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Effect of Modified Atmosphere Packaging on Microbial and Physical Qualities of Turkey Meat

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Abstract: The effect of modified atmosphere (80% oxygen +20% carbon dioxide) packaging, vacuum packaging and aerobic packaging on the microbial qualities viz., Total Viable Count (TVC) and anaerobic count, physical qualities viz., pH and drip loss and sensory quality viz., odour score of fresh and stored turkey meat at 4±1°C was studied. TVC, anaerobic counts, drip loss and odour score were the lowest in samples packaged under modified atmosphere. Turkey meat packaged under modified atmosphere and vacuum kept well up to twenty-one days of storage but based on the odour score turkey packaged under vacuum revealed to be better. It could be concluded that turkey meat packaged under modified atmosphere kept safely up to 14 days of storage at 4±1°C based on the desirable TVC, anaerobic counts and drip loss. Whereas turkey meat packaged under vacuum could be safely kept up to 21 days of storage.

Key words: Modified atmosphere packaging, total viable count, anaerobic count, pH, drip loss, odour score

INTRODUCTION

The important advancement in packaging technique to satisfy the consumers' need is application of Modified Atmosphere Packaging (MAP). Modified atmospheric packaged foods have become increasingly more available, as food manufacturers have attempted to meet consumer demands for fresh, refrigerated foods with extended shelf life. The principle of MAP is the replacement of air in the package with a different fixed gas mixture. Once the gas mixture is introduced, no further control of the gas composition is performed and the composition will inevitably change (Silvertsvik *et al*., 2002).

Narendra Babu *et al*. (2002) stated that TVC of the buffalo meat packed in modified atmosphere was significantly ($p<0.001$) lower than sample packed ordinarily due to 20% carbon dioxide. TVC of samples packaged under aerobic and modified atmosphere was increasing with increase in storage periods. The mean TVC was less than 10^7 g^{-1} or log 7 g^{-1} in the samples packaged in modified atmosphere up to 15 days of storage. Jayanthi (2003) pronounced that the anaerobic count of chevon packed in aerobic, vacuum and modified atmosphere methods increased as the storage period prolonged and highly significant ($p<0.01$) difference was revealed between the storage periods. The aerobic count of chevon packaged in modified atmosphere was the lowest among the three methods of packaging.

Among the total poultry meat production, broiler meat contributes about 70% followed by turkey meat about 7.5% (FAO, 2001). The world turkey meat production is 5.3 million metric tones and in Asian developing countries the meat production is 36,756 metric tones (FAO, 2004). The special significance in turkey is that they have higher bodyweight; meat is tastier and nutritious with higher protein content (20.42%) and lower fat content (8.02%) than broiler meat. Turkey meat attracts all classes of people because there are no religious and cultural barriers; especially demand rises during festival occasions. Increased consumer demand for fresh, preservative free turkey meat has stimulated changes in new preservative techniques in the meat industry.

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Jayanthi (2003) pronounced that the anaerobic counts of chevon packed in aerobic, vacuum and modified atmosphere methods increased as the storage period prolonged and highly significant ($p<0.01$) difference was revealed between the storage periods. Narendra Babu *et al*. (2002) opined that the lowest pH of the buffalo beef packaged in modified atmosphere was significantly ($p<0.05$) lower than samples packaged ordinarily.

Sekar *et al*. (2005) concluded that the drip loss in buffalo meat packaged in aerobic, vacuum and modified atmosphere method increased significantly ($p<0.01$) with storage at 4±1°C.

The odour score of buffalo meat (Narendra Babu *et al*., 2002) and chevon (Jayanthi, 2003) packaged in ordinary method was inferior to that of those meat packaged in modified atmosphere.

The scientific information on the effect of modified atmosphere packaging on fresh turkey meat quality is scarce. Hence the present study was taken with the following objectives,

- To assess the effect of modified atmosphere packaging in extending the shelf life of turkey meat.
- To study the effect of modified atmosphere packaging on microbial, physical and organoleptic qualities of turkey meat.
- To compare the effect of modified atmosphere packaging with that of vacuum and aerobic packaging of turkey meat.

MATERIALS AND METHODS

Fresh meat samples were collected from twelve turkeys of 16 to 24 weeks of age slaughtered and dressed in the Poultry Research Station, Nandanam, Chennai and utilized in the present study. The samples were wrapped in clean and sterile polyethylene bags and kept in a thermocole box containing ice cubes and transported to the Department of Meat Science and Technology, Madras Veterinary College, Chennai within 40 min. After removing the separable fat, tendons and bones, each sample was cut into thirteen sub samples each weighing 100 g of about 2.5 cm thickness.

Packaging was done in sterile polyester polyethylene (PET/poly) pouches (Thickness 62 micron, Oxygen transmission rate 140 to 150 cc/sq m/24 h/atm) under aerobic vacuum (using Komet double chamber vacuum packaging machine) and modified atmosphere packaging (80% O_2 and 20% CO_2). Four sub samples were utilised in each method. The remaining one piece of meat was used for fresh sample analysis carried out on the day of packaging and they were used as initial values for all the other treatments. The packaged samples were stored at 4±1°C and subjected to analysis on the third, seventh, fourteenth and twenty-first day of storage. In MAP, head space of meat to gas volume ratio was 1:1. The following parameters were studied for fresh, packed and stored samples - Total viable count, anaerobic count, pH, drip loss and odour score.

Microbiological Quality

Total Viable Count (TVC) and Anaerobic Count

Total viable count and anaerobic counts were determined according to the methods described by APHA (1984) with slight modifications. For sampling and making initial 10^{-1} dilution and ten fold serial dilutions, plating with Plate agar (HIMEDIA) incubation and counting respectively.

Physical Qualities

pH

The pH of the meat sample was analysed by using a digital pH meter (Cyberscan pH 510, Merck). Five gram of the fresh and packaged meat samples were taken and are homogenized with 45 mL of distilled water in a laboratory blender for about 1 min. The pH was recorded by

immersing the combined glass electrodes of digital pH meter in to the homogenate. The pH meter was calibrated with standard buffer solutions of pH 4 and 11 as per the user manual instructions, prior to measurement.

Drip Loss

The amount of drip in each pack was estimated by weighing the pack of meat before opening and subtracting the weight of meat plus packing after blotting dry. Drip loss was expressed as percentage of the initial weight of meat sample (Taylor *et al*., 1990)

Sensory Evaluation

Odour Score Assessment

The organoleptic acceptability of fresh, packaged and stored samples were judged by a trained laboratory panel of five members by assessing the odour score values and by awarding marks on a 10 point scale as described by Pearson (1968). A descending numerical rating was given to lesser acceptable samples and putrid odour was at the bottom of the scorecard with one point rating.

Statistical Analysis

The data obtained in this study were analysed by randomized block design treating the three packaging methods as blocks and the four periods of storage treatment as main effect. Using two-way analysis of variance and two-way interactions, main effects were analyzed for significance as outlined by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The mean (±SE) and ANOVA values of total viable count, anaerobic count, pH and drip loss and odour score of turkey meat packaged under aerobic, vacuum and modified atmosphere in PET/Poly pouches and stored up to 21 days at 4±1°C are presented in Table 1 to 3.

Microbiological Qualities

Total Viable Count (TVC) (log value/g)

The mean TVC of samples in aerobic, vacuum, modified atmosphere, increased from the day of storage up to the twenty-first day of storage (Table 1). Narendra Babu *et al.* (2002) and Jayanthi

Table 1: Mean (±SE) of total viable count, anaerobic count (log value/g) of fresh and packaged turkey meat stored at 4±1°C

Packaging methods	Storage periods (days)					Overall mean (pooled
TVC	0	3	7	14	21	over days)
Aerobic	3.40±0.13	4.02±0.11	4.64±0.16	4.81±0.15	4.83±0.19	4.34±0.15
Vacuum	3.40±0.13	3.81±0.19	4.29±0.24	4.57±0.18	4.99±0.14	4.21±0.18
Modified Atmosphere	3.40±0.13	4.05±0.14	4.25±0.16	4.25±0.17	4.60±0.13	4.11±0.15
Over all mean (Pooled over methods)	3.40±0.13	3.96±0.15	4.39±0.19	4.54±0.17	4.86±0.15	
Anaerobic count						
Aerobic	3.43±0.16	3.83±0.26	4.14±0.19	4.81.±0.15	4.85±0.18	4.21±0.19
Vacuum	3.43±0.16	3.95±0.20	4.07±0.29	4.58±0.21	4.92±0.15	4.24±0.20
Modified Atmosphere	3.43±0.16	3.76±0.17	4.05±0.23	4.25±0.17	4.29±0.22	3.95±0.19
Over all mean (Pooled over methods)	3.43±0.16	3.84±0.21	4.09±0.24	4.63±0.18	4.69±0.18	

Table 2: Mean (±) of pH, drip loss and odour score of fresh and packaged turkey meat stored at 4±1°C

Packaging methods	Storage periods (days)					Overall means (Pooled over days)
pH	0	3	7	14	21	
Aerobic	5.94±0.04	5.75±0.07	5.81±0.07	5.83±0.05	6.01±0.10	5.87±0.06
Vacuum	5.94±0.04	5.71±0.08	5.76±0.06	5.78±0.07	5.91±0.13	5.82±0.07
Modified atmosphere	5.94±0.04	5.76±0.04	5.81±0.13	5.82±0.06	5.94±0.10	5.85±0.08
Overall mean (Pooled over methods)	5.94±0.04	5.74±0.07	5.79±0.09	5.81±0.06	5.95±0.11	5.85±0.07
drip loss						
Aerobic	0.00±0.00	1.62±0.27	2.96±0.33	3.26±0.49	3.93±0.39	2.35±0.29
Vacuum	0.00±0.00	1.40±0.05	2.78±0.29	4.13±0.73	4.43±0.65	2.55±0.34
Modified atmosphere	0.00±0.00	1.03±0.13	2.43±0.20	2.71±0.26	3.24±0.26	1.88±0.17
over all mean (Pooled over methods)	0.00±0.00	1.35±0.15	2.72±0.27	3.37±0.49	3.87±0.43	
Odour score						
Aerobic	9.12±0.09	7.62±0.15	7.28±0.13	6.58±0.09	6.0±0.10	7.32±0.11
Vacuum	9.12±0.09	8.05±0.16	8.02±0.14	7.42±0.12	7.08±0.06	7.94±0.12
Modified atmosphere	9.12±0.09	7.58±0.11	7.13±0.18	6.42±0.05	5.85±0.08	7.22±0.10
Over all mean (Pooled over methods)	9.12±0.09	7.75±0.14	7.48±0.15	6.81±0.08	6.31±0.08	

Table 3: Analysis of variance of pH, drip loss and odour scores of fresh and packaged turkey meat stored at 4±1°C

Source of variation	df	Mean squares				
		pH	Drip loss	Odour score	TVC	Anaerobic count
Between packaging methods	2	0.04^{NS}	7.02**	9.04**	0.60^{NS}	1.48*
Between storage periods	4	0.32**	89.64**	41.15**	11.61**	10.20**
Between packaging methods× storage periods.	8	0.01^{NS}	1.34^{NS}	0.83**	0.32^{NS}	0.35^{NS}
Error		0.07	1.44	0.16	0.31	0.47

*Significant ($p<0.05$), **Highly significant ($p<0.01$): NS: Not Significant

(2003) reported consistent results. There was a highly significant ($p<0.01$) difference noticed between storage periods. Turkey meat stored up to 3 days had the lowest TVC.

The overall mean TVC of samples packaged in all the methods were increased with increasing storage periods (Table 2). This result was in accordance with Stringer *et al.* (1969), Sheridan (1997), Narendra Babu *et al.* (2002) and Jayanthi (2003).

The samples packaged under vacuum had a lower TVC on comparison to aerobically packaged method. This result coincided with the findings of Dushyanthan *et al.* (2000b).

TVC of turkey meat packaged under modified atmosphere was increasing with the increase in storage periods. This might be implied to growth of lactic acid bacteria, *B. thermosphacta*, Pseudomonas and Enterobacteriaceae. This increase in TVC was in correspondent to the reports of Sheridan *et al.* (1997), Narendra Babu *et al.* (2002) and Jayanthi (2003).

The increase in TVC of samples packaged in aerobic method was in agreement to the findings of Stringer *et al.* (1969), Narendra Babu *et al.* (2002) and Jayanthi (2003). The increase in TVC of samples packaged in vacuum method when compared to MAP sample was in accordance to the findings of Jayanthi (2003). The mean TVC was less than 10^7 g^{-1} or log 7 g^{-1} in the samples packaged in modified atmosphere up to 21 days of storage. This was similar to the report of Georgala and Davidson (1970), Narendra Babu *et al.* (2002) and Jayanthi (2003).

Anaerobic Count

Mean anaerobic count of samples packaged in aerobic, vacuum and modified atmosphere methods increased from the day of packaging up to the twenty-first day of storage. This result was in concordance to the findings of Jayanthi (2003).

Analysis of variance between the packaging methods showed significant ($p<0.05$) difference and between the storage periods highly significant ($p<0.01$) difference was noticed. The later inference coincided with that of Jayanthi (2003).

Turkey meat packaged under modified atmosphere and stored up to 3 days had the lowest anaerobic count. This finding could be signified to the presence of 80% oxygen under MAP (Ahvenainen, 1989; Smith *et al*., 1991; Jayanthi, 2003).

Physico Chemical Qualities

pH

The fall in pH was noted initially and gradual increase there after up to the twenty-first day of storage in all the methods of packaging was in congruence with the findings of Narendra Babu *et al.* (2002) and Sekar (2005). The initial fall in pH is a normal postmortem consequence, owing to the post-mortem glycolysis and subsequent lactic acid accumulation. A lower pH of the turkey meat packaged in MAP noticed is due to the presence of CO_2, which could reduce the pH by dissolution in to the surface of fresh meat (Table 2). This finding was an agreement with that of Narendra Babu *et al.* (2002).

The lowest pH noticed in vacuum packaged turkey meat samples and stored up to the twenty first day was more or less corroborative to the findings of Dushyanthan *et al.* (1997, 2000b and 2001) could be attributed to the anaerobic environment in vacuum packaged meat as well as the increase in storage period.

Drip Loss

The gradual increase in mean drip loss values of the samples packaged in all the three methods from the day of packaging to the twenty-first day of storage (Table 2) was similar to the findings of Payne *et al.* (1998) and Sekar *et al.* (2005). Highly significant ($p<0.01$) differences between the packaging methods and storage periods noticed in this study were more or less concordant to the results reported by Sekar *et al.* (2005).

The highest drip loss noticed in turkey meat packaged under vacuum and stored up to 21 days was congruous to the findings of Rousset and Renerre (1991) and Sekar *et al.* (2005). The increased drip loss in vacuum packaged turkey meat could be attributed to the squeezing of meat that is associated with the vacuum packaging as reported by Payne *et al.* (1998).

The lower drip loss noticed in MAP turkey meat may be attributed to the head space gas pressure maintained in the MAP as confirmed to the reports of Daniels *et al.* (1985).

Odour Score

The decrease in mean odour score of the samples packaged in all the three methods from the day of packaging to twenty-first day of packaging was congruent to the result reported by Ahmed *et al.*

(1990), where a significant decrease in odour score of turkey meat after 72 h of storage at 5±°C was evident. Highly significant ($p<0.01$) differences noticed between packaging methods, between storage periods and interaction between packaging methods and storage periods were concomitant to the findings of Narendra Babu *et al.* (2002) and Jayanthi (2003).

Turkey meat samples packaged under modified atmosphere and stored up to 21 days denoted the lowest odour score when compared to those packaged under aerobic and vacuum methods. Turkey meat had a lower fat content but higher proportion of unsaturated fatty acids and hence more susceptible to oxidative changes. These changes are more in turkey meat packaged under modified atmosphere and aerobic methods, which was revealed the lowest odour score in MAP samples. This finding was supported by the findings of Kim *et al.* (2002).

Highest odour score was noticed in turkey meat packaged under vacuum and stored up to 3 days due to the production of the least volatile compounds consisting mainly dimethyl sulphides and 2-propanone under vacuum than aerobically and modified atmosphere packaged ones as reported by Nam *et al.* (2001), Nam and Ahn (2002) and Nam and Ahn (2003).

The reports published by Narendra Babu *et al.* (2002) and Sekar (2003) were contrary to the findings of this study. This can be imputed to the fact that turkey meat has the lowest fat content and the highest proportion of unsaturated fatty acids when compared to beef, buffalo meat, pork and mutton as promulgated by Kim *et al.* (2002).

The results of this study indicated that the turkey meat packaged in modified atmosphere displayed a desirable TVC, anaerobic count and drip loss. But the odour score of samples packaged under modified atmosphere was the lowest. Vacuum packaged turkey meat disclosed a better odour score and hence could be interpreted as the best method for storage of turkey meat at 4±1°C up to 21 days (Table 3).

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