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EFFECT OF PACKAGING METHODS AND STORAGE PERIODS ON PHYSICO-CHEMICAL CHARACTERISTICS OF GOAT MEAT

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Abstract: Chevon packed under modified atmosphere (80 per cent oxygen + 20 percent carbon dioxide), vacuum and acerbic packagings on fresh and stored at 4 ± 1ºC upto 21 days were investigated. Twelve samples were packed in aerobic, vacuum and modified atmosphere (80% oxygen and 20% carbon dioxide) packaging methods (each four pieces) and one piece was used for fresh sample analysis carried out on the day of packaging and was used as initial values for all three treatments. The results revealed that hue, chroma value, colour, appearance, odour score and water holding capacity were significantly higher ($P< 0.01$) in samples packaged in modified atmosphere packaged sample compared to vacuum and aerobic packaged samples. The extract release volume and p^H values differed significantly ($P<0.01$) for different storage periods. Thiobarbituric acid number and Tyrosine values revealed no significant differences between package methods and storage periods. The present study concludes that the chevon can be preserved safely up to twenty one days in modified atmosphere packaging (80 per cent oxygen + 20 per cent carbon dioxide) in PET / Poly pouches at 4±1ºC. In case of vacuum and aerobic packages the chevon samples can be preserved safely upto fourteen days.
Keywords: Goat meat, Aerobic, Modified atmosphere, Vacuum Package.

Introduction

The demand for chevon in India is high due to its wider acceptability over any other type of meat because of its leanness, chewability and there are no religious taboos against goat slaughter and chevon consumption. Consumer relates the colour and appearance of the chevon to the freshness of the product. Due to ever increasing socio-economic status of the consumer, they are ready to spend more to purchase packaged meat, which they consider safe to consume. To satisfy the present day consumer's demand, newer techniques like vacuum packaging and modified atmosphere packaging have emerged. By modification of gaseous composition within the package, we can restrain the deleterious biochemical reaction, growth of spoilage micro-organisms and the respiration rate of meat, so that the self-life of the meat can be extended (Kerry *et al.,* 2006). The most suitable gas mixture for retailing fresh red meat is found to be 20% CO_2+80% O_2 (Ahvenainen *et al.,* 1989). Modified atmosphere

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package of red meat for retail sale can prolong the microbiological shelf life when compared to traditional oxygen permeable overwrap (Wicklund *et al.,* 2006). In the view of the contribution of goat meat to the Indian economy and the necessity for proper packaging of meat, this study was carried out to determine the effect of different package methods and storage periods on physico-chemical property of chevon.

Materials and Methods

Preparation of meat samples

Fresh muscle samples were collected from 9 months old goat slaughtered under the Halal method. The samples were received within 45 min of slaughter and subjected to the different packaging treatments, viz., aerobic, vacuum and modified atmosphere (80% oxygen and 20% carbon dioxide) using sterile polyester polyethylene (PET/Poly) pouches (thickness – 62 lm, oxygen transmission rate – 140–150 cc/sq.m/24 h/atm at 37°C). After removing the visible fat and tendons, sample was separated into 13 portions, each weighing 100 g and about 2.5 cm thick. Of the 13 portions four were placed in the pouches and sealed (aerobic method); four were vacuum packed and another four were packed under modified atmosphere. The remaining one portion was used for fresh sample analysis on the day of packaging and was used as initial values for all three treatments. The packed samples were assessed for Colour, Appearance score, Odour score, pH, Water Holding Capacity (WHC), Extract Release Volume (ERV), Thiobarbituric Acid Number (TBA number) and Tyrosine Value (TV) on the third, seventh, 14th, and 21st day of storage at 4 ± 1 °C. In MAP the meat to gas volume ratio was 1:1.

Physicochemical parameters

Hue and Chroma Value

Hue and Chroma Value of Fresh, packaged and stored samples were calculated by comparing the colour strips in the Munsell colour book.

Colour and appearance score assessment

Fresh, packaged and stored samples were subjectively evaluated by a trained five-member panel for muscle colour, using a nine-point scale (9 = Bright red, 1 Greenish Grey) and appearance using a nine-point scale (9 = Appealing high, 1 = not so pleasing high)

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 score card with one point rating.

pH

The pH of the fresh and stored goat meat was measured using a digital pH meter. About 5 gm of sample were cut into small pieces to which 45 ml of distilled water was added and a slurry was made using a blender and the pH was recorded.

Water Holding Capacity

Water holding capacity of fresh and packaged samples was assessed by adopting the filter paper press method as outlined by Hofmann *et al.* (1982) with certain modifications.

Water holding capacity = (Area of Inner circle/Area of Outer circle) x 100.

(Percentage)

Extract Release Volume

The extract release volume (ERV) of fresh and stored chevon was estimated by the method outlined by Pearson (1967).

Thiobarbituric acid number and Tyrosine value (TV)

Thiobarbituric acid number (TBA) reagent was prepared according to Pearson (1973) by dissolving 0.2883g of thiobarbituric acid in sufficient quantity of 90 per cent glacial acetic acid and by light warming, the volume being made up to 100ml with 90 per cent glacial acetic acid. Thiobarbituric acid (TBA) number and Tyrosine value were measured by using a modified method of Strange *et al.* (1977) with a little variation in the technique using spectrophotometer (u Quant, Bio-Tek Instruments Inc.) at medium sensitivity.

Statistical analysis

The data obtained in this study were analyzed 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

Hue value

The mean hue value of the sample packaged in modified atmosphere increased from the day of packaging to seventh day and then decreased gradually till twenty first day. Whereas, it decreased from the day of packaging to twenty first day of storage in vacuum and aerobic packaging (Table 1). This finding is in agreement with Baltzer (1969).

The analysis of variance revealed a highly significant (P<0.01) difference between packaging methods. The highest mean hue value (9.38±0.33) was recorded in the samples packaged in modified atmosphere at seventh day of storage. This finding is in accordance with Smith *et al.* (1991) and Hotchkiss *et al.* (1989) who revealed that samples packed in MAP maintained the red colour of the meat up to twenty one days and this is mainly due to high concentration of oxygen (80 per cent) in the present study. The mean hue value of the samples in modified atmosphere did not influence by the storage period.

Chroma Value

The mean Chroma of the samples packaged in modified atmosphere increased from the day of packaging to third day and then decreased gradually to twenty first day of storage. This value in samples packaged aerobically and in vacuum decreased from the day of packaging to twenty first day of storage (Table- 1).

The analysis of variance of Chroma value showed a highly significant (P<0.01) difference between day of packaging to twenty first day of storage. Due to higher concentration of oxygen present in the MAP the overall mean Chroma value was significantly higher in MAP sample than the sample in the aerobic and vacuum packaging.

Colour Score

Sample packed in MAP recorded the higher mean colour score at the third day of storage. However, it remained same upto day seven of storage and then decreased gradually to twenty first day of storage. The mean colour score of the samples packaged aerobically and vacuum decreased from the day of packaging to twenty first day of storage (Table- 2).

The analysis of variance revealed a highly significant (P<0.01) difference between the packaging methods, storage periods and interaction between packaging methods and storage periods. This finding in accordance with Sekar *et al.* (2006). The mean colour score in the samples packaged in MAP was higher in the present study. The colour of the sample in this package was red up to third day and rosy red till twenty one days of storage. The samples packaged aerobically and vacuum showed that the colour was rosy red upto seventh day and light red upto fourteenth day and it was purple in colour on twentieth day of storage. This finding is in agreement with Narendra Babu *et al.* (2002).

Appearance Score

The highest mean appearance score was recorded in the samples packaged in modified atmosphere at the third day of storage and it remained same upto day seven. The analysis of variance revealed highly significant (p<0.01) difference between packaging methods, storage

periods and interaction between packaging methods and storage periods. The mean appearance score of the samples packaged in modified atmosphere increased from the day of packaging to third day and then decreased gradually to twenty first day of storage (Table -2). In the present study, the appearance of the samples packaged in modified atmosphere was appealing up to twenty one days of storage. The appearance of the samples packaged both in aerobic and vacuum methods showed pleasing appearance up to fourteenth day of storage.

Odour score

The mean odour score of the samples stored in modified atmosphere, aerobic packaging and vacuum packaging decreased from the day of packaging to twenty first day of packaging (Table -2). This result is in agreement with that of result reported by Ahmed *et al.* (1990). A highly significant ($P<0.01$) difference for odour score was observed between packaging methods and storage periods and this was in concomitant to the findings of Rajkumar *et al.* (2007). The odour in the samples packed in MAP were acceptable up to twenty one day of storage whereas in vacuum packaging and aerobic packaging the samples were just acceptable up to fourteenth day of storage. On the twenty first day of storage the samples scored acceptable in modified atmosphere packaging, where as in the vacuum packaging and aerobic packaging the samples scored as just spoiled.

pH

The mean pH of the fresh sample significantly ($P<0.01$) differed between periods. A fall in pH was observed initially up to 3 days in the case of aerobically packed samples and up to 7 days in case of the vacuum and MAP samples (Table- 3). The pH increased thereafter up to 21 days of storage in all the treatments. The initial fall in pH is a normal postmortem changes owing to the postmortem glycolysis and subsequent lactic acid accumulation. The overall decrease during the first three days of storage and progressive increase thereafter agrees with the findings of Narendra Babu *et al.,* (2002).

The lowest mean pH 5.88±0.08 was recorded in the samples packaged in modified atmosphere at the seventh day of storage. It is due to the presence of carbon dioxide, which reduces pH by dissolution into the surface fresh meat. This finding is similar to that of Ahvenainen (1989).

Water holding capacity

The mean water holding capacity of samples in modified atmosphere, vacuum, aerobic packaging decreased from the day of packaging to twenty first day of storage (Table- 3). This is in agreement with Honikel et al. (1981), Venkataranujam (1994) and Dushyanthan *et*

al. (2000a). The results revealed a highly significant (P<0.01) difference between storage periods, packaging methods and interaction between packaging methods and storage periods. Samples packed in MAP had higher WHC than vacuum and aerobic packaging.

Extract release volume (ERV)

The mean ERV of fresh sample is in accordance with the findings of Venkataranujam (1994), Dushyanthan *et al.* (2001).The results revealed that highly significant (P<0.0) difference between storage periods. This finding was similar to result of Dushyanthan *et al.* (2001). The ERV of the samples packaged in MAP was highest among all the three packaging methods and it revealed no significant difference (Table- 3).

Thiobarbituric acid number (TBA) and Tyrosine value (TV)

The results revealed that there was no significant difference between packaging methods and storage periods for Thiobarbituric acid number (TBA) and Tyrosine value (TV) (Table-4). Even though there was no significant difference between the treatments, the overall mean TBA number in vacuum packaged samples was lowest among all the treatments. This may be due to the absence of oxygen in the vacuum packing.

However the overall mean TV in the modified atmosphere packaged sample was lowest throughout the storage periods compared to that of vacuum and aerobically stored samples. The mean TV of the samples increased from the day of packaging to twenty first day of storage. This result is in accordance with findings of Jagadeesh babu *et al.* (1998).

Conclusions

The chevon can be preserved safely up to twenty one days of storage in modified atmosphere packaging (80 per cent oxygen + 20 per cent carbon dioxide) in PET / Poly pouches at 4±1ºC. In case of vacuum and aerobic packages the chevon samples can be preserved safely upto fourteen days of storage. The consumer appeal was high till twenty one days of storage in modified atmosphere of 80 per cent oxygen + 20 per cent carbon dioxide in PET/poly pouches at 4 ± 1ºC.

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Table- 1: Mean (± SE) of hue and chroma value of fresh and packaged chevon stored at 4 ± 1°C

Packaging methods	Storage periods (days)					Overall mean (Pooled over days)
	0	3	7	14	21	
HUE						
Aerobic	8.33 ± 0.64	7.71 ± 1.21	6.88 ± 0.54	6.88 ± 1.11	5.83 ± 0.71	**7.13^{A} ± 0.84**
Vacuum	8.33 ± 0.64	7.08 ± 1.01	6.67 ± 0.47	6.04 ± 0.95	5.83 ± 0.56	**6.79^{A} ± 0.73**
Modified atmosphere	8.33 ± 0.64	8.54 ± 0.48	9.38 ± 0.33	8.33 ± 0.35	7.92 ± 0.28	**8.50^{B} ± 0.42**
Over all mean	**8.33^{Z} ± 0.64**	**7.78^{YZ} ± 0.90**	**7.64^{YZ} ± 0.45**	**7.08^{XY} ± 0.80**	**6.53^{X} ± 0.51**	
CHROMA						
Aerobic	6.50^{bc} ± 0.50	4.67^{a} ± 0.28	5.77^{ab} ± 0.28	4.33^{a} ± 0.41	4.17^{a} ± 0.51	**5.00^{A} ± 0.40**
Vacuum	6.50^{bc} ± 0.50	5.17^{a} ± 0.30	4.67^{a} ± 0.28	4.67^{a} ± 0.28	4.33^{a} ± 0.22	**6.00^{A} ± 0.32**
Modified atmosphere	6.50^{bc} ± 0.50	8.00^{d} ± 0.49	7.00^{cd} ± 0.67	6.67^{c} ± 0.82	4.83^{cd} ± 0.46	**7.00^{B} ± 0.59**
Over All mean (Pooled over methods)	**6.50^{Y} ± 0.50**	**5.94^{XY} ± 0.36**	**5.67^{XY} ± 0.41**	**5.22^{XY} ± 0.51**	**5.11^{X} ± 0.40**	

Overall means bearing different superscripts between row (A.B) and between columns (X,Y,Z) differ significantly (P<0.01).

Interaction means bearing different superscripts (a,b,c,d) differ significantly (P<0.05 or P<0.01).

Table -2: Mean (± SE) of odour, appearance and odour stores for fresh and packaged chevon stored at 4 ± 1°C

Packaging methods	Storage periods (days)					Overall mean (Pooled over days)
	0	3	7	14	21	
COLOUR SCORE						
Aerobic	7.48^{efg}	7.15^{def}	$6.70^{de} \pm 0.11$	$5.78^{b} \pm 0.32$	$4.97^{a} \pm 0.52$	$\mathbf{6.42^{A} \pm 0.23}$
Vacuum	7.48^{efg}	$6.85^{de} \pm$	$6.55^{bcd} \pm 0.07$	5.87^{bc}	$5.18^{a} \pm 0.44$	$\mathbf{6.39^{A} \pm 0.19}$
Modified atmosphere	7.48^{efg}	$8.17^{g} \pm 0.08$	$7.93^{fg} \pm 0.07$	7.18^{def}	$6.67^{cd} \pm 0.07$	$\mathbf{7.49^{B} \pm 0.09}$
Over all mean (Pooled over methods)	$\mathbf{7.48^{Z} \pm 0.10}$	$\mathbf{7.39^{Z} \pm 0.09}$	$\mathbf{7.06^{Z} \pm 0.09}$	$\mathbf{6.28^{Y} \pm 0.23}$	$\mathbf{5.61^{X} \pm 0.35}$	
APPEARANCE SCORE						
Aerobic	7.65^{efg}	$7.17^{def} \pm$	$6.53^{cd} \pm 0.11$	$5.42^{b} \pm$	$4.62^{a} \pm 0.48$	$\mathbf{6.28^{A} \pm 0.21}$
Vacuum	$7.65^{efg} \pm$	$6.88^{cd} \pm$	$6.23^{c} \pm 0.12$	$5.48^{b} \pm$	$4.83^{ab} \pm 0.35$	$\mathbf{6.22^{A} \pm 0.18}$
Modified atmosphere	$7.65^{efg} \pm$	$8.33^{g} \pm 0.05$	$7.88^{fg} \pm 0.09$	7.12^{dc}	$6.58^{acd} \pm 0.07$	$\mathbf{7.51^{B} \pm 0.07}$
Over all moan (Pooled over methods)	$\mathbf{7.65^{Z} \pm 0.05}$	$\mathbf{7.47^{Z} \pm 0.07}$	$\mathbf{6.88^{Y} \pm 0.10}$	$\mathbf{6.01^{X} \pm}$	$\mathbf{5.34^{W} \pm 0.30}$	
ODOUR SCORE						
Aerobic	$9.15^{f} \pm 0.15$	$0.08^{e} \pm 0.10$	$7.27^{c} \pm 0.12$	$6.10^{b} \pm$	$4.97^{a} \pm 0.48$	$\mathbf{7.11^{A} \pm 0.25}$
Vacuum	$9.15^{f} \pm 0.15$	$7.98^{de} \pm$	$7.27^{c} \pm 0.14$	$6.17^{b} \pm$	$5.22^{a} \pm 0.41$	$\mathbf{7.16^{A} \pm 0.23}$
Modified atmosphere	$9.15^{f} \pm 0.15$	$8.78^{f} \pm 0.04$	$8.10^{e} \pm 0.09$	7.37^{cd}	$6.73^{bc} \pm 0.05$	$\mathbf{8.03^{B} \pm 0.09}$
Over All mean (Pooled over	$\mathbf{9.15^{Z} \pm 0.15}$	$\mathbf{8.28^{Y} \pm 0.08}$	$\mathbf{7.54^{X} \pm 0.11}$	$\mathbf{6.54^{W}}$	$\mathbf{5.64^{V} \pm 0.32}$	

Overall means bearing different superscripts between row (A.B) and between columns (V,W,X,Y,Z) differ significantly (P<0.01).

Interaction means bearing different superscripts (a,b,c,d,e,f,g) differ significantly (P<0.01 or P<0.05).

Table 3: Mean (± SE) of pH, water holding capacity, extract release volume of fresh and packaged chevon stored at 4 ± 1°C

Packaging methods	Storage periods (days)					Overall mean (Pooled over days)
	0	3	7	14	21	
pH						
Aerobic	6.25 ± 0.06	5.93 ± 0.10	5.98 ± 0.06	6.03 ± 0.09	6.06 ± 0.11	**6.05 ± 0.09**
Vacuum	6.25 ± 0.06	6.00 ± 0.09	5.92 ± 0.08	5.99 ± 0.08	6.03 ± 0.10	**6.04 ± 0.09**
Modified atmosphere	6.25 ± 0.06	5.99 ± 0.11	5.88 ± 0.08	5.92 ± 0.10	6.00 ± 0.09	**6.01 ± 0.09**
Over all mean (Pooled over	**6.25^{Y} ± 0.06**	**5.97^{X} ± 0.10**	**5.93^{X} ±**	**5.98 ^{X} ± 0.09**	**6.03^{X} ±0.10**	
WHC (Percentage)						
Aerobic	99.88^{f}	62.73^{e} ±	50.85^{ab} ± 2.12	47.41^{a} ± 2.66	50.53^{ab} ± 2.44	**62.28^{A} ± 1.83**
Vacuum	99.88^{f}	61.08^{de} ± 2.5	53.68^{abcd} ±	59.60^{cde} ± 1.77	47.70^{a} ± 2.33	**64.39^{AB} ± 2.01**
Modified atmosphere	99.88^{f}	64.03^{e} ±	61.21^{de} ±	51.95^{abc} ± 2.30	57.21^{bcde} ±	**66.85^{B} ± 1.83**
Over all moan (Pooled over	**99.88^{Z}**	**62.61^{Y} ± 2.37**	**55.25^{X} ± 2.67**	**52.99^{X} ± 2.25**	**51.81^{X} ± 2.15**	
Extract Release Volume						
Aerobic	31.92 ± 2.24	21.08 ± 1.33	20.58± 1.63	18.75± 1.27	19.50± 1.54	**22.37 ± 1.61**
Vacuum	31.92 ± 2.24	21.50 ±2.07	21.08± 1.49	19.25 ± 1.79	19.33± 0.94	**22.62± 1.71**
Modified atmosphere	31.92 ±	21.92 ± 1.99	23.00 ± 1.83	20.83 ± 2.08	22.58± 1.84	**24.05± 2.06**
Over all moan (Pooled over	**31.92^{Y} ±**	**21.50^{X} ± 1.80**	**21.56^{X} ± 1.66**	**19.61^{X}±1.71**	**20.47^{X} ±1.44**	

Overall means bearing different superscripts between rows (A,B) and between columns (Y,Z) differ significantly (P<0.01).
Interaction means bearing different superscripts (a,b,c,d,e,f) differ significantly (P<0.01).

Table- 4: Mean (± SE) of thiobarbituric acid and tyrosine value of fresh and packaged chevon stored at 4 ± 1°C

Packaging methods	Storage periods (days)					Overall mean (Pooled over days)
	0	3	7	14	21	
TBA (number)						
Aerobic	0.06 ± 0.01	0.08±0.02	0.06±0.01	0.13±0.06	0.10± 0.01	**0.09 ±0.02**
Vacuum	0.06 ± 0.01	0.08±0.02	0.05± 0.01	0.09±0.01	0.07±0.02	**0.07±0.02**
Modified atmosphere	0.06 ± 0.01	0.07 ± 0.01	0.10 ±0.03	0.11 ±0.02	0.09 ± 0.02	**0.09 ±0.02**
Over all mean (Pooled over	**0.06±0.01**	0.08±0.02	**0.07 ± 0.02**	**0.11 ± 0.03**	**0.09 ±0.02**	
TV (mg/100g)						
Aerobic	8.02 ± 0.70	8.13±0.99	8.69± 1.70	9.02±1.10	10.58±1.45	**8.89± 1.19**
Vacuum	8.02± 0.70	8.31±0.47	9.50± 0.28	9.48 ±2.43	10.94±1.74	**9.25± 1.12**
Modified atmosphere	8.02± 0.70	8.04 ± 0.11	8.69 ± 1.24	8.73 ± 1.44	9.48± 0.82	**8.59 ± 0.86**
Over all mean (Pooled over	**8.02 ± 0.70**	**8.16 ± 0.52**	**8.96 ± 1.08**	**9.08±1.66**	**10.33 ±1.34**	