|---------------|-----------|-----------|-----|
| Moisture      | 77.83±0.385 | 77.50±0.385 | 0.2 |
| Dry matter    | 22.10±0.385 | 22.42±0.385 | 0.2 |
| Fat content   | 0.25±1.000  | 0.25±1.000  | 0.059|
| Ash content   | 1.71±0.096  | 1.83±0.096  | 0.029|
| Crude fibre   | 0.71±0.096  | 0.58±0.096  | 0.051|
| Crude protein | 13.96±1.000 | 13.96±1.000 | 0.161|
| NFE           | 5.42±0.280  | 5.71±0.280  | 0.088|
| MDA(Tbars)    | 0.70±0.257  | 0.94±0.257  | 0.148|

Table 2: Effect of Marination Method on Proximate Composition and Oxidative Stability of Marinated Beef

abc = Means Value with Same Superscript Horizontally Are Not Significantly Different at 5% Level

SEM= Standard Error of Mean

NFE= Nitrogen Free Extract

MDA= Malonaldehyde

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Table 3: Effect of Marination Method on Proximate Composition and Oxidative Stability of Marinated Beef

SEM= Standard Error of Mean

NFE= Nitrogen Free Extract

MDA= Malonaldehyde
Table 4: Shows Interaction Effect of Treatment and Method of Marination on Proximate Composition and Oxidative Stability of Marinated Beef

| Trt Method | Moisture | Dry Matter | Fat Content | Ash Content | Crude Fibre | Crude Protein | NFE | MDA (Tbars) |
|------------|---------|-----------|-------------|-------------|-------------|---------------|-----|-------------|
| 1          | 78.19±1.00 | 21.18±1.000 | 0.30±1.000 | 0.35±0.982 | 13.75±1.00 | 5.44±1.00 | 0.63±0.00 | 0.48±0.00 |
| 2          | 79.07±1.000 | 20.92±1.000 | 0.27±1.000 | 0.50±0.982 | 14.06±1.00 | 5.37±1.00 | 0.74±0.00 | 0.49±0.00 |
| 3          | 78.37±1.000 | 21.62±1.000 | 0.46±1.000 | 0.53±0.982 | 13.46±1.00 | 5.41±1.00 | 0.79±0.00 | 0.49±0.00 |
| 4          | 76.59±1.000 | 23.40±1.000 | 0.42±1.000 | 0.59±0.982 | 14.61±1.00 | 5.96±1.00 | 0.78±0.00 | 0.78±0.00 |
| 5          | 78.00±1.000 | 21.99±1.000 | 0.39±1.000 | 0.55±0.982 | 13.92±1.00 | 5.50±1.00 | 0.92±0.00 | 0.82±0.00 |
| 6          | 76.74±1.000 | 23.25±1.000 | 0.35±1.000 | 0.57±0.982 | 14.76±1.00 | 5.63±1.00 | 1.31±0.00 | 0.93±0.00 |
| 7          | 75.96±1.000 | 24.03±1.000 | 0.42±1.000 | 0.57±0.982 | 15.26±1.00 | 5.77±1.00 | 0.93±0.00 | 0.29±0.00 |

**Table 4:** Shows Interaction Effect of Treatment and Method of Marination on Proximate Composition and Oxidative Stability of Marinated Beef

*ABCD= Means Value with Same Superscript Horizontally Are Not Significantly Different at 5% Level*

*SEM= Standard Error of Mean*

*NFE= Nitrogen Free Extract*

*MDA= Malonaldehyde*

### 3.2. Cooking and Refrigeration Loss

Table 5, shows effect of treatment had no significant (p>0.05) differences in cookloss and percentage cooklosses. Table 6 shows effect of marination method had no significant (p> 0.05) differences on cookloss and percentage cookloss of marinated beef. Table 7 shows Interaction effect of treatment and method of marination had no significant differences (p>0.05) cookloss and percentage cookloss on marinated beef. Cooking loss is actually the loss of water from the outer surface of meat that is expelled out by applying heat treatment. The findings of present study illustrated that varies range of meat for cooking loss among different treatments from ranged from 25.15 to 29.50 %. Highest amount of cooking losses was observed in beef marinated in control while beef marinated in red wine shows lowest amount of cooking loss. It was evident from the data that cooking loss among treatments was non-significant. The
result of present study was congruent with the finding of Aaslyng et al. (2003). They reported that cooking loss can also be related to pH of meat, with decrease in pH the cooking loss increases.

| Parameter | Control | Red wine | Turmeric | Lemon | SEM |
|-----------|---------|----------|----------|-------|-----|
| Initial   | 55.42±0.929 | 55.33±0.929 | 55.17±0.929 | 55.67±0.929 | 0.538 |
| Final     | 39.05±0.319  | 41.47±0.319  | 38.85±0.319  | 40.31±0.319  | 1.099 |
| cook loss | 16.37±0.054  | 13.86±0.054  | 16.32±0.054  | 15.35±0.054  | 0.858 |
| Percentage| 29.50±0.243  | 25.15±0.243  | 29.48±0.243  | 27.72±0.243  | 1.68 |

Table 5: Effect of Treatment on Cook Loss and Percentage Cookloss of Marinated Beef

| Parameter | Injection | Immersion | SEM |
|-----------|-----------|-----------|-----|
| Initial   | 55.54±0.593 | 55.88±0.593 | 0.381 |
| Final     | 40.25±0.552 | 39.59±0.552 | 0.777 |
| Cook loss | 15.28±0.670  | 15.65±0.670  | 0.607 |
| Percentage| 27.57±0.642  | 28.36±0.642  | 1.188 |

Table 6: Effect of Marination Method on Cookloss and Percentage Cook Loss of Marinated Beef

Table 7: Interaction Effects of Treatment and Method on Cookloss of Marinated Beef

3.3. pH of Marinated and Unmarinated Beef

Table 8 shows Effect of Treatment on pH of marinated beef. There were significant differences (p<0.05) among the treatment. Table 9 shows Effect of method on pH of marinated beef. There were no significant difference (p≥0.05) on the initial and final pH of immerssed and injected beef.

Table 10 shows the interaction between treatment and method which had significant differences (p<0.05) on the final pH. The pH of the meat has a special importance in its processing, directly influencing shelf life, color and quality of the meat (Fernandes & Tornberg, 1991; Simela, 2005). pH value of un-marinated beef ranged between 6.30 to 6.31 which agrees with the findings of Khalid et al. (2019) with a pH of 6.00. The lowest value of pH was reached at the samples marinated in marinade consisting of lemon juice with a pH of 3.58 compared to other marinades whose pH falls between 4.71 to 6.15. This is due to the natural acidity of lemon as reported by Ganguly, (2013) caused by citric acid in its composition. The highest value for pH was reached in immersion marination method which is similar with the finding of Gao et al. (2015), who indicated that the tumbling marination stimulates the activity of various proteolytic enzymes. These proteolytic enzymes are known to facilitate the protein degradation of the meat (Lawrie and Ledward, 2006), further increasing the pH value of muscle protein.
### Table 8: Treatment Effect of pH on Marinated Beef

| Parameter | Control | Red Wine | Turmeric | Lemon | SEM |
|-----------|---------|----------|----------|-------|-----|
| Initial   | 6.31±1.00 | 6.30±1.00 | 6.30±1.00 | 6.31±1.00 | 0.063 |
| Final     | 6.15±0.00 | 4.71±0.00 | 5.68±0.00 | 3.58±0.00 | 0.051 |

Note: Means Value With Same Superscript Horizontally Are Not Significantly Different at 5% Level.

### Table 9: Shows Effect of Method on pH of Marinated Beef

| Parameter | Injection | Immersion | SEM |
|-----------|-----------|-----------|-----|
| Initial   | 4.97±0.813 | 5.09±0.813 | 0.025 |
| Final     | 4.97±0.005 | 6.32±0.005 | 0.026 |

SEM = Standard Error of Mean

### Table 10: Interactive Effect of Treatment and Method on pH of Marinated Beef

| Treatment | Control | Red Wine | Turmeric | Lemon | SEM |
|-----------|---------|----------|----------|-------|-----|
| Method 1  | 1       | 2        | 1        | 2     | 1   |
| Method 2  | 1       | 2        | 1        | 2     | 1   |

Note: Means Value with Same Superscript Horizontally Are Not Significantly Different at 5% Level.

3.4 Sensory Scores

Table 11 shows Effect treatment on sensory scores of marinated beef. Treatment (marinade) had significant difference (p<0.05) on sensory scores of colour, juiciness, meaty flavour, tenderness, overall flavour, overall acceptability. Marinades had no significant effect (p>0.05) on saltiness of marinated beef. Table 12 shows Effect of marination method on sensory scores of marinated beef. Marination method had no significant differences (p>0.05) on colour and juiciness of marinated beef. Table 13 shows Interactive effect of treatment and method on sensory scores of marinated beef. The interaction of treatment and method has significant differences (p<0.05) on colour, juiciness, meaty flavour, tenderness, overall flavour and overall acceptability however interaction has no significant differences (p>0.05) on saltiness of marinated beef.

Marinades are sauces that are designed to flavour and tenderise meat and marination is commonly used to improve functional and sensory properties of meat (Latif, 2011). Color score of beef marinated in red wine was significantly lower (5.43) than other marinades. Redwine scored lowest in colour because of anthocyanins produced on the skin of grape used in wine production. However beef marinated in turmeric had the most like colour. This is because turmeric has an attractive yellow colour hence making the colour of beef more acceptable. In addition, from beef marinated in lemon juice were intermediate with respect to colour scores. This is due to the pale look as a result of its low pH after marination. Furthermore beef marinated in lemon juice were least tender and juicy compared to other marinades, which is contrary to the report of Burke et al (2003) who marinated beef shin in 31% of lemon juice and found increase in tenderness and juiciness of the marinated beef. The difference may be as a result of lower percentage of lemon juice used in this experiment which result in lesser proteolysis in the marinated samples thus decreasing water binding ability and solubility of myosin, actin and all other myofibrillar components in the beef (Shuling et al., 2002). Numerically beef marinated in control and turmeric had the best meaty flavour while beef marinated in red wine was the most salty among beef from other marinades. In addition, control and turmeric marinade produced the most tender beef. This is because turmeric produces a natural antioxidant capacity similar to ascorbic acid thereby increasing meat quality (Simone et al., 2015). Curcuma longa rhizome powder, called turmeric, is a spice used in food preparations for its flavour, colour and antioxidant properties due to the presence of curcumin. Curcumin is a curcuminoid and one of the major components of turmeric. It has a primary antioxidant effect against oxygen free radicals as it has the ability to break the oxidant chain reaction by its conjugated structure (Naganuma et al., 2006, Puangsombat et al., 2011; Sharma et al., 2012) also control and turmeric had the best flavour among the experimental marinades while redwine had the poorest flavour this may be due to the alcohol and acids present in the wine. However beef marinated in control and turmeric were the most acceptable.
among other marinades, this is because distilled water and turmeric did not alter most physical properties of beef such as flavour and juiciness as it tenderizes beef compared to other experimental marinades.

### Table 11: Effect of Treatment on Sensory Score of Marinated Beef

| Parameter          | Control          | Red Wine         | Turmeric         | Lemon  | SEM  | P-value |
|--------------------|------------------|------------------|------------------|--------|------|---------|
| Colour             | 6.81±0.000       | 5.43±0.000       | 6.86±0.000       | 5.76±0.000 | 0.167 | 0       |
| Juiciness          | 6.66±0.000       | 4.90±0.000       | 6.36±0.000       | 4.83±0.000 | 0.164 | 0       |
| Meaty flavour      | 6.83±0.000       | 5.10±0.000       | 6.66±0.000       | 5.54±0.000 | 0.155 | 0       |
| Tenderness         | 6.49±0.000       | 5.02±0.000       | 6.20±0.000       | 4.77±0.000 | 0.193 | 0       |
| Saltiness          | 4.60±0.279       | 4.89±0.279       | 4.79±0.279       | 4.58±0.279 | 0.137 | 0.279   |
| Overall flavour    | 6.70±0.000       | 5.20±0.000       | 6.30±0.000       | 5.73±0.000 | 0.175 | 0       |
| Overall acceptability | 6.86±0.000     | 5.07±0.000       | 6.50±0.000       | 5.93±0.000 | 0.162 | 0       |

### Table 12: Effect of Marination Method on Sensory Score of Marinated Beef

| Parameter          | Injection          | Immersion        | SEM  | SEM  |
|--------------------|--------------------|------------------|------|------|
| Colour             | 6.11 ±0.558        | 6.20±0.558       | 0.16 |      |
| Juiciness          | 5.52 ±0.337        | 5.69±0.337       | 0.172|      |
| Meaty flavour      | 5.72± 0.012        | 6.17±0.012       | 0.163|      |
| Tenderness         | 5.31 ±0.026        | 5.76±0.026       | 0.185|      |
| Saltiness          | 4.86 ±0.052        | 4.60±0.052       | 0.131|      |
| Overall flavour    | 5.71± 0.024        | 6.12±0.024       | 0.168|      |
| Overall acceptability | 5.75 ±0.003     | 6.27±0.003       | 0.155|      |

### Table 13: Interaction Effect of Treatment and Method of Marination on Sensory Score of Marinated Beef

| Treatment  | Method   | 1       | 2       | 3       | 4       | SEM  |
|------------|----------|---------|---------|---------|---------|------|
| 1 = Control| Injection| 6.4±0.000 | 6.6±0.000 | 6.4±0.000 | 6.4±0.000 | 0.264 |
| 2 = Redwine| Injection| 6.4±0.000 | 6.6±0.000 | 6.4±0.000 | 6.4±0.000 | 0.232 |
| 3 = Turmeric| Injection| 6.4±0.000 | 6.6±0.000 | 6.4±0.000 | 6.4±0.000 | 0.22  |
| 4 = Lemon Juice| Injection| 6.4±0.000 | 6.6±0.000 | 6.4±0.000 | 6.4±0.000 | 0.249 |

**SEM = Standard Error of Mean**

*Trt 1 = Control, Trt 2 = Redwine, Trt 3 = Turmeric, Trt 4 = Lemon Juice*
4. Conclusion
The study showed that Redwine had the least cookloss and percentage cookloss across all treatments. Colour of marinated beef were significantly influenced by marinades used for marination However lemon juice and turmeric had the most desirable colour, turmeric and distilled water produced the tenderest beef, flavour and overall acceptability. However in terms of sensory scores immersion method of marination had the highest score except for saltiness, Therefore, it could be concluded that the best beef quality can be obtained by immersing beef with control or turmeric based marinades, as they produced beef with the best overall acceptability concerning sensory test after marination compared with other marinade.

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