ISSN 0189-0514

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J. Anim. Prod. Res. (2016) 28(1):25-32

EFFECT OF RIGOR STATE AND CURING TEMPERATURE ON THE PROCESSED YIELD AND PHYSICO-CHEMICAL PROPERTIES OF BROILER MEAT

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ABSTRACT

A study was conducted using 16 (sixteen) half carcasses of broiler chickens with the aim of improving the yield and quality of meat products. The effects of rigor state and curing temperature on yield and quality of smoked-cooked meat were investigated using a 2 x 2 factorial arrangement. The meat was cured pre-rigor and post-rigor in hot and cold brine solution, after which they were smoked for approximately two hours to an internal temperature of 69±1ºC. The results showed that rigor states significantly ($P<0.05$) affected dry matter, moisture, lipid and nitrite content. Lower moisture (20.23 %) and lipid content (10.37 %) was observed in the post-rigor meat but with higher nitrite content (131.06 ppm). Curing temperatures significantly ($P<0.05$) affected the yield, dry matter, moisture, nitrite and salt contents of the product. The yield of meat and moisture content was higher in cold cure (14.60 % and 32.68 % respectively) but with a lower nitrite and salt content. Furthermore, the interaction between curing temperature and rigor state was also significant ($P<0.05$) with post rigor and cold cure interacting best with a yield of 15.88 % and lipid content of 10.35 %. Lowest moisture content was observed in the post-rigor hot cure treatment (15.49 %). Nitrite and salt contents were lower in the pre-rigor cold cure treatment (108.90 and 1.86 % respectively) with also higher ash content (5.62 %). It is concluded that optimum yield can be achieved through cold curing in post- rigor state.

Keywords: carcass, yield, quality, rigor, curing, brine

INTRODUCTION

Thermal processing, curing and smoking may be considered as the three most commonly encountered operations in meat preservation and processing (Kor-dylas, 1990). Current meat-curing practice based on the ancient art of preserving meat with salt, employs the addition of nitrite along with salt, sugar, reducing agents and phosphates to meat (Rubin *et al.*, 1992). The two methods of curing are wet and dry curing which can be done at the pre-rigor or post-rigor states. In the wet cure method, the curing solution can be either hot or cold. Some researchers (Lauritzsen *et al.*, 1993; Ogunsola and Okubanjo, 2001) reported that curing temperature and state of rigor prior to curing affects the quality and yield of the processed product. Lauritzsen *et al.* (1993) reported that pre-rigor salting led to a larger reduction in weight, a higher water loss and a lower uptake of sodium chloride than in fish salted post-rigor. Lower yield in pre-rigor cured rabbit meat and an accelerated curing process of pre-rigor rabbit meat with hot brine at 45^{0}C was reported by Ogunsola and Okubanjo (2001). Hot processing or boning (the removal or cutting of carcasses into parts or meat while it is still hot (about 37- 39 °C) can increase yield, promote more uniform colour and better water holding capacity but reduces tenderness, promotes abnormal shape of joints and difficulty in handling such meats (Warriss, 2000; Fletcher, 2002). Cold cured carcass has been reported to give higher yield than hot cured carcass, due to the longitudinal shrinkage of the muscle fibre and connective tissue network, with increased temperature which leads to higher water loss (Offer, 1984), but increasing the temperature of curing has been shown to accelerate curing time and also bring about uniformity in cured products. The studies conducted by Ogunsola and Okubanjo (2001) and Owen *et al.* (1986) on rabbit meat revealed a significantly higher yield observed in the meat cured at 2^{0}C (conventional curing temperature) than the hot cured carcass (45^{0}C). This study therefore aimed at comparing the effect of rigor state and curing temperature on the processed yield and physico-chemical properties of broiler meat.

MATERIALS AND METHODS

Study location

The study was conducted in Ahmadu Bello University, Samaru - Zaria, Kaduna State, Nigeria located within the Northern Guinea Savannah zone of Nigeria (latitude 11^{o}12$^'$N and Longitude 7^{o}33$^'$E) at an altitude of 610 m above sea level (Akpa *et al.*, 2002). Alphonsus *et al.* (2012) described the climate of the area.

Slaughter and processing treatments

Broiler chickens raised for 12 weeks to an average live weight of about 3.0 kg were used in this study. The birds were fasted overnight and weighed prior to slaughter. They were placed in the slaughter cones, the jugular vein and carotid artery were then severed using a sharp knife. The birds were allowed to bleed for about two minutes and then scalded using hot water at a temperature of 56^{0}C for two minutes. Feathers were removed using a picking machine after which carcasses were eviscerated. Thereafter, the carcasses were split into two equal halves totalling 16 half carcasses. The 16 half carcasses were randomized into four treatments: (1) pre-rigor hot cure (2) pre-rigor cold cure (3) post-rigor hot cure (4) post-rigor cold cure. The carcasses were then weighed and immersed in ice for 30 minutes before curing.

Curing

The half carcasses used for pre-rigor study were cured immediately after chilling before rigor mortis sets in. The post-rigor carcasses were placed in a Ziploc bag and transferred to the refrigerator for 24 hours to allow rigor mortis to fully set in before the carcasses were cured. The curing brine was prepared according to the method described by Ogunsola and Okubanjo (2001) with slight modification. The brine composed of 10 litres water, 1020.58 g salt, 100 g sodium nitrite, 170.10 g sugar. Heating of the curing brine for the hot cure treatment was done in a stainless steel food grade medium with the aid of a water bath to temperature of 35^{0}C. The carcasses were immersed in the curing brine after injection with the brine solution of the same strength to 110 % of the green weight for three hours. The cold cure brine was chilled in a refrigerator to 2^{0}C. Thereafter, carcasses were immersed in the cold brine after injection with cold brine of the same strength to 110 % of the green weight, followed by curing at that temperature for 12 hours. After the appropriate time schedule for each treatment, the carcasses were rinsed with cold water, drained, weighed and then placed in bags for equilibration in the refrigerator. This was done to prevent shrinkage until the samples for the longest treatment had gone through its normal schedule (Ogunsola and Okubanjo, 2001).

Primal cuts and Smoking

The cured carcasses were cut into primal cuts; breast, thigh, drumsticks, back and wings and then weighed prior to smoking. A locally designed smokehouse consisting of two layers was used for smoking the meat. The lower layer was where charcoal was burnt; while the upper was covered with thick wire mesh, where the cut up parts were laid during smoking. The meat was smoked to impart smoky flavour for approximately two hours to an internal temperature of about 69 ± 1^{0}C. The smoked meat was briefly cooled, weighed and packed for further analysis.

Processing yield

Yield was determined as described by Naveena *et al.* (2006) as follows:

$$\text{Percentage (\%) cured yield} = \frac{Half\ carcass\ weight\ after\ curing}{Half\ carcass\ weight\ before\ curing} \times 100$$

Proximate, Nitrite and salt Analysis

Smoked meat samples were taken to the laboratory for analysis of dry matter, ash, moisture, crude protein, nitrite and salt using the procedure outlined by AOAC (2000).

Statistical analysis

Data obtained were subjected to general linear model (GLM) procedure of SAS (SAS, 2002) and significant means were separated using the least significance difference method. The following model was used:

$$Y_{ijk} = \mu + R_i + C_j + RC_{ij} + e_{ijk}$$

Where;

Y_{ijk} = observation on the carcass of the j^{th} curing temperature in the i^{th} rigor state;

μ = overall mean; R_i = effect of the i^{th} rigor state; C_j = effect of the j^{th} curing temperature; RC_{ij}= effect of interaction between the i^{th} rigor state and j^{th} curing temperature; e_{ijk} = random error.

RESULTS

Tables 1 to 3 show the effect of rigor state, curing temperature and their interaction on the percentage yield, dry matter, moisture, ash, crude protein, lipid, nitrite and salt content of carcasses. The yield of half carcasses as affected by state of rigor showed no significant difference ($P > 0.05$) after curing, however the post-rigor carcasses gave a higher value of 11.43%. The effect of state of rigor on meat samples significantly differed ($P>0.05$) for dry matter, moisture, lipid and nitrite. On the contrary, salt, ash and crude protein were not significantly affected ($P<0.05$) by the state of rigor. The percentage dry matter, moisture, lipid and nitrite (ppm) in the pre rigor and post rigor states were 69.48 and 79.77, 30.52 and 20.23, 12.98 and 10.37, 120.52 and 131.06 respectively.

The hot cured carcasses recorded significantly lower values (P<0.05) in the yield of half cured carcass as affected by curing temperature, a yield of 6.31 % was obtained from hot cured carcasses, while cold cured carcasses had a higher yield (14.60 %). Curing temperature was observed to have significantly affected (P>0.05) the dry matter, moisture, nitrite and salt levels in the broiler meat while on the other hand, ash, crude protein and lipid were not shown to significantly differ (P<0.05). The percentage dry matter, moisture, nitrite (ppm) and salt on the hot cure and cold cure treatments were 81.94 and 67.32, 18.06 and 32.68, 137.66 and 113.92, 2.33 and 1.87 respectively.

The interaction between rigor and curing temperature, post-rigor cold cure treatments gave significantly higher yield (P < 0.05) of 15.88 %; with the least values observed in the pre-rigor and post-rigor hot cured meat. There was no significant difference in crude protein values obtained for all treatments. The moisture content of the pre-rigor cold cured meat (40.41 %) was significantly higher than all other treatments but was not statistically different in the value obtained in the post-rigor cold cure. The ash content was also higher in the pre-rigor cold cure. The mean values obtained in the lipid content showed no statistical difference in the pre-rigor hot cured and pre-rigor cold cured meat and were significantly (P > 0.05) of higher values (13.27 and 12.68 respectively). Higher nitrite (143.19 ppm) and salt contents were observed in the post-rigor hot cure but the salt content value was not significantly different (P> 0.05) from the pre-rigor hot cured treatment.

Table 1: Effect of rigor state on physico-chemical properties of smoked cooked broiler meat

Parameters	Pre-rigor	Post-Rigor	LOS
Cured Yield (%)	9.49±1.61	11.43± 1.89	NS
Dry Matter (%)	$69.48{\pm}4.19^{b}$	$79.77{\pm}\ 3.41^{a}$	*
Moisture (%)	$30.52{\pm}4.19^{a}$	$20.23{\pm}3.41^{b}$	*
Ash (%)	5.10±1.07	4.48±0.69	NS
CP (%)	51.14±3.50	52.88±2.55	NS
Lipid (%)	$12.98{\pm}0.27^{a}$	$10.37{\pm}0.89^{b}$	*
Nitrite (ppm)	$120.52{\pm}4.43^{b}$	$131.06{\pm}4.62^{a}$	*
Salt (%)	2.06±0.11	2.13±0.10	NS

Values represent means and standard error of inhibition zones; ^{a,b} Means in each row with different superscript letters differ significantly (P < 0.05); NS = Non-significant, LOS = Level of Significance,* = Statistically significant

Effect of rigor state and curing temperature

Table 2: Effect of curing temperature on the physico-chemical properties of smoked cooked broiler meat

Parameters	Hot Cure	Cold Cure	LOS
Cured Yield (%)	6.31 ±0.60[b]	14.60±1.08[a]	*
Dry Matter (%)	81.94±1.57[a]	67.32±4.36[b]	*
Moisture (%)	18.06±1.57[b]	32.68±4.36[a]	*
Ash (%)	4.41±0.87	5.17±0.92	NS
Crude Protein (%)	50.19±3.07	53.82±2.93	NS
Lipid (%)	11.83±0.90	11.51±0.72	NS
Nitrite (ppm)	137.66±2.17[a]	113.92±2.01[b]	*
Salt (%)	2.33±0.04[a]	1.87±0.08[b]	*

Values represent means and standard error of inhibition zones; [a,b] Means in each row with different superscript letters differ significantly ($P < 0.05$); NS = Non-significant, LOS = Level of Significance,* = Statistically significant

Table 3: Effect of interaction between rigor state and curing temperature on the physico-chemical properties of smoked cooked broiler meat

	Pre-rigor		Post-rigor		
Parameters	Hot Cure	Cold Cure	Hot Cure	Cold cure	LOS
Cured Yield (%)	5.66 ±0.75[c]	13.33±1.34[b]	6.97 ±0.91[c]	15.88±1.59[a]	*
Dry Matter (%)	79.37±1.57[a]	59.59±3.76[b]	84.51±2.13[a]	75.04±5.89[ab]	*
Moisture (%)	20.63±1.57[b]	40.41±3.76[a]	15.49±2.13[b]	24.96±5.89[ab]	*
Ash (%)	4.58±1.60[b]	5.62±1.61[a]	4.25±0.99[b]	4.72±1.11[b]	*
Crude Protein (%)	43.26±3.39	59.02±2.09	57.13±0.70	48.63±4.22	NS
Lipid (%)	13.27±0.06[a]	12.68±0.52[a]	10.39±1.56[b]	10.35±1.12[b]	*
Nitrite (ppm)	132.13±0.36[b]	108.90±1.35[d]	143.19±1.18[a]	118.94±0.43[c]	*
Salt (%)	2.27±0.06[a]	1.86±0.16[b]	2.38±0.04[a]	1.88±0.06[b]	*

Values represent means and standard error of inhibition zones; [a ,b,c] Means in each row with different superscript letters differ significantly ($P < 0.05$); NS = Non-significant, LOS = Level of Significance,* = Statistically significant

DISCUSSION

The effect of rigor state on the yield of half carcass was not significant ($P > 0.05$), but there was numerical difference which was higher in the post-rigor state. This may be due to lower tendency of drip loss (loss of water and other nutrients) in the meat as a result of closed network between the actin and myosin complex of the muscle. The higher moisture content observed in the pre-rigor meat could be due to high pH of pre-rigor meat which enhances higher water holding capacity (Claus and Sorheim, 2006). The higher lipid content observed in the pre-rigor meat could be due to the absence of rigor mortis at this state. Rigor mortis causes shrinkage of myofibrils, reduced water holding ability and increase exudate drip loss along with oil. A higher residual nitrite level was observed in the post-rigor carcass but were both within the limits recommended by U.S.D.A. (2010) which is 200ppm for brined and injected meat. The result is in accordance with the reports of Ogunsola and Okubanjo (2001), who observed that curing pre-rigor rabbit meat led to reduction in weight of the meat.

The yield and moisture of cold cured carcass which was observed to be significantly higher than the hot cured carcass, could be due to transverse shrinkage of the fibre axis caused by the high temperature of the brine. The longer time the cold cured meat was retained in the brine, may have led to its high yield, which may increase the time for uptake of water and salts. The result agrees with the reports of Ogunsola and Okubanjo (2001). They observed that there was lower yield obtained from rabbit meat cured at 45^0C when compared with the conventional method. The nitrite and salt levels which were higher in the hot cure treatment could be due to the fact that in the hot cure treatment, there may be some ease in the binding of salt and nitrite to the protein, hence a higher value.

The result of yield observed in the interaction between rigor and curing temperature, which was higher in the post-rigor cold cured treatment could be due to the synergic effect of longer curing time and higher retention of nutrient absorbed as a result of closed network of myofibrils. The high moisture and ash content observed in the pre-rigor cold cure may also be as a result of the longer curing time in brine, high ATP, high pH of pre-rigor muscle, which promotes higher intake of water due to the loose network of actin and myosin filaments (Pisula and Tyburcy 1996; Claus and Sorheim, 2006), and it is responsible for 95% of WHC in meat (Allais, 2010) and Myosin is the most essential (Xiong, 2000), hence, the high ash content as brine is composed of dissolved solutes. The lipid content which was higher in the pre-rigor hot cured and pre-rigor cold cured meat could be due to the absence of rigor which reduces shrinkage loss. The trend observed in the nitrite and salt values could be due to the accelerated distribution of dissolved solutes as a result of high temperature of hot brine. However, Lauritzsen *et al*. (1993) observed a lower salt uptake in pre-rigor salted fish. The result was similar to the findings of Ogunsola and Okubanjo (2001).

CONCLUSION

It can be concluded that lower moisture and lipid content can be achieved by curing chicken meat in the post-rigor state with nitrite content within the permissible level. Curing meat at lower temperatures significantly increases the yield and also maintains lower nitrite and salt limits. Furthermore, post rigor and cold cure interacts best to produce a higher yield and acceptable lipid content. In terms of moisture content, the post-rigor hot cure treatment was best. Higher ash content and lower nitrite and salt contents can be achieved in the pre-rigor cold cure treatment.

ACKNOWLEDGEMENT

Our heartfelt gratitude goes to Professor A.O. Okubanjo, Professor J.J. Omage, Mr. A.A. Musa and the entire staff of Food Science Laboratory, Ahmadu Bello University for their immense contributions during the laboratory exertion and review of the write-up.

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