Meat Research
Vol 3, Issue 6: 1-6, Article 75
ISSN: 2790-1971
https://doi.org/10.55002/mr.3.6.75
http://www.bmsa.info/meatresearch

[1]Meat Science Laboratory; Department of Animal Production, Olabisi Onabanjo University, Ayetoro Campus, P.M.B 0012 Ayetoro Ogun State, Nigeria.
[2]Department of Wildlife and Ecotourism Management, University of Ibadan, Ibadan Oyo State, Nigeria.
[3]Department of Animal Science, Faculty of Animal Husbandry, Bangladesh Agricultural University, Mymensingh-2202 Bangladesh.

*** Corresponding author**

ES Apata
E- mail:
apata.ebunoluwa@oouagoiwoye.edu.ng

Keywords:

Chicken
Evaluation
Local packaging materials
Meat
Quality

Article Info:

Received: 13 November 2023
Accepted: 27 December 2023
Published online: 31 December 2023

Research Article

Quality evaluation of chicken meat preserved with local packaging materials

*ES Apata[1], B Ahmad[1], OC Apata[2], OO Olaleye[1] and MA Hashem[3]

Abstract

This study investigated the influence of using local materials – plastic containers, polythene bags, printing paper wrappers and cardboard carton boxes in packaging poultry meat for preservation over 28days. 45 spent Shika Brown layers reared on the Teaching and Research Farm of Olabisi Onabanjo University Ayetoro Campus were procured and slaughtered. The carcasses were packaged in group of 3 and each treatment had 9 carcasses per treatment thus TO = Control (No packaging), T1 = Plastic containers, T2 = Polythene bags; T3 = Printing paper wrappers T4 = Cardboard Carton boxes and the chicken carcasses were preserved in a freezer at – 18^{o}C for 28 days. Data collected on physicochemical, microbiological, lipid oxidation and organoleptic properties of the meat were evaluated at the end of 28 days with analysis of variance (ANOVA) in a completely randomized design (CRD) and analyzed statistically at ($p<0.05$). The results showed that chicken meat packaged with plastic containers (T1) had the highest ($p<0.05$) quality attributes at the end of preservation time closely followed by meat packaged with polythene bags (T2), while carton (T4) and control treatments (T0) furnished the least ($p<0.05$) meat quality attributes. It was recommended therefore, that chicken meat could be better packaged with plastic containers in developing countries in lieu of very costly and unavailable modern packaging materials for better quality of chicken meat.

Introduction

Packaging is a scientific method of containing food products against physical, chemical and biological damage and also makes the product more attractive to the consumers (Bhat and Bhat, 2011; Hashem et al., 2023a and 2023b). The need for packaging can be linked to the progress of civilization and the requirement to preserve perishable foods for longer period of time in order to maintain the quality and safety of the food products from time of manufacture through the distribution channel down to the consumers as well as being environmentally friendly (Hurme et al., 2002; Apata, 2011).

Thus meat packaging constitutes an important aspect of food industries and many meat packaging systems are available with different attributes and applications which supermarkets and individual consumers utilize to ensure long shelf life and good quality for their products (Koch et al., 2009). These packaging systems range from over wrap packaging for short time, chilled storage and retail display to 100% carbon dioxide atmosphere packaging for long time chilled storage as well as vacuum or modified atmosphere packaging are being increasingly applied for distribution and retail sales of meat and meat products (Han, 2005; Sang et al., 2010). There have been remarkable developments in the polymeric and edible packaging films incorporated with antimicrobial agents that improve the packaging materials which can protect the products from spoilage micro-organisms, as well as rodents, dust and other contaminants (Cha et al., 2002; Mecitoglu et al., 2006). The production and consumption of poultry meat have increased continuously during the last decades in many parts of the world including developing countries and this has led to increased processing and distribution of poultry meat in packages (Bhat and Bhat, 2011, Bithi et al., 2020). However, most of the recently produced packaging system materials are costly and non-available in the developing countries.

Since poultry meat is highly vulnerable to microbial spoilage, packaging of the meat has been a challenge in developing countries especially in the tropical zones of the world (James et al., 2002; Azad et al.2022; Boby et al., 2021). Therefore, most poultry meat producers and marketers alike, revert to the use of locally available packaging materials such as plastic containers, polythene bags, printing paper wrappers and carton boxes. However, there is dearth of information on the possible consequences of these local packaging materials on the quality of poultry meat hence, the justification of this study. The main objective of this study therefore, was to investigate the effect of using local packaging materials on the quality factors of chicken meat in order to close the gap in the literature.

Materials and methods

Location of study

This study was carried out in the Meat Science Laboratory of the Department of Animal Production, College of Agricultural Sciences, Olabisi Onabanjo University, Ayetoro Campus, Ogun State.

Experimental birds

A total of 45 spent "Shika Brown" layers were procured from the Teaching and Research Farm of the College of Agricultural Sciences, Olabisi Onabanjo University, Ayetoro for the purpose of this study.

Slaughtering of birds

The birds were fasted for 8 hours overnight and were brought to the Meat Science Laboratory where they were weighed, stunned, bled, dressed, eviscerated and reweighed to get the dressed carcass weight and chilled at 4°C for 24 hours before packaging.

Packaging materials

Four different local packaging materials were used in this study. They included; plastic containers, polythene bags, printing paper wrappers, and Carton boxes; hence each of the local packaging materials constituted a treatment with a control. Thus: T0: Control (No packaging), T1 = Plastic Containers, T2 = Polythene bags, T3 = Printing Paper wrappers, T4 = Cardboard Carton boxes. The packaging materials were disinfected with detol ® and sundried in netted box before usage.

Packaging and preservation

The chicken carcasses were packaged in group of 3 so that each treatment group had 9 carcasses per treatment. The packaged chicken carcasses were preserved in a prefrozen freezer at -18°C for 28 days following the procedures of Lawries and Ledward (2006) and Rathore *et al.* (2010)

Measurement of parameters

Thawing of chicken carcasses

Carcasses were thawed in a pre-cleaned refrigerator for 24 hours at 4°C immediately they were removed from freezer according to USDA (2012).

Raw meat colour

This was measured after preservation for 28 days since chicken carcass colour were normal (light pink) using visual method as described by American Meat Science Association, (AMSA, 2012). Samples of meat from breast cut were placed in a tray and displaced in the laboratory to simulate retail condition. Visual colour values were recorded based on intensity and homogeneity of the meat samples using a colour scale that ranged from 1-8 with higher score representing a more attractive and homogenous colour.

Cooking loss

This was determined by removing meat samples of 10g and 6cm from the breast cut and were wrapped in an polythene bags and boiled in water in a pre-heated cooking pot for 20minutes on an adjustable Pifco Japan Electric hot plate – Model ECP 202 until the geometric centre of the meat samples was heated to 72°C following the procedures of Malgorzata et al. (2005) and Disha et al. 2020. The meat samples were removed from the pot and cooled to room temperature (29°C) and were reweighed and cooking loss was calculated thus:

$$\text{Cooking Loss} = \frac{\text{Raw meat Weight} - \text{Cooked Meat Weight}}{\text{Raw Meat Weight}} \times 100$$

Thermal shortening

The same meat samples used for determining cooking loss were used to measure thermal shortening according to Apata (2011). The final length of cooked meat samples was taken and the thermal shortening calculated as:

$$\frac{\text{Raw meat length} - \text{Cooked meat length}}{\text{Raw meat Length}} \times 100$$

Drip loss

This was determined according to Malgorzata et al. (2005). Weight of empty polythene bag was taken (Wp). Meat sample (10g) was weighed and put into the bag (Wp + m) and stored in a refrigerator at 4^0c for 48hrs. The meat sample was removed from the refrigerator and the weight of the bag plus the juice drained by the meat samples was taken (Wp+j). Drip loss was expressed as percentage of the initial weight of the meat sample, thus:

$$\frac{Wp+j-Wp}{Wp+m-WP} \times 100$$

Shear force

Ten of meat samples from each treatment were weighed and wrapped in polythene bags and boiled for 20minutes on adjustable Pifco Japan Electric hot plate model ECP 202 to an internal temperature of 72°C. They were removed and cooled to room temperature (29°C) for 10minutes, reweighed, bagged and chilled at 4°C for 18hrs. The meat samples were equilibrated to room temperature and 1.25cm diameter cores parallel to muscle fibre orientation were excised using a hand coring device (Apata, 2011). The meat samples were then sheared at three locations with Wartner Bratzler V-notch blade shearing instrument and average value of the three shearings were recorded (Qiaofen and Da-Wen, 2005). .

Proximate and pH analysis

The moisture, crude protein, ether extract (fat) and ash was determined following the procedures described by AOAC (2002) while the pH of the meat samples was determined using a potable pH meter, Model H18434 micro-computer, Havanna Instrument, Romania as describe by Marchiori and de-felicio (2003).

Microbiological analysis

Ten (10) g of meat sample from each treatment was blended with 90 ml of 0.1% (w/v) peptone water for 60 sec with a blender (Japan Nakai-Model 202). All the microbiological analysis were conducted following the procedures of Marchiori and de-felicio (2003) and Qiaofen and Da-Wen (2005).

Lipid oxidation

The Thiobarbituric acid (TBA) of the meat samples was determined using the method described by Pensel (1990) while the Modified Peroxide Value (mPV) was carried out according to AOAC (2002).

Organoleptic evaluation

Evaluation of sensory characteristics of cooked meat colour, flavour, tenderness, juiciness, texture and overall acceptability of meat samples was carried out on a 9-point hedonic scale according to the procedures (AMSA, 2015). 10 – member semi-trained taste panel was used. The taste panelists were drawn from students in the Department of Animal Production, Olabisi Onabanjo University, Ayetoro Campus. The meat samples were coded after boiling for 20minutes to an internal temperature of 72°C and cooled to room temperature (29°C). The taste panelists were served the meat on a clean saucer and were provided with water and biscuit in between treatment meat samples.

Experimental design and statistical analysis

Completely randomised design (CRD) was utilised and the statistical model as shown below:

$Yij = \mu + Ti +$ random error, Where;

Yij = any observation for which $X1 = i$

μ = general mean

Ti = effect of having treatment level i; was employed for thin study and replicated thrice.

The statistical analysis of the data collected was carried out with analysis of variance (ANOVA) using (SAS, 2002) while significant means were separated with Duncan multiple range test of the same software.

Results and Discussion

The results of physical properties of chicken meat packaged with local materials and preserved for 28 days are presented on Table 1. There were significant (P<0.05) differences in all the variables among the different treatments as well as in the periods of preservation. However, T1 had the highest raw meat colour, and lower cooking, drip losses, thermal shortening and shear force values (P<0.05) compared with other treatments, though closely followed by T2, while T0 had the least desirable physical properties with the exception of comparably better raw meat colour against lower (p<0.05) colour of meat in T4. Meat colour is an essential quality that consumers cherish and put into consideration before making any meat purchase based on the attractiveness of meat. The colour of meat is largely influenced by the amount of myoglobin (mb) content, nature of the meat as well as chemical composition, the physical state of the muscle and its structure (Apata, 2011). Therefore, chicken meat preserved with plastic containers furnished higher colour scores probably because the plastic container was able to sustain the myoglobin content of the meat from depleting due to compact nature of plastic which might have disallowed oxidation of the meat. The lower cooking, dripping losses, thermal shortening and shear force values observed in this study could be due to minimal drainage of the meat juices which were kept intact in the meat during preservation. The results obtained from this study on physical properties of poultry meat agreed with the report of Pettersen et al. (2004) who opined that plastic and polythene packaging materials gave better preservation properties of meat and that most of the properties either increased or decreased depending on the extent of oxygen penetration of the packaging materials as observed in this study.

Table 1. Physical characteristics of chicken meat preserved with different local packaging materials (p<0.05)

Treatments	Variables				
	RMC (%)	CKL (%)	DPL (%)	TMS (%)	SHF(Kg/cm^3)
T0	$6.00{\pm}0.01^c$	$5.37{\pm}0.20^a$	$5.63{\pm}0.10^a$	$4.53{\pm}0.49^a$	$5.67{\pm}0.53^a$
T1	$8.00{\pm}0.21^a$	$2.31{\pm}0.13^d$	$2.10{\pm}0.18^d$	$2.27{\pm}0.58^c$	$3.20{\pm}0.37^c$
T2	$7.00{\pm}0.13^b$	$3.52{\pm}0.10^c$	$3.23{\pm}0.87^c$	$3.33{\pm}0.16^b$	$3.32{\pm}0.65^c$
T3	$6.00{\pm}0.25^c$	$4.53{\pm}0.13^b$	$4.30{\pm}0.87^b$	$4.50{\pm}0.30^a$	$4.32{\pm}0.02^b$
T4	$5.00{\pm}0.23^d$	$4.35{\pm}0.020^b$	$4.30{\pm}0.87^b$	$3.37{\pm}0.37^b$	$4.38{\pm}0.73^b$

Means on the same column with different superscripts are statistically significant (p<005), RMC = Raw Meat Colour, CKL = Cooking loss, DPL = Drip loss, TMS = Thermal Shortening, SHF = Shear force.

The results of the proximate composition of chicken meat (Table 2) showed that significant (p<0.05) difference occurred only in the moisture contents of meat samples packaged and preserved with different materials with T1, T2 and T3 having similar but higher (p<0.05) values than T0 (Control). This could be due to the fact that plastic, polythene and printing paper wrappers were able to withhold the meat juices and did not allow leaching or exudation to occur to the meat and most of the moisture was retained in the meat unlike what was obtained in the control and treatment 4 whereby meat samples were physically exposed and free exit of juices was possible and cardboard carton boxes were easily percolated by liquid and there could be free movement of juices from the meat. There is inverse relationship between moisture content and protein in meat; as the amount of moisture is high, the level of protein decreases and vice-versa. This is probably because protein gets dissolved in moisture when the latter is higher and protein increased when moisture decreased as it was observed in this study. It was observed in this study that plastic, polythene and printing paper wrappers in that order gave better packaging values probably due to the fact that they are impermeable to liquid and reduce microbial accessibility and multiplication in the meat as reported by Apata (2011).

Table 2. Proximate composition and pH of preserved chicken meat as affected by local packaging materials

Treatments	**Variables**					
	MC(%)	**CP(%)**	**EE(%)**	**ASH(%)**	**NFE(%)**	**pH**
T0	65.40 ± 2.06^{b}	20.89 ± 1.05	8.20 ± 0.50	1.33 ± 0.13	4.13 ± 0.47^{a}	5.96 ± 0.64
T1	70.42 ± 0.79^{a}	20.00 ± 0.40	8.32 ± 0.28	1.20 ± 0.17	0.06 ± 0.01^{d}	6.24 ± 0.19
T2	70.31 ± 0.74^{a}	19.93 ± 0.13	8.42 ± 0.28	1.21 ± 0.27	0.13 ± 0.10^{c}	6.40 ± 0.20
T3	70.09 ± 0.95^{a}	19.98 ± 0.38	8.50 ± 0.31	1.20 ± 0.29	0.23 ± 0.12^{b}	6.44 ± 0.25
T4	69.87 ± 1.03^{ab}	20.01 ± 0.40	8.58 ± 0.38	1.28 ± 0.29	0.26 ± 0.10^{b}	6.32 ± 0.32

Means on the same column with different superscripts are statistically significant (p<005). MC = Moisture Content, CP = Crude Protein, EE = Ether Extract NFE = Nitrogen Free Extract.

Table 3 presents the results of lipid oxidation of chicken meat packaged and preserved using local materials. The values of lipid oxidation obtained with modified peroxide value method were higher ($p<0.05$) than those values obtained through thiobaarturic acid test probably because of the temperature differential however, TBA and mPV increased in conjunction during preservation which agreed with the report of Li et al. (2012) and Rahman et al. (2014) who stated that TBA or mPV increased significantly ($p<0.05$) at the expiration of freezing preservation period. However, T1 had the lowest ($p<0.05$) values of TBA and mPV while T0 had highest ($p<0.05$) followed by T4. Lipid oxidation is a major quality in deteriorative process in muscle foods resulting in a variety of breakdown of products which produce undesirable off-odours and flavours (John et al., 2005). This could be possible due to high oxidation of meat not been packaged with any material and it might have been attacked by oxygen ingress in the freezing system unlike those meat that were shielded by packaging materials against oxidating effect of oxygen especially meat preserved with plastic. It was reported that a preservative packaging material should ideally inhibit undesirable enzyme activities (Scetar et al., 2010).

Table 3. Lipid oxidation of preserved chicken meat as influenced by local packaging materials ($p<0.05$)

Treatments	**Variable**	
	TBA(mg/kg)	**mPV(meq/kg)**
T0	0.05 ± 00.3^{bp}	1.10 ± 0.84^{ap}
T1	0.02 ± 0.01^{by}	0.32 ± 0.43^{ay}
T2	0.03 ± 0.01^{bx}	0.53 ± 0.04^{ax}
T3	0.03 ± 0.01^{bx}	0.82 ± 0.63^{aq}
T4	0.04 ± 0.02^{bq}	0.88 ± 0.52^{aq}

Means on the same row or column with different superscripts are statistically significant ($p<0.05$). TBA = Thiobarbuturic Acid mPV = Modified Peroxid Value.

The results of microbial status of chicken meat packaged and preserved using local materials revealed that there were significant ($p<0.05$) differences in the values of microorganisms and among and within the treatments (Table 4). Total viable count (TVC) value was higher ($P<0.05$) than Total Coliform Count (TCC), while Total Fungal Count (TFC) value was least ($p<0.05$). The microbial load was lower ($p<0.05$) in T1, followed by T2 while it was higher ($p<0.05$) in T0, T3 and T4 respectively. The results showed the extent to which the local packaging materials could prevent the microbial invasion of preserved meat due to their preservative capacity. The report of Mecitoglu et al. (2006) showed that polymeric packaging materials gave better and longer shelf-life to fresh meat and meat products preserved over time as observed in this study, poultry meat packaged with plastic container had lower values of microbial load compared with other packaging materials tested. Packaging materials are used to avoid contamination, delay spoilage, permit some enzymatic activity to improve desirable meat qualities (Kerry et al., 2006). The number of aerobic bacteria (TVC) was higher probably due to the fact they can survive mostly under abundant oxygen supply. The chicken meat without packaging was exposed to oxygen ingress more than those preserved with packaging materials thus, recorded highest aerobic load but not above the consumable level of 10^{10} cfu/g at which rate meat is considered spoiled (Insausti et al., 2001; Uzeh et al., 2006).

Table 4. Microbiological Properties of Preserved Chicken meat as affected by local packaging materials and duration of preservation

Treatments	**Variable**		
	TVC(cfu/g)	**TCC (cfu/g)**	**TFC (cfu/g)**
T0	6.00 ± 0.75^{ap}	4.53 ± 1.78^{bp}	3.87 ± 2.26^{cp}
T1	3.43 ± 1.54^{ax}	2.35 ± 1.07^{bx}	1.23 ± 1.56^{cx}
T2	4.50 ± 2.36^{aq}	3.43 ± 2.45^{bq}	2.37 ± 3.20^{cq}
T3	5.63 ± 3.47^{ap}	4.60 ± 0.91^{bp}	3.39 ± 2.88^{cp}
T4	5.80 ± 2.96^{ap}	4.75 ± 2.16^{bp}	3.48 ± 3.27^{cp}

Means on the same row or column with different superscripts are statistically significant (p<005), TVC = Total Viable Count, TCC = Total Coliform Count, TFC = Total Fungal Count.

It was observed (Table 5) that all the sensory attributes of poultry meat packaged and preserved using plastic containers (T1) were better ($p<0.05$) followed by that packaged with polythene bags (T2) compared with those packaged with printing paper wrapper (T3) and cardboard carton (T4) as well as T0 (control). These results confirmed the fact that poulty meat has to be preserved to a limited time period based on the local packaging material used (Koch et al., 2009). The aim of any packaging material for fresh meat is to prevent or delay undesirable changes to the appearance/colour, flavor, odour/aroma, texture as well as inhibit undesirable enzyme activities, but not interfere with or inhibit activities that are beneficial to the meat. However, any non-enzymatic reaction that affects the organoleptic qualities of raw meat are invariably undesirable and should be preferably slowed or prevented by a preservative packaging (Scetar et al., 2010). In this study, it was observed that the use of plastic material to package chicken meat for preservation really slowed down deterioration of eating qualities of the meat thereby agreeing with the report of other previous workers.

Table 5. Organoleptic characteristics of preserved chicken meat as influenced by local packaging materials

Treatments	Variable					
	COL	**FLV**	**TDN**	**JCN**	**TEX**	**OA**
T0	3.00 ± 0.53^{d}	3.03 ± 1.13^{c}	3.00 ± 0.42^{c}	3.00 ± 2.11^{b}	3.07 ± 1.59^{c}	4.40 ± 1.09^{d}
T1	6.00 ± 0.58^{a}	5.26 ± 0.52^{a}	5.63 ± 1.62^{a}	4.80 ± 1.28^{a}	5.40 ± 1.93^{a}	7.93 ± 1.06^{a}
T2	5.00 ± 0.56^{b}	4.10 ± 1.80^{b}	4.20 ± 1.72^{b}	3.40 ± 1.81^{b}	4.33 ± 1.79^{b}	6.57 ± 0.42^{b}
T3	4.00 ± 1.31^{c}	3.47 ± 1.35^{c}	4.13 ± 0.61^{b}	3.47 ± 2.21^{b}	4.30 ± 1.57^{b}	5.41 ± 0.91^{c}
T4	3.00 ± 1.11^{d}	3.20 ± 2.00^{c}	4.00 ± 1.33^{b}	3.25 ± 1.12^{b}	3.27 ± 0.88^{c}	4.30 ± 2.21^{d}

Means on the same column with different superscripts are statistically significant (p<005); COL = Colour, FLV = Flavour, TDN = Tenderness, JCN = Juiciness, TEX = Texture, OA = Overall Acceptability.

Conclusions

Based on the results of this study, it was concluded that poultry meat quality was affected by local packaging materials over 28days of preservation in the freezer at – 18°C.

The quality factors of poultry meat packaged with plastic containers were far better than those meat packaged with other local materials which was closely followed by those of meat packaged with polythene bags, while those meat packaged with cardboard carton had the least quality factors beside the control.

It is therefore, recommended that plastic containers be used for packaging poultry meat especially in developing countries like Nigeria in lieu of very costly and unavailable modern packaging materials for better quality of chicken meat.

Conflicts of interest

The authors declared that there are no conflicts of interest

References

AMSA. 2012. Meat colour measurement Guidelines (Revised ed): American Meat Science Association http://www.meatscient.org Assessed 20/8/2017.

AMSA. 2015. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurement of Meat. American Meat Sci. Assoc. 2nd Ed, Version 10 http://www.meatscience.org.Assessed 20/08/2017.

AOAC. 2002. Official Methods of Analysis (19th ed) International. Inc Washington, D.C US.

APHA. 1992. Compendium of methods for the microbiological examination of foods (3rd ed.) American Public Health Association (eds) Vaderzant, C. and Splitlstoesser, D.F. Ann Arbor, Michigan, USA

Apata ES. 2011. Quality attributes of Red-Sokoto buck meat as influenced by post-slaughter processing methods Ph.D Thesis in the Department of Animal Science, University of Ibadan, Ibadan Oyo State, Nigeria.

Azad MAK, Sakib MN, Murshed HM, Hashem MA, Ali MS, Habib M, Billah MM. 2022. Indigenous transport methods: Hormonal responses and physicochemical properties of lamb meat. Meat Research, 2(2): 1-6.

Bithi MAA, Hossain MA, Rahman SME, Rahman MM, Hashem MA. 2020. Sensory, nutritive, antioxidant and antimicrobial activity of telakucha (Coccnia cordifolia) leaves extract in broiler meatballs. Journal of Meat Science and Technology, 8(2): 23-31.

Boby F, HossainMA, Hossain MM, Rahman MM, Azad MAK, Hashem MA. 2021. Effect of long coriander leaf (Eryngium foetidum) extract as a natural antioxidant on chicken meatballs during at freezing temperature. SAARC Journal of Agriculture, 19(2): 271-283.

Bhat ZF, Bhat H. 2011. Recent trends in poultry Packaging: A Review American Journal of Food Technology, 6(7): 531-540.

Cha DS, Choi JH, Chinnan MS, Park HJ. 2002. Antimicrobial films based on Na-alginate and K-carrageenan. Lebensm – Wiss Technology, 35:716-719.

Disha MNA, Hossain MA, Kamal MT, Rahman MM, Hashem MA. 2020. Effect of different levels of lemon extract on quality and shelf life of chicken meatballs during frozen storage. SAARC Journal of Agriculture, 18(2): 139-156.

Han JH. 2005. New Technologies in Food Packaging: Overview. In: Innovations in food packaging, Han, J.E. (Ed). Elsevier Academic Press, Amsterdam, Pp 3-11.

Hashem MA, Himo FA, Arafath MS, Numan AA, Azad MAK. 2023a. Influence of aerial and vacuum packaging on the quality and shelf life of beef treated with extra virgin olive oil. Meat Research, 3(3): 1-10.

Hashem MA, Yasmin M, Ali MS, Sabid AA, Noman MAA. 2023b. Effect of Vacuum and Aerial Packaging on the Quality and Shelf Life of Broiler Meat Treated with Extra Virgin Olive Oil. Meat Research, 3(4): 1-7.

Hossain MA, Rahman MM, Rahman MW, Hossain MM, Hashem MA. 2023. Effect of supplementary feeding on the production traits, carcass and meat quality of Jamuna basin lambs. Journal of Animal Science and Technology. 65(1): 209-224.

Hurme E, Malm TS, Ahvenaimen R. 2002. Active and Intelligent Packaging. In: Minimal Processing Technologies in the food Industry, Ohlson, T. (Ed). Bengtsson Woodhead Publishing Ltd, CRC Press, Cambridge Pp 87-123.

Insausti K, Berian MJ, Purroy A, Alberti P, Gorraiz C, Alzueta MJ. 2001. Shelf-Life of beef from local spanish cattle breeds stored under modified atmosphere. Meat Science, 5:273-281.

James ME, Kooshesh S, Johnson MG. 2002. Control of Listeriamonocytogenes on the surface of refrigerated, ready to eat chicken coated with zein film coatings containing nisin and/or calcium propionate. Journal of Food Science, 67:2754-2757.

John L, Cornforth DP, Carpenter CE, Sorheim O, Pettee B, Whittier DR. 2005. Colour and thiobarbituric acid values of cooked top sirloin steaks in modified atmospheres of 80% oxygen or 0.4% carbon monoxide or vacuum. Meat Science, 69: 441- 449.

Kerry JP, O'Grady MN, Hogan SA. 2006. Past, current and potential utilization of active and intelligent packaging systems for meat and muscle-based products: A review. Meat Science, 74: 113-130.

Koch AG, Christensen H, Sorensen PE, Meinert L. 2009. Requirements to shelf life of fresh meat and meat products. Proceedings of the 55th Congress of Meat Science and Technology August 16-21, Copenhagen, Denmark. Pp 1273 – 1276

Lawries RA, Ledward DA. 2006. Lawries Meat Science 7th edition, UK. Cambridge Wood Head Publishing Ltd.

Li J, Xu X, Zhou G. 2012. Effect of freeze-thaw cycles on meat quality of beef striploin. Jiangsu Journal of Agricultural Sciences, 95:230-237.

Malgorzata S, Kazimierz L, Henry KK, Jrry W, Leszek G, Joanna Z, Edyta R. 2005. The effect of cattle genotype on texture of selected muscles during post-mortem ageing. Electronic Journal of Polish Agriculture University of Food Science and Technology, 8(3):1-9.

Marchiori AF, de-felicio PF. 2003. Quality of Wild boar meat and commercial Pork. Science Agriculture (Piracicaba, Braz) 60(1):1-10.

Mecitoglu C, Yemenicioglu A, Arslanoglu A, Elmac ZS, Korel F, Cetin AE. 2006. Incorporation of partially purified hen egg white lysozyme into zein films for antimicrobial food packaging. Food Research International, 39:12-21.

Pensel A. 1990. Influence of experimental conditions on porcine muscle and its effect on oxidation. MSc Thesis Department of Animal Sciences. The Ohio State University, Columbus, Ohio, USA

Pettersen MK, Mielnik MB, Eie T, Skrede G, Nilson A. 2004. Lipid Oxidation in frozen, mechanically deboned Turkey meat as affected by packaging parameters and storage conditions. Poultry Science, 83:1240-1248.

Qiaofen C, Da-Wen S. 2005. Application of PLSR in correlating physical and chemical properties of Pork ham with different cooking methods. Meat Science, 70:691-698

Rahman MH, Hossain MM, Rahman SME, Amin MR, Deog – Hwan OH. 2014. Evaluation of Physicochemical deterioration and lipid oxidation of beef muscle affected by freeze thaw cycles. Korean Journal of Food Science and Animal Resources 35(6): 772-782.

Rana MS, Hashem MA, Murshed HM, Bhuiyan MK, Rahman MM. 2020. Influence of bulking materials on the organic matter degradation during composting of cattle manure. Journal of Agriculture, Food and Environment, 1(3):33-38.

Rathore HA, Masud T, Sammi S, Majeed S. 2010. Innovative approach of active packaging in cardboard carton and its effects on overall quality attributes such as weight loss, total soluble solids, pH, acidity and ascorbic acid contents of Chaunsa white variety of mango at ambient temperature during storage. Pakistan Journal of Nutrition, 9:452-458.

Sang KJ, Mandal PK, 11-Suk K, Suk-Nam K. 2010. Effects of packaging methods and refrigerated storage on the quality of dry cured pork neck. Asian Journal of Animal and Veterinary Advances, 5:526-536.

SAS. 2002. Statistical Analysis System SAS/Stat User's Guide Version 9 SAS Institute Inc. Garry, NC: USA

Scetar M, Mia K, Kata G. 2010. Trends in meat and meat products packaging – A review. Croatian Journal of Food Science and Technology, 2(1): 32-48.

USDA. 2012. United States Department of Agriculture; Agricultural Research Service. Table of Cooking Yields for Meat and Poultry-Nutrient data Laboratory. http://www.ars.usda.gov/nutrientdata. Assessed 20/08/2017

Uzeh RE, Ohenhen RE, Adeniji OO. 2006. Bacterial contamination of Tsire – Suya – A Nigerian meat product. Pakistan Journal of Nutrition, 5(5): 458-460.