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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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The Effect of Open-market Retail Conditions in Nigeria on Oxidative Deterioration of Imported Frozen Upper Arms (*Brachium*) of Turkeys

Gbenga Emmanuel Onibi
Department of Animal Production and Health, School of Agriculture and Agricultural Technology,
Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria

Abstract: The effect of different periods of display and/or storage, as practiced under retail conditions for frozen turkey upper arms in Nigerian open markets, on physical appearance, odour and extent of lipid peroxidation of the meat was investigated. Five batches of frozen turkey shipments, sampled bi-monthly at 45 upper arms per batch were used. The frozen upper arms from each batch were displayed on the counter for up to 3 days, but re-frozen overnight. Five samples from the same batch were removed at 6 hourly intervals, giving a total of 9 treatments per batch. The samples were assessed for physical quality attributes (appearance and odour) by a 7-member panel using a 9-point Hedonic scale. The turkey upper arms were dissected and the moisture and lipid contents of the muscles measured. Extent of oxidation of muscle was determined by quantifying the malonaldehyde (MDA) concentration using the thiobarbituric acid reactive substances test. Muscle, bone and skin were found to represent 65.05 ± 4.28, 23.51 ± 4.21 and 14.44 ± 2.49% by weight of the intact upper arms. The relationship between the intact upper arms and the skin, bone and muscle, as measured by the correlation coefficient were found to be 0.60, 0.50 and 0.95 respectively ($P<0.001$). A strong relationship ($r = 0.95$, $P<0.001$) was found between physical appearance and odour of the meat. The physical appearance and odour of turkey upper arms were adversely affected ($P<0.01$) by increasing length of display and/or storage. The meat were disliked at the afternoon (for odour) and evening (for physical appearance) of the second day of display. Moisture and lipid contents of samples were 69.89 ± 0.94 and 4.58 ± 0.75% respectively. MDA concentrations of the turkey upper arms were found to increase with increased length of display and/or storage and were 2.90 ± 0.82 mg MDA/kg muscle for the "fresh" and 4.87 ± 0.83 mg MDA/kg muscle at the end of third day of display and/or storage.

Key words: Nigerian open-market, turkey upper arms, oxidative deterioration

Introduction

Meat, the flesh and organs of animals and fowls suitable for use as food (Judge *et al*., 1975), has long occupied a special place in human diet. Rising standard of a family, community and nation leads to increase in the quantity and quality of meat and fish products consumed. Meat is consumed by humans for a variety of reasons including taste, nutrient, prestige, tradition and availability (Rogowski, 1980). Elliot and Ezenwa (1988) reported that meat and fish are well accepted in the diet of Nigerians, are considered as essential protein food and also a focal point of a meal.

Poultry meat vary in acceptability to purchasers according to specie, cut (part), presentation, colour, tenderness, juiciness and flavour. They are susceptible to both microbial and oxidative deterioration. The changes in meat quality due to lipid oxidation are manifested by adverse changes in flavour, colour, texture and nutritive value, and the production of toxic compounds like malonaldehyde (MDA) and cholesterol oxides (Erikkson, 1982; Pearson *et al*., 1983; Gray and Pearson, 1987; Faustman *et al*., 1989; Monahan *et al*., 1992; Onibi, 2000a). The visual appearance of meat strongly influences consumers' purchase decision (Faustman *et al*., 1989). Consumers discriminate against meat cuts that have lost their fresh appearance and meat that becomes discoloured is often ground and marketed in a reduced value form.

In Nigeria, the handling, transportation and marketing of imported frozen turkey parts, of which the upper arm (*Brachium*) is one of the parts, are questionable. The turkey meat are mostly brought into the country through the various land borders and are transported in unrefrigerated cars or vans to the various marketing outlets in the urban centres. The epileptic power supply prevalent in these outlets further worsens the condition of the meat. In the local market, the frozen turkey parts are mostly displayed on counters without packaging and refrigeration, and are subjected to intense sunshine, high heat and humidity. These factors are prooxidants that accelerate oxidation of unsaturated fatty acids. One of the products produced as a result of oxidation of lipids in muscle food is MDA which has been extensively measured by the 2-thiobarbituric acid reactive substances test (Sinnhuber *et al*., 1958; Gray, 1978; Melton, 1983). Lipid oxidation products; MDA and cholesterol oxides have respectively been shown to be carcinogenic (Shamberger *et al*., 1974) and initiators of arteriosclerosis lesions in blood vessels (Peng *et al*., 1987).

This study was therefore conducted to determine the changes in visual appearance, odour and MDA concentration of imported frozen turkey upper arms under simulated Nigerian retail conditions.

Materials and Methods

Two hundred and twenty five (225) frozen upper arms of turkeys from 5 different batches of shipment, sampled bi-monthly at 45 upper arms per batch were purchased through frozen meat wholesaler in Akure, Ondo State, Nigeria. The frozen turkey upper arms were sourced by the wholesaler from Cotounou, Republic of Benin and were transported overnight. Upon receipt in the early hour of the morning, the frozen turkey meat were taken to the laboratory. The 45 turkey upper arms from each batch of shipment were allotted to the 9 treatments listed below at 5 turkey arms per treatment.

The experimental treatments were:

A Frozen turkey upper arms upon receipt ("fresh").
B Frozen turkey upper arms that were displayed on the counter for 6 hours (day 1).
C Frozen turkey upper arms that were displayed on the counter for 12 hours (day 1).
D Frozen turkey upper arms that were displayed on the counter for 12 hours and thereafter frozen overnight (day 2).
E Same as Treatment D and then re-displayed on the counter for additional 6 hours (day 2).
F Same as Treatment D and then re-displayed on the counter for additional 12 hours (day 2).
G Same as Treatment F and thereafter frozen overnight (day 3).
H Same as Treatment G and then re-displayed on the counter for additional 6 hours (day 3).
I Same as Treatment G and then re-displayed on the counter for additional 12 hours (day 3).

Turkey upper arms on Treatment A were removed for chemical analysis while those on the remaining treatments were displayed in fly-proof counter placed in front of the Departmental laboratory. The samples were sprinkled with drinkable water and turned hourly, simulating common retail practices in Nigeria. At the end of each day, the samples were packed in polythene bags, labeled and stored overnight in the freezer at -18 ^{0}C. Samples for re-display were removed in the morning (8.00 a.m.) of the following day and subjected to the same simulated retail conditions as done for the first day. The same procedure was repeated for the third day. Questionnaires were administered to a seven-member panel, using a nine-point Hedonic scale (1 = dislike extremely, 5 = not like nor dislike and 9 = like extremely), to assess the turkey arms at the end of each treatment period for physical appearance (colour and appeal for purchase) and odour. Members of the panel were selected from those that had been trained by the Department of Food Science and Technology of the University. Odour was evaluated based on smell perceived from each meat type on each treatment for acceptability for purchase. The same seven-member panel was used throughout and the assessment was carried out at the end of each display and/or storage treatment. After the assessment, muscles of each sample were dissected. The weights of the skin, bone and muscle of each upper arm on treatments A, B and C were taken to determine the relationship between intact and dissected arms. Muscles from the same batch of shipment on the same treatment were then chopped, mixed thoroughly and processed for chemical analysis within 2 hours of collection. Moisture and lipid contents of samples on treatment A ("fresh") were measured according to AOAC (1990) methods. Extent of lipid oxidation of the muscle tissues from the upper arms was determined using the extraction 2-thiobarbituric acid procedure described by Salih *et al.* (1987). Results were expressed as mg malonaldehyde (MDA)/kg muscle. All chemical analyses were carried out in duplicate. Data were subjected to regression analysis and analysis of variance (ANOVA) (following square root transformation for score data) where appropriate using the Minitab Statistical Package (v. 10.2, Minitab Inc., P.A., USA).

Results and Discussion

Physical appearance and odour of turkey upper arms: The results of physical appearance and odour of sampled turkey upper arms are shown in Table 1. The treatments significantly influenced ($P<0.01$) the physical appearance and odour of the meat. The highest score was recorded for upper arms of turkeys on Treatment A (8.60 ± 0.55) and lowest for those on Treatment I (1.20 ± 0.45). The scores decreased progressively from Treatments A to I. This showed that the physical appearance and odour of turkey upper arms on Treatment A (representing "fresh" sample) were best and those on Treatment I were extremely disliked by the panelists. No significant difference ($P>0.05$) in physical appearance was observed between turkey upper arms on Treatments B and C, D and E, E and F, and F and G. The odour score of turkey upper arms on Treatment A to G were significantly different ($P<0.05$) from one another. However, no significant difference ($P>0.05$) was observed in odour score of turkey upper arms on Treatments H and I. A strong relationship ($r = 0.945$; $P<0.001$) was found between physical appearance and odour of the turkey upper arms.

The trend of results obtained for physical appearance and odour may be attributed to the period of exposure of the meat to environmental conditions during display; the longer the exposure period, the lower the good quality score. The importance of physical appearance and odour in acceptability or rejection of meat by consumers cannot be overemphasized. Liu *et al.* (1995) established

Table 1: Physical appearance and odour of turkey upper arms

Treatment	Physical appearance	Odour
A	8.60 ± 0.55^{a}	8.60 ± 0.55^{a}
B	7.60 ± 0.55^{b}	7.60 ± 0.55^{b}
C	6.80 ± 0.84^{b}	6.60 ± 0.55^{c}
D	5.80 ± 0.45^{c}	5.60 ± 0.55^{d}
E	5.00 ± 0.71^{cd}	4.40 ± 0.55^{e}
F	4.40 ± 0.89^{de}	3.40 ± 0.55^{f}
G	3.60 ± 0.55^{e}	2.60 ± 0.55^{g}
H	2.60 ± 0.55^{f}	1.60 ± 0.55^{h}
I	1.20 ± 0.45^{g}	1.20 ± 0.45^{h}
Statistical significance	**	**
r	0.945 (P<0.001)	

Mean ± SD. n = 7 (representing 7 members of the scoring panel). ** = P<0.01. Means with different superscripts within the same column differ significantly (P<0.05). r = Correlation between physical appearance and odour of turkey upper arms.

that the three sensory properties by which consumers readily judge meat quality are appearance, texture and flavour. Earlier, Faustman *et al.* (1989) identified that visual appearance strongly influence consumer purchase decision. Consumers, they argue, discriminate against meat cuts that have lost their fresh appearance. The same view was upheld by Ikeme (1990) who reported that quality changes in poultry carcass meat, in the tropics, occur so fast as to preclude safe handling without refrigeration for more than a few hours after slaughter. Thus, the rate of quality deterioration and more particularly of spoilage, depends on the form in which the carcass is sold. Joseph (1998) also showed that sensory quality scores of colour, juiciness, flavour and overall acceptability decreased in frozen stored (-20 ^{0}C for 4 weeks) meat types compared with fresh meat.

Relationship between dissected parts of turkey upper arms: Table 2 shows the proportion of muscle, bone and skin as percentage of the intact upper arms and the correlation between these parts. The muscle had the highest percentage (65.05 ± 4.28%) followed by bone (23.51 ± 4.21%) and skin had the least (14.44 ± 2.49%). Weak positive relationships existed between intact upper arms and skin (r = 0.597), intact upper arms and bone (r = 0.501) and muscle and skin (r = 0.476). The relationships between the bone and skin, and muscle and skin were very poor (r = 0.075 and 0.268 respectively). Intact upper arms and muscle showed a very strong positive relationship (r = 0.95; P<0.001; regression equation y = -16.2 + 0.738x).

It could be deduced therefore that about 65, 24 and 14% by weight of intact turkey upper arms would be muscle, bone and skin respectively. The muscle weight could also be well predicted from the intact upper arm weight and vice versa. There is dearth of information on these proportional weights.

Moisture and lipid contents of turkey upper arm muscles: Table 3 shows the percent moisture and lipid contents of turkey upper arms. The moisture content of 69.89 ± 0.94% obtained fell within the range of 65 and 76% reported for meat by Ikeme (1990): Onibi (2000b). The lipid content of the sample was found to be 4.58 ± 0.75%. This value also was between 4 and 12% reported by Ikeme (1990) and Onibi (2000b) for poultry muscle.

Lipid Oxidation in turkey upper arm muscles: The results of extent of lipid oxidation in turkey upper arm muscles under different length of display and/or storage are presented in Table 4. Muscle lipid oxidation was significantly (P<0.05) affected by treatments. The MDA concentration was lowest (2.90 ± 0.82 mg MDA/kg muscle) for Treatment A ("fresh" sample) and increased to 4.87 ± 0.83 mg MDA/kg muscle for samples on Treatment I. No significant difference (P>0.05) was found between samples on Treatments A, B, C, D and E. Samples on Treatments E, F, G, H and I were not also significantly influenced (P>0.05) by treatments though there was a steady increase in MDA concentration from 3.89 ± 0.44 mg MDA/kg muscle (Treatment E) to 4.87 ± 0.83 mg MDA/kg muscle (Treatment I).

Thus, there was an increase in MDA concentration of samples with increase in length of display and/or storage. This corroborates earlier reports by Onibi *et al.* (2000) that deteriorative changes continue to occur during display/refrigerated storage of meat. Dineen *et al.* (2001) also reported that during display or storage of muscle food, ferritin lost iron and this was found to initiate membrane lipid peroxidation. Heating, as may occur on exposure of meat to sunshine could increase the rate of tissue lipid peroxidation. Heat disrupts muscle cell structure and releases oxygen form oxymyoglobin thereby increasing the exposure of tissue lipids to attack by oxygen and catalysts, and making them readily susceptible to oxidation (Dawson and Gartner, 1983). In fact, lipid peroxidation had been identified as one of the primary mechanisms of quality deterioration in displayed/stored foods, especially muscle tissues (Kanner *et al.*, 1987; Simic and Taylor, 1987; Asghar *et al.*, 1988; Rhee, 1988).

Conclusions and recommendations: The physical quality attributes (appearance and odour) and oxidative stability of turkey upper arms were adversely affected by the retailed conditions investigated. The meat were disliked at the afternoon (for odour) and evening (for physical appearance) of the second day of display. Malonaldehyde concentration of the turkey upper arms was found to increase with increased length of display and/or storage. A strong relationship (r = 0.95) between

Table 2: Relationship between intact and dissected parts of turkey upper arms

	Intact upper arms	Muscle	Bone	Skin
Proportion (as % of intact upper arms)	100	65.05 ± 4.28	23.51 ± 4.21	14.44 ± 2.49
Correlation (r) matrix				
Skin	0.597			
Bone	0.501			0.075
Muscle	0.950		0.268	0.476

Mean ± SD. n = 75 (representing dissected samples at 5/treatment/each of the shipment batches of treatments A, B and C only. Regression equation for relationship between intact upper arms and:
Skin y = 2.91 + 0.123x, Bone y = 13.3 + 0.139x, Muscle y = -16.2 + 0.738x

Table 3: Moisture and lipid contents (%) of turkey upper arm muscles

Moisture	Lipid
69.89 ± 0.94	4.58 ± 0.75

Mean ± SD. n = 5 (representing pooled samples on treatment A and 5 shipment batches.

Table 4: Lipid oxidation (mg MDA/kg muscle) in turkey upper arm muscles

Treatment	MDA Concentration
A	2.90 ± 0.82^{a}
B	3.07 ± 0.40^{ab}
C	3.62 ± 0.82^{abc}
D	3.58 ± 0.63^{abc}
E	3.89 ± 0.44^{abcd}
F	4.06 ± 0.84^{bcd}
G	4.18 ± 0.74^{cd}
H	4.37 ± 1.33^{cd}
I	4.87 ± 0.83^{d}
Statistical significance	*

Mean ± SD. n = 5 (representing pooled samples on each treatment and 5 shipment batches. * $P<0.05$. Means with different superscripts differ significantly ($P<0.05$).

physical appearance and odour of turkey upper arms was found. On weight basis, muscle, bone and skin represented 65, 24 and 14% of the intact upper arms of turkey. The relationship between the intact upper arms and the skin, bone and muscle, as measured by the correlation coefficient were 0.60, 0.50 and 0.95 respectively.

It is recommended that the Nigerian government should legislate against the practice of displaying fresh and frozen meat on counters in the markets in order to safeguard the health of the populace. Individual meat seller should be made to use insulated containers containing ice blocks or flakes. This will keep the temperature of retailed meat low thereby reducing the rate of lipid oxidation. Since electricity supply from the national grid is unreliable, owners of wholesale meat shops should be made to install electric power generators in their premises as a prerequisite for licensing. There should be responsible health/meat inspectors to ensure strict compliance with regulations. Nigerian consumers should also be enlightened about the possible toxicological and microbiological effects of buying cheap, discoloured, fly-borne and often filthy meat. The effect of the open-market retail practices on the microbial load of the turkey meat should be investigated.

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