EFFECT OF UTILISING DIFFERENT CONCENTRATIONS OF FOOD GRADE VINEGAR AS PRESERVATIVE ON THE QUALITY OF BEEF

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ABSTRACT

The influence of different concentrations of food grade vinegar as preservative on beef quality was evaluated in this study. Five levels of vinegar concentrations were tested and each constituted a treatment viz: T0 = (control) Freezer, T1 = 5%, T2 = 4%, T3 = 3%, T4 = 2%, and T5 = 1%. 1.5kg beef was purchased, chilled at 4^{o}C for 24 hours, and apportioned to 6 parts of 250g per treatment. Beef samples were injected with vinegar (25 ml) in each treatment using a hypodermic needle and syringe and were immersed in same concentration in plastic containers and preserved for 14 days. The results indicated that vinegar concentrations significantly ($p<0.05$) affected beef quality factors especially beef in T3 (3%) which furnished lower values of detrimental physical factors; cooking loss (12.23), thermal shortening (5.20) and drip loss (10.40), lipid oxidation mPV (0.11), TBA (0.22), microbial load TVC (4.60), TCC (3.29), TFC (2.38) and TAC (3.43) relative to other levels of vinegar concentrations. The same treatment (T3) elicited higher, cooking yield (87.77), raw meat colour (6.00), protein (20.47), flavour (6.70), texture (6.87) and overall acceptability (7.67) in comparison with other treatments of vinegar. It was recommended therefore; 3% vinegar could be utilized to preserve beef since it enlisted high shelf-life quality factors and acceptability.

Keywords: *Beef, food-grade, preservation, quality, vinegar concentration.*

INTRODUCTION

Meat is very rich in energy and preferred by consumers due to its high nutritive value of quality protein, vitamins and minerals (Jamilah *et al.,* 2008). However, as nutritious as meat is, it has reduced life span even less than a day under room temperature of 15 to 30^{o}C and few days at refrigerated temperature of 0 – 10^{o}C due to spoilage especially when preserved (Insausti et al., 2001). Fresh meat has particular chemical and biological traits, while its components attract microbes which continue immediately after exsanguination till it is consumed, and eventually its life span is cut short and may be strongly influenced by initial beef microbial status, packaging materials and storage conditions (Eneji *et al.,* 2007).

The life span of fresh meat depends on many conditions including the acidity or basicity (pH), water activity, growth of microorganisms and temperature (Holley *et al.,* 2004). The value of pH of meat differs ranging from 4.8 – 7.2 according to the content of glycogen in the live

animal before slaughter, however the optimal pH varies from 5.4 – 6.0 and as pH becomes higher in meat, the binding properties of water also increases, while low pH promotes oxidation of haem pigments thereby affecting the meat colour (Miller, 2001; Abril *et al*., 2002). The activity of water (a_w) which constitutes the amount of water that is not physically or chemically attached as well as the water available for deteriorative changes from microbial activities in meat is a very essential factor during preservation and in the maintenance of meat quality (Young *et al.,* 2001; Pharm, 2001).

Effectiveness of vinegar as anti-microbial differs widely due to its concentration, pH and molarity, hence its usage in reducing bacteria population on carcasses and in extending the shelf-life of meat (Jamilah *et al.,* 2008). It was reported by Eniolorunda *et al.* (2014) that beef properties appeared preferable when it was preserved with 5% vinegar. However, the scores for most eating qualities such as flavour and colour that are foremost traits in meat quality and acceptability assessment were very low. This study was carried out therefore, to investigate the effect of using lower levels of vinegar on the physicochemical, keeping and organoleptic properties of beef.

MATERIALS AND METHODS

Location of study

This research work was conducted in the Department of Animal Productions Meat Science Laboratory of the Olabisi Onabanjo University, Ayetoro Campus, Ogun State.

Vinegar

Vinegar (1 litre) was purchased from Jaagee Science, Chemicals and Technology Equipment Supplies, Ibadan, Oyo State. The acid was prepared into 5% (5 ml into 100 ml distilled water), 4% (4 ml into 100 ml distilled water), 3% (3ml into 100 ml distilled water) 2 % (2 ml into 100 ml distilled water) and 1% (1 ml into 100 ml distilled water) respectively. Each level of vinegar represented a treatment and it was used to preserve 250 g of beef while the meat used as control was preserved in a freezer (Tropical Freezer Model Senior Master 7.5kg/24h capacity by Hangzhou Qianjlang Refrigerator Group Co. Ltd, China).

Meat samples

Beef from White Fulani (*Bos indicus*) spent cow weighing 1.5 kg was purchased at Ayetoro slaughter slab. The meat samples (except control which was immersed in distilled water) were chilled at 4^{o}C for 24 hours and were injected with 25 mls of each corresponding vinegar concentration using a needle and syringe and further immersed in closed plastic containers with the same respective vinegar levels except the control. The arrangement of the treatments was as follows:

T0: Control 250g beef in freezer at -18^{o}C; T1: 250g beef with 5% vinegar
T2: 250g beef with 4% vinegar; T3: 250g beef with 3% vinegar
T4: 250g beef with 2% vinegar; T5: 250g beef with 1% vinegar

The meat samples were preserved in the laboratory for 14 days at the end of which samples were removed for physical, proximate, pH, microbial and sensory analysis.

Physical analysis of meat

Raw meat colour: This was determined using visual colour intensity (redness) on a scale ranging from 1 to 8 (AMSA, 2012) with higher scores representing more attractive and homogenous red colour. The meat from each treatment were displayed in a tray and the meat colour was evaluated by a 10-member sensory panel.

Cooking Loss: 10 g meat samples of 6 cm in length were removed from each treatment; wrapped in polythene bags and boiled in a preheated cooking pot for 20 mins on a Pifco Japan Electric hot plate model – No ECP 202 till the meat samples were heated to 72^{o}C temperature. The meat samples were removed and allowed to cool to room temperature (27^{o}C). They were reweighed and their cooking losses calculated (Malgorzota *et al.,* 2005) thus:

$$\text{Cooking loss} = \frac{Wt_{m1} - Wt_{m2}}{Wt_{m1}} \times 100$$

Where:
Wt_{m1} = *Initial weight of meat (g)*
Wt_{m2} = *Final weight of meat (g)*

Thermal shortening: The same meat samples utilized for cooking loss were also used to measure thermal shortening. The lengths of meat samples were re-measured after boiling and the final length recorded using a metal rule (Apata, *2011*). Thermal shortening of meat samples was calculated as:

$$\textit{Thermal shortening} = \frac{L_{m1} - L_{m2}}{L_{m1}} \times 100$$

Where:
L_{m1} = *Initial length (cm)*
L_{m2} = *Final length (cm)*

Drip loss: This variable was determined by suspending weighed meat samples (10g) from each treatment in polythene bags which were hung in a refrigerator at 4°C for meat samples exudate to drip into the bags. Meat samples were removed after 48 hrs and the surface moisture was eliminated with an absorbing paper before they were re-weighed as well as the exudate. The drip loss

$$\textit{Drip loss} = \frac{Wtp_1 + j - Wp_1}{Wtp_2 + m - Wtp_2} \times 100$$

Where:
Wtp + j = Initial weight of paper + juice (g)
Wtp1 = Initial weight of paper (g)
Wtp2 + m = Final weight of paper + meat (g)
Wtp2 = Final weight of paper (g).

Shear force: The shear force of beef was determined according to of Honikel (1998), Malgorzota *et al* .(2005) and Qiaofen and Da-Wen (2005). Ten (10) g of beef from individual treatments were enwrapped in airtight nylon containers, boiled in a cooking pot for 20 minutes using an electric plate (Pifco Japan No ECP 202) until their geometric centre temperature of 72°C was reached. The meat samples were evacuated and cooled to ambient temperature of 27°C. The meat core of 1.50 cm was made using manual coring device (Apata, 2011). The meat samples were shared at three locations using Warner – Bratzler V-notch shearing instrument (Test Resources (TR) USA).

Proximate composition: Proximate composition was carried out following the procedures of AOAC (2002)..

Moisture of meat: 2g of meat samples from each treatment were oven dried at 105°C for 24 hours till a constant weight was obtained and calculated thus:

$$\textit{Moisture (\%)} = \frac{M_{wt1} - M_{wt2}}{M_{wt1}} \times 100$$

Where
M_{wt1} = *Initial weight of meat*
M_{wt2} = *Final weight of meat*

Crude protein: The crude protein values of meat samples were determined with *Kjedahl* procedures. The actual crude protein values of the meat samples were obtained by converting Nitrogen content of meat with constant 6.25, then crude protein was obtained thus: (6.25 x N%).

Ether extract (Fat): This was obtained using the method of Soxhlet extraction with petroleum

$$\textit{Oil (fat)} = \frac{W_{t0} - M_{wt2}}{W_{tm}} \times 100$$

Where
W_{t0} = *Weight of oil*
W_{tm} = *Weight of meat*

Ash content: It was determined by igniting 2g of ground meat samples in a Muffle furnace at 600°C for 4 hours until ashes were formed after 4 hours, and the values of ash were obtained as:

$$Ash = \frac{Weight\ of\ ash}{Weight\ of\ meat} \text{x } 100$$

Nitrogen free extract (NFE): The values for this variable were determined using mathematical calculation. Thus, (100% - values of moisture, protein, ether extract and ash).

Meat samples pH: 10g of meat samples from each treatment were homogenized for 5minutes with 90 ml distilled water using laboratory mixer model 242 NAKAI JAPAN with 5 mm blade. The meat pH was measured using a micro computer pH meter model H18424, HAVANNA INSTRUMENTS, ROMANIA following the method of Marchiori and de Felicio (2003).

Lipid oxidation

This was determined with Thiobarbituric acid (TBA) and Modified Peroxide Value (mPV) tests following the procedures of Pensel (1990) and AOAC, 2002, respectively. A 5g of coursely ground unrendered meat fat (breast fat) sample from each treatment was placed in a polyethylene bag. An additional empty polyethylene bag was prepared as a blank and 50ml of cold 20% Trichloro vinegar (TCA) (2±2°C) and 1.6% m-phosphoric acid mixture were added to each meat sample in the polyethylene bags and ground in a 5mm blender (NAKAI JAPAN mixer Model 242) for 2 minutes. 50ml of cold distilled water (2±2°C) was added into each bag and the contents blended for an additional 30 seconds. The slurry was filtered with Whatman No 1 filter paper to remove the debris. 5.0ml of the filtrate was added to 5.0ml of freshly prepared 0.02M – thiobarbituric acid and mixed thoroughly for 5seconds. The samples were stored in the dark cupboard at room temperature of 29 °C for 15 hours until the colour developed. The colour was measured using a Gilford Response UV-VIS spectrophotometer (Ciba Corning Diagnostic CO, Oberlin Ohio, USA) at 530mm wavelength.

Modified Peroxide Value (mPV) was determined following the procedures of AOAC (2002) using 5g meat sample from each treatment at preservation period of 14 days blended and extracted with 30ml of ice cold vinegar: chloroform mixture (ratio 1:1) which was vigorously swirled. 0.5ml of saturated potassium iodide (K1) was added, 30ml distilled water was added subsequently and the solution mixed thoroughly. The mixture was allowed to stand for 10minutes at room temperature (29°C) in a dark cupboard and was titrated with 0.01 sodium thiosulphate ($Na_2S_2O_3$) gradually with vigorous shaking. 0.5ml starch indicator (1% starch + 0.3% chloroform) was added. When the pale yellow colour of upper aqueous layer disappeared, the end point was recorded. The mPV was calculated thus:

$$mPV = \frac{(S)(N)(100)}{N}$$

Where:
mPV = Modified peroxide value (meq/gfat)
S = Sulphate salt
N = Normality of Sulphate salt (0.01).

Microbiological analysis

10g of meat samples were blended with 90 ml of distilled water to determine microbial loads of meats following the procedures of American Public Health Association (APHA, 1992) and Association of Official and Analytical Chemist (AOAC, 2002). 10 g of beef from each treatment were blended with 90 ml of 0.1% peptone water for 60 seconds using a laboratory mincer (plate 5 mm, model 242, Nakai Co, Japan). 9 ml of distilled water was pipette into clean test tubes covered with cotton wool and aluminium foil and autoclaved at 121°C for 15 minutes. 1 ml of homogenized beef sample was used from each treatment for serial dilution of between 10^{-1} to 10^{-4} and they were spread on duplicate petri-dishes. Bacteria numbers were determined on plates bearing colonies. Aerobic plate counts (TVC) were obtained on plate count agar (DIFCO, USA) incubated at 32°C for 4 hours. Enterobacteria count (TCC) on violet red bile agar (DIFCO USA) and was overlaid with same me-

dium and incubated at 37°C for 24 hours and for total fungal count (TFC) was on potato dextrose agar (FLUKA/LABLEMCO, UK) which was inverted and incubated at 28 – 30°C for 5 days. The macroscopic and microscopic observations of the colonies were carried out after incubation using high power objective with immersion oil using an Olympus microscope (Model 210 – 230, NY, USA). The colonies were counted on each plate and expressed as cfu/g of samples.

Organoleptic analysis: This was carried out using a ten member taste panel following the procedures of AMSA (2015). The panelists were drawn from students of Animal Production Department, Olabisi Onabanjo University Ayetoro Campus. They were semi-trained and provided unsalted cracker biscuits and water for use in between meat samples from each treatment. The meat samples were coded and presented sequentially to the panelists on a clean saucer after boiling for 20 mins and were evaluated independently of the other. The panelists rated the meat samples for colour, flavour, tenderness, juiciness, texture and overall acceptability on a 9-point hedonic scale on which 1 = dislike extremely and 9 = like extremely.

Experimental design and statistical analysis: Completely randomized design (CRD) was used for this study. The treatments were replicated thrice and all data collected were analysed statistically with analysis of variance (ANOVA) using the statistical tool of SAS, (2002). Significant means were separated with Duncan's multiple range test of the same analytical system at ($p<0.05$).

RESULTS AND DISCUSSION

There were significant ($p<0.05$) differences in the physical properties of beef preserved with different concentrations of vinegar (Table 1). The colour of raw beef increased as the concentrations of vinegar increased up to 6.00 ($p<0.05$) scores (T3, T4 and T5) and compared favourably with the colour of beef preferred in freezer. Treatments 1 to 3 had higher ($p<0.05$) cooking yield, lower ($p<0.05$) cooking loss, thermal shortening, drip loss percentages and shearforce values while T4 and T5 furnished lower yield and high cooking and drip losses as well as thermal shortening and shearforce values. It was observed that though, T1 had higher ($p<0.05$) yield value and lower values for cooking loss, drip loss, thermal shortening and shearforce, the colour score for meat samples in this treatment was rather too low as a result of high volume of vinegar compared to what was obtained in T3, T4 and T5 respectively. These results therefore confirmed the report of Eniolorunda *et al.* (2014) that at 5% concentration of vinegar the meat colour was very low in intensity, the preserved meat colour did not depreciate beyond consumable level, and moreover, the purpose of improving the shelf-life of meat was achieved

Table 1: Physical properties of preserved beef as affected by different concentrations of vinegar

	Treatments					
Variable	T0	T1	T2	T3	T4	T5
COL (%)	7.00±0.17^{a}	2.00±1.80^{d}	3.00±0.75^{c}	6.00±0.10^{b}	6.00±0.10^{b}	6.00±0.10^{b}
CKL (%)	20.33±0.06^{a}	10.87±0.23^{d}	12.20±0.46^{c}	12.23±0.35^{c}	15.17±0.67^{b}	15.70±0.55^{b}
CKY (%)	79.67±0.12^{d}	89.13±0.36^{a}	87.80±0.25^{b}	87.77±0.10^{b}	84.83±0.12^{c}	84.30±0.06^{c}
THS (%)	10.70±0.20^{a}	5.33±0.06^{c}	5.57±0.06^{c}	5.20±0.17^{c}	8.27±0.21^{b}	8.03±0.50^{b}
DPL (%)	15.27±0.75^{a}	8.23±0.20^{d}	10.33±0.44^{c}	10.40±0.36^{c}	12.57±0.50^{b}	12.60±0.52^{b}
SHF (%)	5.70±0.06^{a}	4.20±0.03^{b}	4.35±1.15^{b}	4.37±1.90^{b}	5.63±0.75^{a}	5.65±1.10^{a}

Means on the same row with different superscripts are statistically significant ($p<0.05$)
COL = Colour, CKL = Cooking Loss, CKY = Cooking Yield, THS = Thermal Shortening, DPL = Driploss, SHF = Shearforce

according to Apata *et al*. (2014). The report of Jamilah *et al* . (2008) also indicated that concentration of 3% vinegar was quite effective in extending the shelf life of beef with rather better colour, therefore, the concentration of vinegar can be decreased to 3% for more attractive meat and effective preservation.

For any meat to be accepted by consumer, colour plays a vital role besides palatability factors. This is due to the fact that appearance of meat if attractive, invites consumers. That is the more reason why meat colour stability over periods of preservation has to be monitored and the medium of preservation should be certain that it supports meat colour intensity as reported by Apata (2011). Another important aspect of meat preservation is that of yield. It is very useful in determining whether the medium of preservation prevents drips or draining of the meat for its nutrients at the end of the storage time.

It was observed in this study that the yield of meat samples preserved with vinegar did not shrink beyond the expected limit as reported by Eniolorunda *et al.* (2014) which was between 50 – 70%. This showed that commercial meat vendors could utilize vinegar to preserve the leftover meat with 3% vinegar without serious deleterious consequences coupled with higher yield as a result of little or no nutrients drainage as vinegar kept the meat cells intact through the preservation periods.

It was observed that figures for protein and ash increased in T2 and T3 (Table 2) as the values of moisture contents and pH were lower ($p<0.05$). It might be because protein and ash became concentrated because moisture content was lower in these treatments (Mikel *et al.,* 1996) who postulated that protein and ash content of meat become increased and moisture reduced due to the action of vinegar that might have acted to shrink the meat thereby draining the moisture in the meat into acid solution in which it was immersed. It was observed that fat values were lower ($p<0.05$) in meat samples in treatments 1, 2 and 3 when compared to the values obtained for T4 and T5. These high values in T4 and T5 could have been due to broken down fat by vinegar at higher concentrations in these treatments thus confirming the report of Reinagel (2009) and Tomoo *et al.* (2009). The increase in the value of moisture in T4 and T5 could be as a result of the hygroscopic activity of vinegar which therefore coagulated crude protein as well as fat and increased pH of the meat. This condition stabilized the preserved meat and increased its quality status (Jamilah *et al.,* 2008). Moisture content of any meat samples enhances yield, water holding capacity, tenderness while in addition to marbling also increase meat juiciness, therefore reasonable amount of moisture is required in any meat for it to be accepted more by consumers. It was observed in this study that beef preserved with vinegar maintained high

Table 2: Proximate composition and pH of beef preserved with different concentrations of vinegar

	Treatments					
Variables	T0	T1	T2	T3	T4	T5
MC (%)	60.19±0.34^{b}	53.89±0.37^{f}	55.39±0.54^{d}	57.04±0.22^{d}	60.20±0.58^{c}	61.33±0.53^{a}
CP (%)	20.70±0.24^{a}	20.61±0.20^{a}	20.53±0.45^{a}	20.47±0.17^{a}	19.33±0.36^{b}	19.24±0.25^{b}
EE (%)	4.68±0.07^{d}	5.48±0.09^{c}	6.57±0.12^{b}	6.55±0.10^{b}	7.60±0.17^{a}	7.62±0.10^{a}
Ash (%)	2.24±0.09^{a}	2.20±0.05^{a}	2.27±0.05^{a}	2.24±0.09^{a}	1.16±0.07^{b}	1.17±0.07^{b}
NFE (%)	11.19±0.08^{d}	17.82±0.06^{a}	15.24±0.05^{b}	13.70±0.07^{c}	11.71±0.07^{d}	10.64±0.01^{e}
pH (%)	4.65±0.19^{b}	3.53±0.14^{c}	4.57±0.09^{b}	4.62±0.09^{b}	5.63±0.13^{a}	5.67±0.07^{a}

Means on the same row with different superscripts are statistically significant ($p<0.05$)
MC = Moisture content, CP = Crude protein, EE = Ether extract, NFE = Nitrogen free extract

level of moisture which made for high texture and acceptability (Eniolorunda *et al.,* 2014). Protein is one of the main reasons for meat consumption and any preservative media for meat should conserve protein in meat for use by man. In this study, protein was not adversely affected by vinegar used as preservative medium as protein was kept not below the normal level needed by consumers in meat which varies from 19 to 23% depending on the species of the animal (Rabia *et al.,* 2018).

The pH of preserved beef with vinegar was not too high to sustain the quality factors of the meat. Meat pH is important as it partly determine the colour and meat quality types either to be pale soft exudative (PSE) or dark firm and dried (DFD) meat. In this study, it was observed that the pH values of beef ranged from 4.65 to 5.67 with the exception of beef preserved with 5% vinegar that fell below the stated range. The fact that the microbial loads of the preserved beef were lower and the eating properties were higher revealed that the pH of the preserved beef was normal and better for meat preserved with vinegar especially at 4.6 to prevent or decrease the growth of pathogenic bacteria on the meat (Sarker *et al.,* 2021).

Table 3: Lipid oxidation values of beef preserved with different concentrations of vinegar

Treatments	Variables	
	mPV(meq/kg)	TBA (mgMA/kg)
T0	0.13 ± 0.02^{bx}	0.23 ± 0.12^{ax}
T1	0.11 ± 0.01^{bz}	0.21 ± 0.10^{az}
T2	0.11 ± 0.01^{bz}	0.22 ± 0.10^{ay}
T3	0.11 ± 0.01^{bz}	0.22 ± 0.10^{ay}
T4	0.12 ± 0.10^{by}	0.22 ± 0.10^{ay}
T5	0.12 ± 0.02^{by}	0.23 ± 0.12^{ax}

[abxy]Means on the same row or column with different superscripts are statistically significant (p<0.05)
mpv = Modified Peroxide Value, tba = Thiobarbituric acid

The thiobarbituric acid (TBA) values increased (Table 3) above those of modified peroxide values in this study, but both TBA and peroxide values were lower ($p<0.05$) in treatments 1, 2 and 3 respectively while they were higher ($p<0.05$) in T4 and T5. The degree of fat decomposition was lower ($p<0.05$) in treatments 1, 2 and 3 probably due to slight increase in concentration of vinegar which might have prevented the enzymatic reactions in the meat which were observed in T0, T4 and T5 due to lower concentration of the vinegar and higher moisture content in meat samples as reported by Shahidi (1994) who opined that there is an inverse relationship between moisture and fat; when there is increase in moisture content in meat breakdown of meat content is facilitated due to increased enzymatic and bacterial activities but the reverse is the case when the acidity of meat is higher and the moisture is drained out of the meat hence, less lipolytic activities of enzymes and micro-organisms (Apata *et al*., 2014). However both TBA and peroxide values were relatively high (Li *et al.,* 2012*;* Rahman *et al.,* 2015) but not exceeding the values that are acceptable for beef consumption (Rahman *et al*., 2014). The level or degree of rancidity in meat is evaluated by the use of lipid oxidation to measure the extent of fat breakdown using either modified peroxide (mPV) or thiobarbituric acid (TBARS) values. Vinegar is a liquid solution and one of the most typical picking agent and it preserves meat by altering water activities or pH thereby prolonging the shelf-life of the meat by inhibiting rancidity (Vaishali *et al.,* 2019).

Significant were observed in the microbiological status of meat preserved with different concentrations of vinegar for 14 days (Table 4). Total viable count (TVC) was higher ($p<0.05$) on the meat samples compared with other organisms, while total fungal count (TFC) was least ($p<0.05$), but the values of microbial loads of organisms in treatments 1, 2 and 3 were lower ($p<0.05$) and compared favourably with those in T0, however microbial loads increased in Treatments 4 and 5. The increase in TVC above other organisms in this study is in line with the report

Table 4: Microbiological properties of preserved beef as affected by different concentrations of vinegar

	Treatments					
Variable	T0	T1	T2	T3	T4	T5
TVC	$4.43x10^{5bx}$	$4.50x10^{5bx}$	$4.55x10^{5bx}$	$4.60x10^{5bx}$	$5.63x10^{5ax}$	$5.67x10^{5ax}$
TCC	$3.20x10^{5by}$	$3.25x10^{5by}$	$3.27x10^{5by}$	$3.29x10^{5by}$	$4.33x10^{5ay}$	$4.35x10^{5ay}$
TFC	$2.20x10^{4bz}$	$2.30x10^{4bz}$	$2.35x10^{5bz}$	$2.38x10^{4bz}$	$3.45x10^{4az}$	$3.47x10^{4az}$
TAC	$2.10x10^{3cz}$	$3.39x10^{3by}$	$3.37x10^{5by}$	$3.43x10^{3by}$	$4.63x10^{3ay}$	$4.65x10^{3ay}$

^{abxyz}Means on the same row or column with different superscripts are statistically signicant ($p<0.05$)
TVC = Total viable count, TCC = Total coliform count, TFC = Total fungal count,
TAC = Total anaerobic count.

Table 5: Organoleptic properties of preserved beef as influenced by different concentrations of vinegar

	Treatments					
Variables	T0	T1	T2	T3	T4	T5
COL	7.00 ± 0.50^{a}	4.00 ± 0.53^{c}	5.00 ± 0.42^{b}	7.00 ± 1.25^{a}	7.00 ± 0.23^{a}	7.00 ± 0.42^{a}
FLV	5.43 ± 0.46^{b}	3.33 ± 0.76^{d}	4.67 ± 0.31^{c}	6.70 ± 0.35^{a}	5.53 ± 1.27^{b}	5.47 ± 0.50^{b}
TDN	5.33 ± 1.70^{c}	4.20 ± 0.15^{d}	4.37 ± 0.20^{c}	5.27 ± 0.50^{c}	6.23 ± 0.04^{b}	7.20 ± 0.53^{a}
JCN	5.40 ± 0.87^{b}	4.23 ± 0.50^{c}	4.33 ± 0.46^{c}	5.40 ± 0.35^{b}	5.27 ± 1.42^{b}	6.33 ± 1.01^{a}
TEX	5.60 ± 0.20^{b}	4.57 ± 1.06^{c}	4.53 ± 1.21^{b}	6.87 ± 0.70^{a}	5.20 ± 1.17^{b}	5.63 ± 1.10^{b}
OA	6.33 ± 0.90^{b}	3.23 ± 0.10^{e}	4.40 ± 0.33^{d}	7.67 ± 0.42^{a}	5.20 ± 0.76^{c}	6.50 ± 0.20^{b}

^{abcd}Means on the same row with different superscripts are statistically significant ($p<0.05$)
COL = Colour, FLV = Flavour, TDN = Tenderness, JCN = Juiciness, TEX = Texture, OA = Overall Acceptability

of Apata *et al*. (2013) however, the significant increase in values of micro-organisms at T4 and T5 could be due to acid decomposition and decrease in hydrogen potential thereby accommodating more organisms, but not above the tolerable level for beef consumption (Insausti*, et al., 2001*) who reported that meat under preservation would still be consumable when the total microbial load is up to 10^{10} cfu/g but not above. In this study the highest microbial load observed was 10^{5} cfu/g of meat which indicated that the meat was still wholesome and safe for consumption.

The organoleptic scores of beef preserved with different concentrations of vinegar are presented on Table 5. There were significant ($p<0.05$) differences in the eating qualities of the meat across the treatments T3, T4 and T5 compared with T0 (control) for colour, flavour and texture while T3 furnished higher overall acceptability due to its higher ($p<0.05$) colour, flavour, juiciness and texture. Colour, flavour, juiciness and perhaps texture are the major factors that motivate acceptability of any food, meat inclusive (Apata *et al.,* 2014). Also, lower levels of microbes and fat could have contributed immensely to the eating quality of meat in this study rather than colour which was relatively lower in the meat. This means that the acceptability of any meat is not limited to the qualities mentioned above but to the overall inherent traits of the meat for acceptability and consumption. If any of them is lacking or inadequate, the meat might be rejected. Therefore the results of sensory characteristics and overall acceptability of preserved beef using vinegar in this study agreed

with their findings and report of Sarker *et al.* (2021) who reported the effective preservation of meat using food grade vinegar.

CONCLUSION

It is very pertinent to prolong the life span of fresh beef in order to provide wholesome meat and this can be done by the use of vinegar. In this study, different concentrations of vinegar were tested that is, 5, 4, 3, 2 and 1% but, 3% (T3) was found to have furnished better beef quality factors especially colour and flavour and compared well with T0 (control) and other treatments. It is recommended therefore, that fresh beef could be preserved with 3% vinegar with better results and without any jeopardizing effects on the consumers.

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