

## Effect of Delayed Chilling Regimes on the Physicochemical Microbiological and Sensory Properties of Beef from N'dama Cattle

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### ABSTRACT

**Purpose :** This study was carried out to investigate the effect of delayed chilling regimes on quality of beef from N'dama cattle due to non-availability or epileptic supply of electricity, as well as non provision of chilling facilities at the slaughter house at Ayetoro town in Ogun State, Nigeria.

**Research Method :** Three kilogrammes of beef (thigh cut) of freshly slaughtered N'dama bull cattle was purchased and subdivided into six parts of 500g, each portion represented a chilling regime or treatment in a randomized experiment as follows: T0 = Immediate (Control), T1 = Chilling after 2hours delay, T2 = chilling after 4hours delay, T3 = chilling after 6hours delay, T4 = chilling after 8hours delay, T5 = chilling after 10hours delay and were chilled at 40C for 24 hours in a refrigerator and were removed for physical, chemical, microbiological and sensory quality analysis at  $p < 0.05$ .

**Findings :** The result showed that there were significant differences in the physical, chemical, microbiological as well as sensory characteristics of the meat irrespective of the chilling regime. Meat colour, water holding capacity, cooking yield, fat, ash, flavor, tenderness, juiciness, texture and over all acceptability of the meat decreased ( $p < 0.05$ ) as the delayed in time increased after 4hours.

**Research Limitation :** This study was limited to the use of beef from N'dama bull cattle at Ayetoro, the headquarters of Yewa North Local Government Area in Ogun State, Nigeria. This was due to the fact that N'dama bull cattle are very common and often slaughter at this point.

**Originality/value :** It was recommended based on the results from this study that beef from N'dama bull cattle should be chilled for 4 hours after slaughter otherwise its quality will deplete which might render the meat to be unacceptable to the consumers.

**Keywords:** Delayed chilling, beef, N'dama cattle, physicochemical, sensory

### INTRODUCTION

Meat and meat products are consumed in almost all communities of the world as it adjudged the richest source of protein (Williams *et al*; 2006). However, it gets easily contaminated by pathogenic microorganisms immediately after slaughter, and therefore, it is important to make meat and meat products safe and wholesome right from the slaughter and processing stages (Singh and Sachan, 2010). The most important and essential step in maintaining meat quality is chilling. It is the method of keeping fresh meat cold enough in order to reduce most of the thermophilic pathogenic micro-organisms

before deboning the meat and it is appropriate in the production of wholesome fresh meat (Van Moeseke *et al*; 2001, Savell *et al*, 2005). In most developing countries, fresh carcasses and meat are not usually chilled at abattoirs

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after slaughter, instead meat is displayed for several hours in the day by local butchers and exposed to environmental dirt which speed up microbial building on the meat and invoke its rapid deterioration (Singh and Sachan, 2010). Chilling of meat is usually at temperatures between 4-7°C for 24 hours for muscle to undergo conversion to meat (Razminovicz *et al.*; 2008). Delayed chilling which is, holding meat carcasses at 15°C for 90 mins before normal chilling had been reported to have characteristic effects on meat quality (Bewater, 2001). Fresh meat carcasses and primal cuts quality are compromised without chilling as maximum meat safety and optimized eating quality are not guaranteed (MPSC, 2012). The aim of this study was to investigate the effect of chilling quality factors of beef with the view to filling the gap in literature.

## MATERIALS AND METHODS

This study was carried out at the Meat Science Laboratory in the Department of Animal Production College of Agricultural Sciences, Olabisi Onabanjo University, Ayetoro Campus, Ogun State. Three kilograms of beef from the high cut of freshly slaughtered N'dama bull was purchased from slaughter slab at Ayetoro, Ogun State and used for this study. The meat was sub-divided into 6 portions of 500g; each portion represented a chilling treatment as follows: T0 = Immediate chilling T1 = Chilling after 2 hours delay, T2 = Chilling after 4 hours delay; T3 = Chilling after 6 hours delay; T4 = Chilling after 8 hours delay; T5 = Chilling after 10 hours delay. The meat was cut and weighed and samples for T0 were chilled immediately. Meat samples for T1-T5 were hung on retort stands prior to chilling after 2, 4, 6, 8 and 10 hours delay and were chilled at 4°C for 24 hours and were removed one after the other for quality assessment (Razminowicz *et al.*, 2008).

## Physical characteristics of chilled meat

**Cooking loss:** This meat variable was measured by broiling 250g meat samples wrapped in aluminum foil paper in an oven for 20 minutes turned at an interval of 10 minutes of broiling until the geometric centre of the meat samples was heated to 72°C according to Honikel (1998). Meat samples were removed from the Oven and allowed to equilibrate to room temperature (27°C) and the meat samples were reweighed and cooking loss calculated thus:

$$\text{Cooking Loss} = \frac{\text{Initial meat Weight} - \text{Final Meat Weight}}{\text{Weight of raw meat after thawing}} \times 100$$

**Drip loss:** This was determined following the procedures of Insausti *et al.*, (2001) weight of empty polythene bags were taken (Wp) and meat sample 10g was weighed and put into the bags (Wp+m) and stored in a refrigerator at 4°C for 24 hours. The meat samples were removed from the refrigerator and the weight of the bags plus the juice drained by the meat samples were measured (Wp+j). The drip loss was calculated as the percentage of the initial weight of the meat samples thus:

$$\text{Drip loss} = \frac{(Wp+j) - (Wp)}{(Wp+m) - (Wp)} \times 100$$

**Thermal shortening:** Thermal shortening of the meat samples was determined using the same meat samples used to measure cooking loss. The length of the meat samples was remeasured after broiling for 20 minutes and cooking to room temperature. The difference in length was expressed as thermal shortening according to Honikel (1998)

$$\text{Thermal shortening} = \frac{\text{Initial length of meat} - \text{final length of meat}}{\text{Initial length of meat}} \times 100$$

**Cold Shortening:** The length of meat samples were measured prior and after 24 hours of chilling and the difference in the length measurement of meat samples was expressed as a percentage reduction in the original length of meat samples according to Kings *et al.*, (2003) thus

Cold shortening: =

$$\frac{\text{Length of meat before chilling} - \text{length of meat after chilling}}{\text{Length of meat before chilling}} \times 100$$

**Cooking yield:** Cooking or percentage yield of meat was determined arithmetically following the procedures of Aduku and Olukoji (2000).

$$\text{This cooking yield} = \frac{\text{Weight of broiled meat}}{\text{Weight of fresh meat}} \times 100$$

**Raw meat colour:** This was determined using visual method described by AMSA (2012). Chilled meat samples were displayed on a tray and meat colour values were determined based on colour intensity (redness) and homogeneity using a colour scale ranging from 1 – 8 where higher score represented a more homogenous red colour.

**Water holding capacity:** This is determined using press method described by (Walukonis *et al.*, 2002). An approximately 1g of meat sample was placed between two 9cm Whatman No 1 filter paper (Model C, Caver Inc. Wabash, USA) which was previously weighed and the meat sample and the filter papers were pressed between 10.2 x 10.2cm<sup>2</sup> plexiglass at about 35.2kg/cm<sup>3</sup> absolute pressure for 1 minute with a vice. The meat samples were removed and both the meat and wetted filter papers were reweighed. Thus

$$\text{WHC} = \frac{\text{Weight of Wet Paper} - \text{Weight of dry paper}}{\text{Weight of Pressed meat}} \times 100$$

**pH of Meat:** The pH of meat samples was taken after 24hours of chilling regimes. 10g of meat sample was homogenized for 5 minutes with 90ml of distilled water with a blender (plate 5mm) of model 242, Nakai Japan. The meat pH was measured with a pH meter model H18424 microcomputer, Havanna Instruments, Romania following the procedures of Marchiori and Defelicio (2003).

**Shear force:** 10g of meat samples were measured out and wrapped in polythene bags and boiled in a pre-heated pressure cooker for 20minutes on an adjustable Pitco Japan electric hot plate (Model No ECP 202) to an internal

temperature of 72<sup>o</sup>c (Malgorzata *et al*; 2005). The meat samples were removed from the pot and cooled to 200m temperature (27<sup>o</sup>c) for 10minutes. The meat samples were re-weighted and wrapped in polythene bags and chilled at 4<sup>o</sup>c for 18hours. They were removed and allowed to equilibrate to 200m temperature and 1.25cm diameter cores parallel to muscle fibre orientation that were removed from the meat samples using a coring device (Qiaofen and Da-wan, 2005). The meat cores were sheared at three locations with Warner – Bratzler V-notch blade shearing instrument (Honikel 1998).

### Chemical analysis of meat

Proximate composition–Meat samples without any subcutaneous fat were ground to homogeneity and the percentage of moisture, fat, ash and protein was determined using A.O A.C (2002) procedures.

### Microbiological analysis

All the microbiological variables mainly of psychophilic count viz: Bacillus, Lactobacillus and Aeromonas were determined following the procedures recommended by AOAC (2002) and APHA (2005).

### Sensory analysis of meat

The meat was evaluated organoleptically using a 10-man semi-trained panelist consisting of the Department Staff and Students using mine-point hedonic scale (AMSA 2015). The panelists were instructed on the nature of the study without disclosing the identity of the meat samples. They were requested to record their preferences on a 9 – point hedonic scale on which 1 = dislike extremely, 9 = like extremely for colour, flavour, tenderness, juiciness, texture and overall acceptability as indicated on the score sheet. The past panelists were provided unsalted biscuit and clean water to raise the mouth between the samples interval.

### Statistical analysis

All data collected from this study were subjected to statistical analysis of variance (ANOVA)

using Statistical Analysis System (SAS, 2002). The significant differences between means were tested using the Duncan multiple range test of the sample software.

## RESULTS AND DISCUSSION

There were significant ( $p < 0.05$ ) differences in the values of physical variables of meat due to differential chilling time. Raw meat colour, cooking yield and water holding capacity (WHC) decreased as the chilling time interval progressed, while cooking and, drip losses, thermal and cold shortening as well as shear force and pH of the meat increased as the chilling time increased. Colour is an important aspect of meat quality and changes from its cherry rich nation to pinkish red when it is not chilled immediately after processing were due to oxidation and further reduction in colour intensity was due formation of metmyoglobin as a result of long exposure to the air. Loses and shortening that occur in meat are a result of drain of juices either during cooking which eventually forms both or when the meat is kept frozen in which case the juices are lost into the containers in which the meat is packaged or directly into the freezer. Often, the drain contains most of the nutrients especially vitamins and minerals that are supposed to be retained for human need. The loses and shortenings in this study culminated in the reduction of water holding capacity and increased Warner Bratzler values

of the meat. The pH of delayed meat before chilling increased as a result of loss of juices and relative accumulation of moisture that could be more basic in nature. The results obtained in the physical characteristics of meat delayed before chilling in this study agreed with the findings of Omojola (2007) and Apata (2011).

The result of physical characteristics of meats are presented in Table 01.

Moisture, extract (fat) and ash decreased as the regime of chilling increased while crude protein and lipid oxidation (TBARS) increased ( $p < 0.05$ ) as the time of delayed chilling of meat samples increased. Moisture and meat protein are directly related as the former increases, the latter would decrease and vice-versa. The decrease in meat moisture in this study could be due to loss of juices recorded during the wasting time before the meat samples were chilled and this could have led to consolidation of protein in the meat, leading to higher or increase in protein contents of delayed meat samples. The more meat was delayed before chilling the more the fat degradation would have occurred resulting in lower values of fat and higher values of TBARS in delayed meat whereas lower values of ash observed in this study, could be due to draining of most of the vulneral contents of the meat during waiting before the meat samples were chilled. The same findings were recorded by (Bowater, 2001), Junction *et al.*, (2001), Van Moeseke *et al.*, (2001) and Singh and Sachan (2010).

**Table 01: Physical Characteristics of beef as influenced by chilling regimes**

Variable (%)	TREATMENTS					
	T0 (Immediate Chilling)	T1 (2hrs)	T2 (4hrs)	T3 (6hrs)	T4 (8hrs)	T5 (10hrs)
Raw Meat Colour	8.00+0.01 <sup>a</sup>	8.00+0.01 <sup>a</sup>	7.00+0.03 <sup>b</sup>	6.00+0.03 <sup>c</sup>	5.00+0.04 <sup>d</sup>	5.00+0.05 <sup>d</sup>
Cooking Loss	15.00+0.06 <sup>c</sup>	20.03+0.06 <sup>d</sup>	22.00+0.06 <sup>c</sup>	25.05+0.06 <sup>b</sup>	32.03+0.06 <sup>a</sup>	35.50+0.06 <sup>a</sup>
Cooking yield	84.90+0.09 <sup>a</sup>	79.97+0.09 <sup>b</sup>	78.00+0.09 <sup>c</sup>	74.95+0.09 <sup>d</sup>	64.97+0.09 <sup>e</sup>	64.50+0.09 <sup>a</sup>
Drip Loss	0.12+0.01 <sup>c</sup>	0.13+0.06 <sup>d</sup>	0.14+0.01 <sup>c</sup>	0.15+0.01 <sup>b</sup>	0.15+0.01 <sup>b</sup>	0.16+0.01 <sup>a</sup>
Thermal Shortening	3.34+0.01 <sup>c</sup>	5.01+0.01 <sup>d</sup>	7.61+0.01 <sup>c</sup>	9.30+0.01 <sup>b</sup>	9.41+0.01 <sup>b</sup>	11.50+0.01 <sup>a</sup>
Cold Shortening	8.25+0.06 <sup>c</sup>	10.24+0.03 <sup>d</sup>	11.48+0.04 <sup>c</sup>	12.73+0.04 <sup>b</sup>	12.76+0.01 <sup>b</sup>	14.02+0.04 <sup>a</sup>
WHC	75.42+4.01 <sup>a</sup>	72.30+0.82 <sup>b</sup>	71.63+3.70 <sup>b</sup>	68.76+5.81 <sup>c</sup>	57.10+3.80 <sup>d</sup>	55.03+5.31 <sup>d</sup>
Shear Force (N)	4.22+0.05 <sup>d</sup>	4.37+0.05 <sup>c</sup>	4.43+0.03 <sup>c</sup>	5.45+0.02 <sup>b</sup>	6.50+0.02 <sup>a</sup>	6.52+0.05 <sup>a</sup>
pH	5.0+0.10 <sup>b</sup>	5.1+0.01 <sup>b</sup>	5.3+0.02 <sup>b</sup>	6.1+0.10 <sup>ab</sup>	6.3+0.01 <sup>a</sup>	6.5+0.00 <sup>a</sup>

Means on the same row with different superscripts are statistically significant ( $p < 0.05$ ) ; WHC = Water Holding Capacity

**Table 02: Chemical composition of beef as affected by chilling regimes**

Variable (%)	TREATMENTS					
	T0 (Immediate Chilling)	T1 (2hrs)	T2 (4hrs)	T3 (6hrs)	T4 (8hrs)	T5 (10hrs)
Moisture	71.73+0.15 <sup>a</sup>	69.60+0.12 <sup>b</sup>	68.58+0.00 <sup>c</sup>	58.55+0.10 <sup>c</sup>	57.52+0.15 <sup>d</sup>	56.52+0.51 <sup>d</sup>
Crude Protein	18.15+0.32 <sup>d</sup>	19.21+0.15 <sup>c</sup>	20.30+0.01 <sup>b</sup>	20.32+0.10 <sup>b</sup>	20.40+0.23 <sup>a</sup>	21.45+0.42 <sup>a</sup>
Ether Extract	3.33+0.23 <sup>d</sup>	3.27+0.11 <sup>a</sup>	2.21+0.06 <sup>b</sup>	2.18+0.06 <sup>b</sup>	2.11+0.06 <sup>b</sup>	1.93+0.06 <sup>b</sup>
Ash	3.21+0.06 <sup>a</sup>	3.10+0.00 <sup>a</sup>	2.05+0.06 <sup>b</sup>	2.03+0.06 <sup>b</sup>	2.00+0.06 <sup>b</sup>	1.00+0.06 <sup>c</sup>
NFE	3.58+0.05 <sup>c</sup>	4.82+0.05 <sup>d</sup>	6.86+0.04 <sup>c</sup>	6.92+0.03 <sup>b</sup>	16.99+0.04 <sup>b</sup>	19.10+0.02 <sup>a</sup>
TBARS	0.07+0.00 <sup>c</sup>	0.10+0.01 <sup>d</sup>	0.13+0.01 <sup>c</sup>	0.15+0.00 <sup>b</sup>	0.15+0.01 <sup>b</sup>	0.17+0.00 <sup>a</sup>
(Meg/kg/fat)	71.73+0.15 <sup>a</sup>	69.60+0.12 <sup>b</sup>	68.58+0.00 <sup>c</sup>	58.55+0.10 <sup>c</sup>	57.52+0.15 <sup>d</sup>	56.52+0.51 <sup>d</sup>

Means on the same row with different superscripts are statistically significant ( $p < 0.05$ ); NFE = Nitrogen Free Extract

The microbial load of meat samples increased as the requirement of chilling increases (Table 3). These results could be because the most common microbes found on the meat samples – Bacillus and Aeromonas spp are thermophilic while lactobacillus is psychrophilic. The number of lactobacillus microbes was higher ( $p < 0.05$ ) than those of Bacillus and Aeromonas probably they could not withstand the coldness of the freezer as lactobacillus home reduction in their number. However, the values of microbes on the meat sample in this study were not above the tolerable values that humans can consume in the meat as reported by Insausti *et al.*, (2001) and Razminowicz *et al.*, (2008).

Table 4 presented the results of sensory evaluation of N'dama cattle meat samples delayed before chilling. There are significant ( $p < 0.05$ ) decreases in all the sensory traits measured in this study as the time of chilling was further delayed to 10hrs. Colour of meat is very important and has much influence in the preference for meat consumption besides flavour, tenderness and juiciness which play a vital role in acceptability of any meat by consumers. This trend was observed in the overall acceptability of meat delayed before chilling.

**Table 03: Microbial load of beef as influenced by chilling regimes**

Variable (cfu/g)	TREATMENTS					
	T0 (Immediate Chilling)	T1 (2hrs)	T2 (4hrs)	T3 (6hrs)	T4 (8hrs)	T5 (10hrs)
Bacillus spp	3.0x10 <sup>5d</sup>	4.2x10 <sup>5c</sup>	4.3x10 <sup>6c</sup>	5.3x10 <sup>6b</sup>	6.4x10 <sup>6a</sup>	6.5x10 <sup>6a</sup>
Lactobacillus	4.0x10 <sup>4d</sup>	5.1x10 <sup>3c</sup>	5.3x10 <sup>3c</sup>	6.3x10 <sup>3b</sup>	7.5x <sup>3a</sup>	7.7x10 <sup>3a</sup>
Aeromonas	3.1x10 <sup>3d</sup>	3.2x10 <sup>3d</sup>	4.2x10 <sup>3c</sup>	5.2x10 <sup>3c</sup>	5.3x10 <sup>3b</sup>	6.4x10 <sup>3a</sup>

Means on the same row with different superscripts are statistically significant ( $p < 0.05$ )

**Table 04: Sensory Scores for cooked meat as affected by chilling regimes**

Variable (%)	TREATMENTS					
	T0 (Immediate Chilling)	T1 (2hrs)	T2 (4hrs)	T3 (6hrs)	T4 (8hrs)	T5 (10hrs)
Cooked meat colour	7.62+0.002 <sup>a</sup>	6.43+0.02 <sup>a</sup>	5.37+0.03 <sup>c</sup>	4.35+0.03 <sup>d</sup>	3.30+0.03 <sup>c</sup>	3.20+0.03 <sup>c</sup>
Flavour	8.27+0.03 <sup>a</sup>	6.74+0.03 <sup>b</sup>	6.67+0.01 <sup>b</sup>	5.31+0.02 <sup>c</sup>	4.45+0.03 <sup>d</sup>	3.40+0.01 <sup>c</sup>
Tenderness	7.54+0.01 <sup>a</sup>	5.34+0.02 <sup>b</sup>	5.25+0.02 <sup>b</sup>	4.20+0.03 <sup>c</sup>	4.16+0.02 <sup>c</sup>	3.11+0.03 <sup>d</sup>
Juiciness	6.70+0.02 <sup>a</sup>	5.55+0.02 <sup>b</sup>	5.30+0.03 <sup>b</sup>	4.27+0.02 <sup>c</sup>	3.25+0.01 <sup>d</sup>	3.12+0.01 <sup>d</sup>
Texture	7.56+0.03 <sup>a</sup>	6.34+0.07 <sup>b</sup>	6.23+0.02 <sup>b</sup>	4.29+0.02 <sup>c</sup>	3.12+0.01 <sup>d</sup>	3.01+0.01 <sup>d</sup>
Overall Acceptability	8.30+0.02 <sup>a</sup>	7.25+0.02 <sup>b</sup>	7.23+0.02 <sup>b</sup>	5.20+0.01 <sup>c</sup>	4.13+0.02 <sup>d</sup>	3.11+0.02 <sup>c</sup>

Means on the same row with different superscripts are statistically significant ( $p < 0.05$ )

The meat sample delayed for 10hrs had lower ( $p<0.05$ ) colour, flavour, tenderness and juiciness as well as texture values hence; to that was accepted least ( $p<0.05$ ) than meat samples that were chilled immediately after processing and the ones chilled at 2 and 4 hours respectively. These results corroborated the reports of Savell *et al.*, (2005) and Razminowicz *et al.*, (2008).

## CONCLUSION

Based on the results of this study, it is concluded that meat from N'dama cattle could be delayed for up to 4hrs before chilling without much deterioration in quality and acceptability attribute of the meat.

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