

Influence of Post-mortem Processing and Cooking Methods on Physicochemical and Organoleptic Properties of Pork

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Abstract

In an effort to improve meat quality for consumers in Nigeria, a study was conducted to test the effect of post-mortem processing methods and cooking methods on physicochemical and organoleptic properties of pork. Twelve crossbred (LW X LR) boars with average weight of 36.00 ± 0.27 kg used for the study were fasted for 12 hours and bled. In a 3x2 factorial arrangement of a completely randomized design, the carcasses were divided into 3 groups each containing four (4) carcasses (2 per replicate) and randomly assigned to three post-mortem processing methods as follows: T1(skinning), T2 (scalding) & T3(singeing). Cooking methods used were boiling and grilling. Parameters measured were total cholesterol, chilling loss, cooking loss, cold shortening, cooking yield, thermal shortening, cold yield, colour, juiciness, tenderness and flavour as well as proximate composition. Data collected were subjected to analysis of variance in accordance with 3x2 factorial design. The results showed that skinning significantly ($P < 0.05$) increased protein while reducing fat and cholesterol in fresh, cooked and grilled meat. This was followed by scalding and singeing in cooked and grilled meat respectively. However, singeing significantly ($P < 0.05$) improved mineral content of fresh, cooked and grilled meat compared to skinning and scalding which did not also differ significantly ($P > 0.05$). However, skinning reduced cooking and cold yield while increasing cold shortening significantly ($P < 0.05$) compared to singeing and scalding which increased cooking and cold yield significantly ($P < 0.05$). Thermal shortening was not affected ($P > 0.05$) by the post-mortem processing methods. Regarding sensory evaluation, skinning improved colour in both cooked and grilled meat, while scalding increased flavour, juiciness and tenderness significantly ($P < 0.05$). This was followed by singeing except in tenderness. From this study it could be concluded that singeing and scalding post-mortem processing methods improved sensory properties while skinning enhanced the nutritional parameters of meat.

Key words: Post-mortem, Scalding, Singeing, Pork, Cooking, Physicochemical, Organoleptic

1.0 Introduction

In many developing countries, pig production has contributed immensely to alleviating poverty. Moreso, pig is one animal that can withstand climate change if properly managed. Pork meat is widely consumed as a source of protein; it is processed into other forms to avoid spoilage (Ekpo *et al.*, 2020; Ekpo *et al.*, 2022). One of the known post slaughter conditions that affect meat generally are the dressing techniques employed to process carcass (Omojola and Adesehinwa, 2006). Pork is one of the most widely consumed red meats (except in Islamic countries), accounting for 35% of global meat consumption (Kim *et al.*, 2024). In consumers' diets, pork is one of the important sources of rich animal protein and other essential nutrients (essential vitamin, mineral, and fatty acids) (Zhang and Wang, 2020). Pork meat quality is defined as the culmination of several important characteristics such as color, smell, flavor, texture, firmness, tenderness, pH, water holding capacity, drip loss, etc. However, from the consumer's perspective, an important factor that influences the final evaluation of meat quality and repeat purchase decisions is the organoleptic properties (such as color, appearance, flavor, texture, juiciness, firmness, and tenderness etc.) that consumers perceive through their senses.

In general, pork quality is recognized as a complex and difficult characteristic because it is evaluated across a wide range of characteristics and attributes that are objectively and subjectively composed, and it is difficult to judge clearly; the final determination of product quality can be influenced by various interaction factors among the quality of the production process described above (Narsaiah *et al.*, 2020). Thus, this research evaluates the pork meat quality and the various factors that have an influence to change the physical and sensory characteristics of pork as influenced by scalding, skinning and singeing methods. The relationship between post-mortem processing and pork quality is complex and not fully understood. This knowledge gap makes it difficult to develop optimal processing methods which will better improve pork quality. A comprehensive investigation into the effects of post-mortem processing methods on the organoleptic and physicochemical characteristics of pork is essential to address these challenges and ensure the production of high-quality, safe, and consistent pork products. Since each of these methods of processing carcass could be sources of variability in meat quality, this study is aimed at assessing both impacts of carcass processing and cooking methods on the physical, nutritional and sensory properties of pork.

2.0 Materials and Methods

2.1 Experimental Site

The study was carried out in the Piggery unit of the department of Animal science, Akwa Ibom State University, Obio Akpa Campus. The farm is located on latitude 5°17'N and 5°27'N and longitude 7°21'E and 7°58'E with a monthly temperature range between 24 to 26°C. The relative humidity varies between 60 - 90 % and the annual rainfall from 3500 - 5000 mm (AKSU-MET, 2024).

2.2 Experimental Animals

A total of twelve crossbred (landrace x large white) boars weighed 35.14 ± 0.17 kg were obtained from the piggery unit of the Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus for this experiment. The experimental animals were slaughtered and processed using three different methods- scalding, skinning and singeing with each method representing a treatment.

2.3 Slaughtering Procedure and Preparation

Pork used for this study was thigh muscles excised from the thigh cut of slaughtered grower pigs. Prior to slaughtering, the animals were fasted for twelve hours, weighed before getting stunned mechanically and bled by severing both the carotid arteries and jugular veins. The slaughtered animals were conventionally skinned, singed, scalded and eviscerated.

(a) Scalding: Carcass was scalded by pouring hot water on the carcass, to loosen the hair and scraped off with a hand metal scrapper until the carcass was clean as described by Omojola and Adeschinwa, (2006); Fasae *et al.*, (2011) and Apata (2014).

(b) Skinning: The pelts of the carcass in this group were removed with a sharp scalpel and knife. A ring was made around one of the hind legs and the knife was inserted under the skin of the leg to open it up, the same was done on the second leg. Another incision was made right from the pelvic up to the neck. The pelt was gradually pulled until it was removed according to the procedure described by Omojola and Adeschinwa, (2006) and Apata (2014).

(c) Singeing: The hairs of the carcass were flamed off over burning fire made with firewood, dry grasses and some few papers; until all the hair had been carefully burnt off with minimal damage to the skin as described by Omojola and Adeschinwa, (2006) and Apata (2014). The carcass was thoroughly washed and scrapped. The carcass was further eviscerated, washed, chilled and fabricated into primal cuts. Meat samples that were used for physicochemical and sensory evaluation were excised from the thigh and cooked with the boiling and grilling method. Parameters measured included visual colour of meat samples, juiciness, tenderness, meaty flavour, overall acceptability as well as cooking loss and cooking yield, cold loss and cold yield, thermal and cold shortening. In addition, nutritional analysis was carried out on the pork processed from the different post mortem processing methods.

2.4 Parameter Measurements

2.4.1 Cooking Loss

Each meat sample was put in an airtight transparent polythene bag to prevent moisture exchange. Initial weight of treatment samples was recorded (using a sensitive scale) before cooking in a water bath at a temperature of 70°C for 20 minutes. The final weights of the samples were taken after allowing cooked samples to cool at room temperature for 20 minutes for the determination of cooking weight loss (Marlgorzata, 2005). Cooking loss was calculated as follows:

$$\text{Cooking loss} = \frac{\text{Initial weight of meat} - \text{final weight of meat} \times 100}{\div \text{Initial weight of meat}}$$

.....Equation 2.1

2.4.2 Thermal Shortening

Initial measurement was determined with the same meat samples used for measuring cooking loss. The lengths of meat samples were remeasured after cooking for 20 minutes and cooling to room temperature, the difference in length was expressed as thermal shortening. Thus:

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

.....Equation 2.2

2.4.3 Cold Loss

Each meat sample was placed in an airtight transparent polythene bag to prevent moisture exchange. Initial weights of treatment samples were recorded (using a sensitive scale) before refrigeration. Samples were then refrigerated at a temperature of 4°C for 24 hours. Final weights of the samples were taken after removal from refrigeration, excess moisture was removed using a paper towel. The difference between the initial and final weights was calculated to determine the cold loss of the meat, as described by Marlorzata (2005).

Cold Loss =

$$\text{Initial weight of meat} - \text{final weight of meat} \times 100 \div \text{Initial weight of meat}$$

.....Equation 2.3

2.4.4 Cold Shortening

Initial measurement was determined with the same meat samples used for measuring cold loss. The lengths of meat samples were remeasured after placing on a tray and chilled at - 4°C for 24 hours, the difference in length was expressed as cold shortening.

$$\text{Cold shortening} = \text{Initial length of meat} - \text{final length of meat} \times 100 \div \text{Initial length of meat}$$

.....Equation 2.4

2.4.5 Proximate Analysis

Proximate composition (dry matter, ash, crude protein, ether extract, moisture, crude fibre) and determination of total cholesterol were carried out according to the official methods of analysis described by the Association of Official Analytical Chemist (AOAC-Official Methods of Analysis, 2019). All analysis were carried out in duplicate. Proximate composition was analyzed for fresh, cooked and grilled meat samples respectively.

2.4.6 Carcass and Sensory Evaluation

At the end of the 56 days feeding trial, a total of 12 pigs (4 per treatment) were selected for carcass assessment. Pigs were randomly selected, weighed and starved for 12 hours then stunned and slaughtered by severing the Jugular vein. This was followed by scalding and evisceration. Carcass cut parts and organ weights were taken. The dressed weight obtained was used to calculate dressing percentage as the ratio of dressed weight to live weight multiplied by 100. Each of the organs (heart, liver, kidney and lungs) as well as the abdominal fat were removed and weighed. Organ weights were expressed as percentage of live weight. The carcass was fabricated into different primal cuts. Meat sample was obtained, cooked before subjecting to sensory evaluation. Meat to bone ratio was also determined. Sensory evaluation of samples of cooked pork was assessed by ten (10) panelists. Meat quality parameters assessed were color, juiciness, flavor, tenderness and overall acceptability. Bite size portions of 10g each were served to panelists who were asked to comment freely on each sample served.

2.4.7 Sensory Evaluation for Meat

Sensory evaluation of samples of cooked and grilled pork was assessed by ten (10) panelists comprising of both staff and students of the Department of Animal science, Akwa Ibom State University. Meat quality parameters assessed were colour, juiciness, tenderness, meaty flavour and overall acceptability. For each parameter the panelist awarded scores using a nine-point hedonic scale. Each scorer was provided with a bottle of table water to serve as flavour neutralizers between samples as described by Ekpo and Utibe (2024).

2.5 Data Analysis

All data obtained were subjected to analysis of variance in accordance with 3x2 factorial made up of 3 postmortem processing methods (skinning, scalding and singeing) and 2 cooking methods (boiling and grilling) using the SAS (2002) statistical package. Where statistical significance was observed, the means were separated using the Duncan Multiple Range Test at a 5% probability level.

3.0 Results and Discussion

The results in Table 3.1 shows the lowest cold loss, cold shortening and cooking loss percentages for T2 (scalding) followed by T3 (singeing) while T1 (skinning) had the highest cold shortening, cold loss and cooking loss (moisture loss). The higher cold shortening and cold loss could be due to the removal of skin leading to the muscle exposure to excessive contraction which results in less tender (tough) meat. The significant ($p < 0.05$) increase in T1 compared to T2 and T3 also indicated drastic reduction in water soluble nutrients of pork processed by skinning method compared to scalding and singeing. This is because the skin acts as a natural barrier reducing moisture evaporation from the underlying muscle.

Ayanwale and Aye (2006) had earlier reported that a high rate of cooking loss is considered a disadvantage in meat production because it leads to reduced tenderness, juiciness and less flavourable meat compared with meat of slow cooking loss. The removal of skin which caused higher cooking loss eventually resulted in the low cooking yield of T1. In contrast, highest meat yield was obtained in T2 (scalding) followed by T3 (singeing). This finding is in agreement with Aduku and Olukosi, (2000) but in contrast to Adeniji *et al.*, (2019) who had cooking loss greatest for singed carcass and considerably low in scalded and skinned carcass of West African dwarf (WAD) sheep, this difference in result may be attributed to the varied species of animal under study. However, the consistent findings of lower cooking loss due to the scalding method in particular from both authors suggest that in the process of scalding which is immersion of pig carcass in hot water or using steam to loosen hair and remove the outer skin layer, moisture might have been absorbed into the muscle thereby improving moisture retention compared with the singeing process.

There were no significant differences ($p > 0.05$) in the thermal shortening of the meat. Ayanwale and Aye (2006) had earlier reported that low rate of cooking loss is considered an advantage in meat production because it leads to improved tenderness, juiciness and more flavourable meat compared with meat of high cooking loss. Generally, fluid losses from meat lead to losses in water soluble vitamins and nutrient which affect juiciness, tenderness and flavour

The results obtained on nutritional composition showed that protein significantly ($P < 0.05$) increased in fresh, cooked and grilled pork for T1 (skinning) followed by T2 (scalding) while T3 (singeing) had the least (Table 3.2). However, significant ($P < 0.05$) reduction of fat percentage and cholesterol was obtained in fresh, cooked and grilled meat from T1 compared to T2 and T3. This was due to removal of skin (T1) which contains high amount of saturated fats often linked to increased low density lipoprotein (bad cholesterol), risk of atherosclerosis, heart attack and stroke. Nevertheless, the reduction in fat invariably increased lean muscle and protein percentage obtained. This result is in line with an earlier report by Okoh (2019). Scalding and singeing methods however allowed skin intact on meat therefore linked to the increased fat percentage obtained. The significant ($p < 0.05$) increase in mineral

Table 3.1: Effect of post mortem processing on physicochemical properties of pork

| Parameter (%) | T1(skinning) | T2 (scalding) | T3(singeing) | SEM |
|--------------------|--------------------|---------------------|--------------------|------|
| Cooking loss | 31.00 ^a | 15.00 ^c | 20.00 ^b | 2.35 |
| Cooking yield | 69.00 ^b | 85.00 ^a | 80.00 ^a | 5.33 |
| Cold loss | 20.00 ^a | 13.00 ^b | 16.00 ^c | 1.68 |
| Cold yield | 80.00 ^c | 87.00 ^{ab} | 84.00 ^a | 3.13 |
| Thermal Shortening | 10.00 | 9.00 | 8.00 | 1.90 |
| Cold shortening | 5.30 ^a | 3.00 ^b | 4.10 ^c | 0.41 |

^{abc} Means bearing different letters of superscript within the same row differ significantly (P<0.05)

Table 3.2: Effect of processing on nutritional composition of pork

| | Treatments | Crude protein | Crude fat | Crude fiber | Ash (mineral) | MC | DM | NFE | Total chol. |
|----------------|--------------|--------------------|-------------------|-------------|-------------------|---------------------|---------------------|--------------------|---------------------|
| Fresh | T1(Skinning) | 17.53 ^a | 2.00 ^c | 0.00 | 1.67 ^b | 64.75 ^b | 34.40 ^a | 13.20 ^a | 286.90 ^c |
| | T2(Scalding) | 16.90 ^b | 2.78 ^a | 0.00 | 1.78 ^b | 65.81 ^a | 34.19 ^b | 12.83 ^b | 289.10 ^a |
| | T3(Singeing) | 16.63 ^c | 2.57 ^b | 0.00 | 1.77 ^a | 65.79 ^{ab} | 34.22 ^{ab} | 13.24 ^a | 287.60 ^b |
| | SEM | 0.07 | 0.04 | 0.00 | 0.02 | 0.01 | 0.01 | 0.10 | 0.33 |
| Cooked | T1(Skinning) | 18.93 ^a | 2.39 ^c | 0.00 | 1.69 ^b | 64.17 ^b | 36.83 ^a | 14.12 ^b | 268.20 ^c |
| | T2(Scalding) | 17.10 ^b | 2.86 ^a | 0.00 | 1.84 ^a | 65.64 ^a | 34.36 ^c | 13.10 ^c | 277.90 ^b |
| | T3(Singeing) | 17.04 ^b | 2.63 ^b | 0.00 | 1.80 ^a | 65.50 ^b | 35.50 ^b | 14.22 ^a | 288.60 ^a |
| | SEM | 0.03 | 0.04 | 0.00 | 0.04 | 0.02 | 0.02 | 0.08 | 2.43 |
| Grilled | T1(Skinning) | 18.89 ^a | 2.15 ^c | 0.00 | 1.70 ^b | 63.57 ^b | 35.96 ^a | 13.22 | 259.80 ^c |
| | T2(Scalding) | 17.18 ^b | 2.54 ^a | 0.00 | 1.76 ^a | 65.15 ^a | 34.60 ^b | 13.20 | 271.50 ^a |
| | T3(Singeing) | 17.13 ^c | 2.36 ^b | 0.00 | 1.79 ^a | 65.29 ^a | 34.55 ^b | 13.27 | 263.50 ^b |
| | SEM | 0.13 | 0.04 | 0.00 | 0.04 | 0.07 | 0.02 | 0.15 | 1.72 |

^{abc} Means bearing different letters of superscript within the same row differ significantly (P<0.05)

MC= Moisture, DM= Dry Matter, NFE= Nitrogen Free Extract, Total Chol = Total Cholesterol

Table 3.3: Effect of post mortem processing on sensory characteristics of grilled pork

| Parameters | T ₁ (Skinning) | T ₂ (Scalding) | T ₃ (Singeing) | SEM |
|-----------------------|---------------------------|---------------------------|---------------------------|------|
| Flavour | 5.90 ^c | 6.70 ^b | 7.03 ^a | 0.25 |
| Juiciness | 7.30 ^c | 7.80 ^a | 8.20 ^a | 0.34 |
| Tenderness | 7.00 ^b | 7.80 ^a | 6.77 ^c | 0.25 |
| Colour | 8.03 ^a | 7.67 ^b | 7.20 ^c | 0.22 |
| Overall acceptability | 6.83 ^b | 7.49 ^a | 7.30 ^{ab} | 0.20 |

Table 3.4: Effect of post mortem processing on sensory characteristics of cooked pork

| Parameters | T1(skinning) | T2(scalding) | T3(singeing) | SEM |
|-----------------------|-------------------|-------------------|--------------------|------|
| Flavor | 7.40 ^c | 8.77 ^a | 8.07 ^{ab} | 0.20 |
| Juiciness | 6.77 ^c | 8.00 ^a | 7.93 ^{ab} | 0.32 |
| Tenderness | 6.43 ^c | 8.10 ^a | 7.80 ^{ab} | 0.35 |
| Colour | 7.77 ^a | 7.07 ^b | 6.43 ^c | 0.30 |
| Overall acceptability | 7.09 ^b | 7.60 ^a | 7.34 ^a | 0.42 |

^{abc} Means bearing different letters of superscript within the same row differ significantly (P<0.05)

content of fresh, cooked and grilled pork obtained in T3 than T1 and T2 which were statistically similar ($p>0.05$) could be due to the intact skin compared to T1(without skin) hence the high mineral content obtained in T3 followed by T2. This agrees with earlier report by Omojola and Adeschinwa (2006).

The sensory evaluation result as presented in Table 3.3 indicated significant ($P < 0.05$) increase in flavour and juiciness for T3 followed by T2 while T1 had the least. The increased juiciness obtained in T2 and T3 is due to increasing water retention compared to T1 which ensure juicier pork. Similarly, the lowest value for flavour recorded in T1 was due to removal of skin. The skin of pork contributes to flavour therefore removing the skin eliminates its fat and connective tissue components which can reduce richness of flavour. Moreso, removal of skin could alter the fat distribution, affecting the mouth feel and overall flavour profile which result in loss of moisture, nutrient and fat. The most probable reason for highest score on flavour in T3 especially for grilled meat is that singeing gives a smoky flavour to meat.

However, for tenderness, significant increase ($p<0.05$) was recorded in T2 followed by T1 and T3 which were not significantly ($p>0.05$) different. The significant ($p<0.05$) increase in tenderness for T2 is not only unconnected with the increased moisture retention capacity of the intact skin but is made possible too due to the process of scalding compared to singeing as earlier mentioned. In contrast, drastic reduction in tenderness for T1 is due to the removal of skin which impacts moisture retention resulting in tougher-texture during cooking. Result for colour showed significant ($p<0.05$) differences among treatments with highest score recorded in T1, followed by T2 while T3 had the least. The significant increase in colour for T1 (skinning) could be attributed to the removal of skin which invariably exposed the muscle to

oxygen which developed the bright red colour (oxymyoglobin) of muscle. The discolouration or uneven skin colour obtained for T3 (singeing) showed the impact of smoke and its masking effect. In all, the overall acceptability indicated highest score for T2 followed by T3. The most probable reason for consumers preference for T2 especially for cooked pork may be a result of combination of good colour, high flavour, tenderness and juiciness. Meat quality has been defined as the characteristics associated with tenderness, juiciness and flavour of lean or muscle structure (Aya *et al*, 2009).

The result obtained in T2 (Table 3.4) followed a similar trend reported by Omojola and Adesehinwa (2006) but in contrast with Adeniji *et al.*, (2019) for flavour, juiciness and tenderness excluding colour. This is probably because the researcher worked on rabbit meat. The sensory evaluation of cooked pork indicated significant ($p < 0.05$) increase in flavour for T2 followed by T3 while T1 (skinning) recorded the least. The probable reason for the lowest value in T1 is that skinning reduces fat which contribute to flavour in meat compared to scalding but most especially singeing under grilling condition develop better flavour due to combination of smoke and skin fat present. The consumers rating of T1 as very low in tenderness and juiciness compared to other treatments could be a reflection of the rapid moisture loss due to higher cooking temperature penetration of the skinless meat. Skin is known to retain moisture which invariably improve tenderness and juiciness of cooked meat as obtained in T2 and T3 (Table 3.4).

Another important sensory parameter is colour which was rated higher ($p < 0.05$) for T1 compared to T2 and T3 in both cooked and grilled meat. This could be due to bright red colouration of skinless muscle compared to scalding and singeing. Even though colour is the first criteria consumers use to judge meat quality, the overall acceptability score showed consumers preference for scalded and singed cooked meat whose colour were not too visible. This may probably be due to the increasing flavour, tenderness and juiciness of these scalded and singed meats. This finding is in agreement with Omojola and Adesehinwa (2006).

For the grilled meat, consumers' score for tenderness showed T2 as highest compared to T1 and T3. This is directly linked to the least cooking loss (higher nutrient and water-soluble vitamins retained) earlier mentioned (Table 3.2). Result for colour showed significant ($p < 0.05$) differences among treatments with highest score (8.03) in T1, (T2) and lowest score for T3. The significant colour increase in T1 (skinning) could be attributable to muscle colour (bright red) as a result of the skin removal. The highest score for T2 in overall acceptability followed by T3 showed that consumers admired both T2 and T3 but preferred T2. Meat quality has been defined as the characteristics associated with tenderness, juiciness and flavour of lean or muscle structure, (Aya, 2000).

4.0 Conclusion

The study has revealed that both scalding and singeing reduced cooking loss while increasing cooking yield, cold yield, mineral percentage and sensory properties (flavour, juiciness and tenderness) in both cooking and grilling meat- processing methods. On the nutritional quality of pork, skinning reduced fat and cholesterol while increasing protein and colour thereby improved quality and healthy meat. However, consumers preferred scalded cooked pork as against singed cooked or grilled meat.

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