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Evaluation of Modified Atmospheric Packaged Chicken Breast Meat during Refrigeration Storage

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ABSTRACT

Modified atmospheric packaging (MAP) is most commonly used nowadays to improve the shelf-life of meat in refrigeration storage. Therefore, this research was undertaken to study the effect of MAP on the quality and shelf-life of chicken breast meat (CBM) under refrigeration storage. This was further compared with aerobic packaging (AP) to find the efficiency of MAP. Three different concentrations used were : 1) MAP-20 (20%O2+30%CO2+50%N2), 2) MAP-10 (10%O2+40%CO2+50%N2), and 3) MAP-0 (0%O2+20%CO2+80%N2). Refrigerated storage of CBM with MAP of 0-20% oxygen significantly ($p<0.05$) decreased the TBARS, deoxymyoglobin, metmyoglobin, L* value, b* value, oxygen, and nitrogen but increased the pH, oxymyoglobin, total meat pigment, a* value, carbon dioxide, nitrogen, standard plate counts and scores of sensory attributes when compared with aerobic packaging. It can be concluded that a MAP-CBM had a shelf-life of 12 days and AP-CBM had 6 days under refrigeration storage.

Keywords: *aerobic packaging, chicken breast meat, modified atmospheric packaging, quality, shelf-life.*

INTRODUCTION

Quality and safety are of prime importance in marketing of any food product. To maintain the quality and enhance the shelf-life of meat and meat products, different technologies have been developed. One among them is modified atmospheric packaging (MAP), which has currentlty turned out to be popular inventive system in retail food packaging (Sezer *et al.*, 2022). MAP is a type of packaging in which atmospheric air is replaced with gas or mixture of gases depending on the type of meat being packed (Kuzelov *et al.*, 2012, Wu *et al.*, 2022).

The main role of oxygen (O_2) is to preserve the bright red color of meat (Arvanitoyannis *et al.*, 2012). The role of carbon dioxide (CO_2) is to exert antimicrobial effect. Nitrogen (N_2) serves as a filler gas to prevent pack collapse caused by CO_2 (Narasimha Rao and Sachindra, 2002, Kandeepan and Tahseen, 2022).

There is a lack of research regarding MAP and comparisons of different gaseous compositions for chicken breast meat (CBM) and the effects of aerobic packaging (AP) versus MAP on chicken meat quality. Therefore this research was undertaken to study the comparative effects of MAP and AP on quality attributes of CBM.

MATERIALS AND METHODS

Meat sample

- Chicken meat samples were procured from the poultry processing plant, ICAR-NMRI, Hyderabad. The samples were packed in low-density polyethylene (LDPE) bags and transported in a chiller box to the packaging lab, ICAR-NMRI, Hyderabad. Then, the fat and connective tissue were trimmed off from the meat samples using a sharp sterile stainless-steel knife. The chicken breast meat (CBM) sample of approximately 200g was weighed and placed in a clean tray (Tray-EVOH; Overwrap-PET/HBPP). The gas mixture (CO_2, O_2 and N_2) for modified atmospheric packaging (MAP) was blended in a Gas mixing machine (Elixir technologies, GAS MIXER - E2M316, Bangalore) attached to carbon dioxide, oxygen, and nitrogen cylinders. Then the gases were flushed into the trays containing CBM and sealed in a tray sealing machine (Elixir technologies, Tray sealer - ETS 300 GS, Bangalore).
- Three different concentrations used in MAP were : 1) MAP-0 (0%O_2+20%CO_2+80%N_2) 2) MAP-10 (10%O_2+40%CO_2+50%N_2), and 3) MAP-20 (20%O_2+30%CO_2+50%N_2). In aerobic packaging (AP), the CBM was placed and the trays were sealed using a tray sealing machine without flushing any gas. The trays were then stored under refrigeration storage at 4±1°C. The AP-CBM samples were analyzed on 0, 3, 6, and 9 days of storage. The MAP-CBM samples were studied at 0, 3, 6, 9, 12, 15, 18, and 21 days of storage.

Physico-chemical parameters

pH

- The pH of the CBM sample was estimated using the portable handheld pH meter (Hannah Instruments, H198163, Romania). The pH meter was calibrated using buffer solutions. The probe was inserted at five different areas of the meat sample and the pH values of five readings were recorded.

Myoglobin content

To extract the myoglobin from the CBM sample Krzywicki (1982) and Shang *et al.* (2020) method was used. The absorbance was recorded with the help of a UV-VIS Spectrophotometer (UV-1700 PharmaSpec, Shimadzu, Japan), at 525nm, 503nm, 557nm, 582nm. The percent of the three forms of myoglobin were calculated using the formula given below:

$Dmb\% = -0.543B_1 + 1.594B_2 + 0.552B_3 - 1.329$

$Omb\% = 0.722B_1 - 1.432B_2 - 1.659B_3 + 2.599$

$Mmb\% = -0.159B_1 - 0.085B_2 + 1.262B_3 - 0.520$

Where $B_1 = A_{582}/A_{525}$, $B_2 = A_{557}/A_{525}$, $B_3 = A_{503}/A_{525}$.

Gas concentration measurement

Gas analyzer Checkmate 3, (Dansensor -L.E 316/2015, a Mocon company, Denmark) was used to measure the concentrations of CO_2, O_2, and N_2 inserting the needle probe inside the packaging. The packaged CBM samples were analyzed every day before the beginning of the sensory evaluation and meat quality parameters analysis. The needle was inserted at five different places and the values were noted.

Microbiological analysis

Microbial analysis was done by standard methods of APHA (2015). Duplicate plates were prepared and the number of microbes were expressed as colony-forming units (CFU) per gram.

Sensory analysis

Sensory attributes of the CBM samples were evaluated organoleptically using an eight-point hedonic score card. The samples were judged based on appearance, color, odor, and sliminess characteristics. The samples were subjected to sensory evaluation by a panel consisting of a minimum of seven members. The sensory evaluation was repeated thrice.

Statistical analysis

Statistical analysis was done using SPSS (version 24.0 for Windows, SPSS, Chicago, USA). The smallest difference (D_5%) for the two means was reported as significantly different (p<0.05).

RESULTS AND DISCUSSION

Physico-chemical parameters

pH

The pH of all the groups was significantly (p<0.05) decreased with storage period (Fig.1). The pH decrease may be due to reaction between carbon dioxide and water, which resulted in the formation of carbonic acid during the first two weeks of storage (Patsias *et al.*, 2008). The results were similar to Gurunathan *et al.*, (2022) who analysed pH values of MAP chicken leg meat at refrigerated conditions for 21 days. Similarly, significant (p<0.05) reduction in the pH values of fresh chicken breast meat MAP-1 (30:70=CO2:N2) and MAP-2 (70:30=CO2:N2), respectively during 25 days of storage time at 4°C which is probably attributed to the production of lactic acid through the lactic acid bacteria metabolism (Chouliara *et al.*, 2007). Stahlke *et al.* (2018) analysed the pH of lamb meat packaged in different MAPs, the pH of all the samples increased with the longer storage period at 4°C for 35 days. The pH of the aerobic packaged chicken breast meat (AP-CBM) was significantly (p<0.05) less than modified atmosphere packaged chicken breast meat (MAP-CBM) groups on days 6 and 9 of the refrigerated storage period. Denaturation of muscle proteins, increased actomyosin contractions, and change in the meat structure may cause rapid decline in muscle pH (Jaberi *et al.*, 2019).

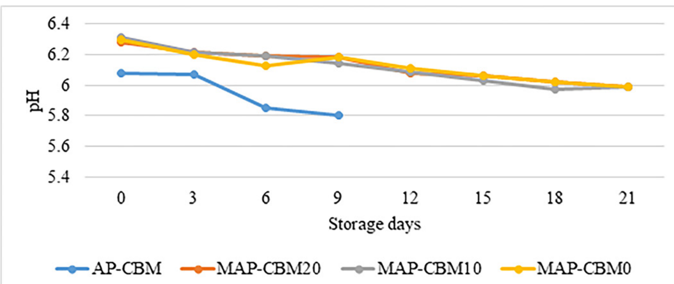

Fig.1: Change in the pH values of chicken breast meat with aerobic and modified atmospheric packaging during refrigeration storage (Mean±SE)

Myoglobin content

- The oxymyoglobin content of all the groups except MAP-CBM20 was found to be significantly (p<0.05) decreased with storage time. The reason might be due to decrease in oxygen percent with storage time in remaining MAP groups. The results are similar to Gurunathan *et al.*, (2022) who analysed myoglobin content of MAP chicken leg meat at refrigerated conditions for 21 days.
- There was a significant difference (p<0.05) in oxymyoglobin (Omb) content between the aerobic and MAP-CBM groups on days 0, 6, and, 9 of refrigerated storage time (Table.1) due to variation in the oxygen percent. There was a significant difference (p<0.05) in Omb content between the MAP-CBM groups during the whole storage time except on day 3. The differences within MAP-CBM groups may be due to differences in the initial gaseous composition of the groups. The deoxymyoglobin (Dmb) content of all the groups was significantly (p<0.05) increased with storage time (Table.1). Initially, Dmb percent was low and Omb percent was high. This may be due to higher initial oxygen percent in the MAP which induced the oxygenation of the deoxymyoglobin to oxymyoglobin. Metmyoglobin (Mmb) reducing enzymes present in muscles catalyze the reduction of Mmb to Dmb which then form Omb in the presence of oxygen. The deoxymyoglobin content of the AP-CBM group was significantly (p<0.05) more than MAP-CBM groups on days 0, 3, 6, and 9 of the refrigerated storage period. There was a significant difference (p<0.05) in Dmb content between the MAP-CBM groups during the whole storage time except on days 9 and 12. Myoglobin is a water-soluble sarcoplasmic protein. It's function and structure in the muscle not only depends on oxygen content but also on temperature, oxygen partial pressure, pH, microbial growth, and muscles reducing capacity (Grujic *et al.*, 2010).
- The metmyoglobin (Mmb) content of the AP-CBM, MAP-CBM10 and, MAP-CBM0 groups significantly (p<0.05) increased with storage time (Table.1) which may be due to loss of myoglobin reducing activity. The metmyoglobin content of the MAP-CBM20 groups significantly (p<0.05) decreased with storage time. The metmyoglobin content of the AP-CBM group and MAP-CBM groups differed significantly (p<0.05) on days 0, 3 and, 9 of the refrigerated storage period. There was a significant difference (p<0.05) in Mmb content between the MAP-CBM groups during the whole storage time except on days 3 and 6. Beef patties MAP (70%O_2+20%CO_2+10%N_2) displayed under light (standard and low-UV lamp) for 8 days 2±1°C, irrespective of antioxidant treatment, had significantly (p<0.05) higher Mmb percentages than those displayed in the dark (Sanchez-Escalante *et al.*, 2011).

Measurement of the concentration of gases

The oxygen percent of all the groups was significantly (p<0.05) decreasing, with storage time (Table.2). The reason might be utilization of oxygen by spoilage bacteria or permeability of packaging material (Jeremiah, 2001). Similarly, Rossaint *et al.* (2015) noticed slight decrease in the concentration of oxygen inside the trays of poultry fillets packaged in MAP-1 (70%O_2 + 30%CO_2) and MAP-2 (70%N_2 + 30%CO_2), during the entire storage period (4°C) for 20 days.

The carbondioxide percent of all the groups except MAP-CBM10 was significantly (p<0.05) decreased with storage time (Table.2). This might be due to solubility of CO_2 in lipid and water present in meat or its conversion to carbonic acid Abdullah *et al.* (2017). Parra *et al.* (2010) found similar results in MAP of dry curd ham slices, where CO_2 content decreased on storage upto 120 days at 4±1°C. The CO_2 content of MAP roast chicken leg samples was reduced by 3, 6, and 8 percent for 20%CO_2 + 80% N_2, 30%

Table 1: Myoglobin changes in aerobic and modified atmospheric packaged chicken breast meat during refrigeration storage (4±1°C)

Groups	Days							
Deoxymyoglobin%	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**
AP-CBM	$23.52±0.69^{aC}$	$25.42±0.25^{aB}$	$25.59±0.22^{aB}$	$27.02±0.01^{aA}$	ND	ND	ND	ND
MAP-CBM20	$20.40±0.90^{bD}$	$21.97±0.59^{bCD}$	$24.74±0.15^{bAB}$	$24.54±0.67^{bAB}$	$24.34±0.98^{aAB}$	$24.30±0.70^{bAB}$	$23.07±0.50^{bBC}$	$26.17±0.26^{aA}$
MAP-CBM10	$19.84±1.00^{bB}$	$24.67±0.21^{aA}$	$25.84±0.20^{aA}$	$24.60±0.73^{bA}$	$24.24±0.82^{aA}$	$25.77±0.44^{aA}$	$24.14±0.52^{abA}$	$25.07±0.17^{bA}$
MAP-CBM0	$25.37±0.15^{aA}$	$25.50±0.26^{aA}$	$24.60±0.29^{bA}$	$24.77±0.61^{bA}$	$25.30±0.35^{aA}$	$24.97±0.04^{aAb}$	$24.84±0.49^{aA}$	$25.00±0.20^{bA}$
Metmyoglobin%	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**
AP-CBM	$54.07±0.85^{cC}$	$58.00±0.20^{bB}$	$61.85±0.60^{aA}$	$62.00±0.37^{aA}$	ND	ND	ND	ND
MAP-CBM20	$62.44±1.16^{aA}$	$60.93±0.50^{aAB}$	$59.95±1.09^{aAB}$	$60.45±0.40^{abAB}$	$59.49±0.62^{bB}$	$58.53±0.17^{bB}$	$59.61±0.96^{bB}$	$59.20±1.10^{bB}$
MAP-CBM10	$57.10±0.45^{bC}$	$59.74±0.67^{aB}$	$59.82±0.68^{aB}$	$58.92±0.74^{bBC}$	$58.90±1.11^{bBC}$	$60.84±0.61^{aB}$	$61.00±0.79^{abB}$	$63.85±0.76^{aA}$
MAP-CBM0	$58.60±0.81^{bD}$	$60.68±0.17^{aBCD}$	$59.72±0.69^{aCD}$	$60.89±0.67^{aBC}$	$62.36±0.90^{aAB}$	$62.38±0.93^{aAB}$	$62.16±0.59^{aAB}$	$64.21±0.59^{aA}$
Oxymyoglobin%								
AP-CBM	$22.20±2.65^{aA}$	$16.14±1.56^{aB}$	$13.44±0.55^{cBC}$	$12.73±0.52^{bC}$	ND	ND	ND	ND
MAP-CBM20	$15.30±1.17^{cA}$	$17.77±0.72^{aA}$	$15.94±0.40^{abA}$	$16.50±0.19^{aA}$	$16.53±0.57^{aA}$	$15.77±0.09^{aA}$	$18.67±1.77^{aA}$	$16.64±1.82^{aA}$
MAP-CBM10	$20.97±1.95^{abA}$	$17.44±0.63^{aB}$	$16.17±0.08^{aBC}$	$15.54±0.73^{aBC}$	$15.54±0.37^{aBC}$	$14.80±0.79^{aBC}$	$14.30±0.81^{bC}$	$11.67±0.49^{bD}$
MAP-CBM0	$16.47±1.03^{bcA}$	$15.60±0.73^{aAB}$	$14.87±0.40^{bABC}$	$13.64±0.69^{bBC}$	$13.60±0.20^{bBC}$	$12.94±0.88^{bC}$	$12.70±0.62^{bC}$	$8.74±0.93^{bD}$

n=6; Means with different superscripts in the same column (small letters) and same row (capital letters) differ significantly ($p<0.05$); AP-CBM= Aerobic packaged chicken breast meat; MAP-CBM20= Modified atmosphere packaged chicken breast meat (20%O2+30% CO2+50%N2); MAP-CBM10= MAP breast meat (10%O2+ 40% CO2+50%N2); MAP-CBM0= MAP breast meat (0% O2 + 20% CO2+80% N2) packaged at 4±1°C.

Table 2: Gaseous concentration changes in aerobic and modified atmospheric packaged chicken breast meat during refrigeration storage (4±1ºC)

Groups	Days							
Oxygen%	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**
AP-CBM	21.09 ± 0.03^{aA}	19.49 ± 0.06^{aB}	19.72 ± 0.21^{aB}	18.47 ± 0.41^{aC}	ND	ND	ND	ND
MAP-CBM20	19.70 ± 0.04^{bA}	17.24 ± 0.04^{bB}	17.14 ± 0.04^{bBC}	16.67 ± 0.26^{bBCD}	16.14 ± 0.75^{aCD}	15.80 ± 0.41^{aDE}	15.67 ± 0.28^{aDE}	14.97 ± 0.09^{aE}
MAP-CBM10	9.83 ± 0.10^{cA}	7.49 ± 0.26^{cB}	7.33 ± 0.09^{cBC}	6.64 ± 0.09^{cCD}	6.27 ± 0.42^{bD}	6.01 ± 0.33^{bDE}	5.92 ± 0.28^{bDE}	5.37 ± 0.15^{bE}
MAP-CBM0	0.38 ± 0.23^{dA}	0.01 ± 0.01^{dB}	0.04 ± 0.02^{dB}	0.01 ± 0.01^{dB}	0.02 ± 0.01^{cB}	0.01 ± 0.01^{cB}	0.01 ± 0.01^{cB}	0.01 ± 0.01^{cB}
Carbondioxide%								
AP-CBM	1.75 ± 0.12^{dA}	1.52 ± 0.10^{dB}	0.93 ± 0.06^{dC}	0.47 ± 0.08^{dD}	ND	ND	ND	ND
MAP-CBM20	30.63 ± 0.22^{bA}	30.53 ± 0.15^{bA}	30.50 ± 0.31^{bA}	29.90 ± 0.10^{bB}	29.27 ± 0.09^{bC}	28.97 ± 0.06^{bC}	28.00 ± 0.07^{bD}	27.57 ± 0.30^{bD}
MAP-CBM10	40.70 ± 0.26^{aA}	40.60 ± 0.91^{aA}	40.80 ± 1.29^{aA}	38.83 ± 0.28^{aA}	38.50 ± 1.02^{aA}	38.44 ± 2.30^{aA}	37.17 ± 2.49^{aA}	35.77 ± 2.71^{aA}
MAP-CBM0	21.97 ± 0.81^{cA}	21.04 ± 0.17^{cAB}	20.47 ± 0.28^{cB}	20.30 ± 0.23^{cB}	19.94 ± 0.07^{cB}	19.64 ± 0.75^{dBC}	19.50 ± 0.67^{cBC}	18.34 ± 0.06^{cC}
Nitrogen%								
AP-CBM	77.18 ± 0.16^{aC}	79.00 ± 0.15^{aB}	79.35 ± 0.18^{aB}	81.07 ± 0.45^{aA}	ND	ND	ND	ND
MAP-CBM20	49.67 ± 0.20^{bF}	52.23 ± 0.10^{bE}	52.37 ± 0.34^{bDE}	53.43 ± 0.30^{dD}	54.60 ± 0.83^{bC}	55.23 ± 0.37^{bBC}	56.33 ± 0.22^{bB}	57.47 ± 0.37^{bA}
MAP-CBM10	49.52 ± 0.32^{bC}	51.91 ± 0.95^{bBC}	51.88 ± 1.36^{bBC}	54.53 ± 0.23^{cABC}	55.23 ± 0.73^{bAB}	55.56 ± 2.50^{bAB}	56.92 ± 2.51^{bAB}	58.87 ± 2.57^{bA}
MAP-CBM0	77.66 ± 0.75^{aD}	78.97 ± 0.17^{aCD}	79.49 ± 0.26^{aBC}	79.69 ± 0.23^{bBC}	80.05 ± 0.59^{aBC}	80.37 ± 0.75^{aABC}	80.50 ± 0.67^{aAB}	81.67 ± 0.06^{aA}

n=6; Means with different superscripts in the same column (small letters) and same row (capital letters) differ significantly ($p<0.05$); AP-CBM= Aerobic packaged chicken breast meat; MAP-CBM20= Modified atmosphere packaged chicken breast meat (20%O2+30% CO2+50%N2); MAP-CBM10= MAP breast meat (10%O2+ 40% CO2+50%N2); MAP-CBM0= MAP breast meat (0% O2 + 20% CO2+80% N2) packaged at 4±1ºC.

CO_2 + 70% N_2, and 40% CO_2 + 60% N_2 treatment in 4 days, and then tended to be stable (Guo *et al*., 2018).The nitrogen percent of all the groups was significantly (p<0.05) increased with storage time (Table.2).

The O_2, CO_2, and N_2 percent of the AP-CBM group and MAP-CBM groups differed significantly (p<0.05) during the refrigerated storage period. In MAP-CBM20, the O_2 and CO_2 decreased by nearly 5 and 3% respectively and N_2 increased by nearly 8%. In MAP-CBM10, the O_2 and CO_2 decreased by nearly 5 and 4% respectively and N_2 increased by nearly 9%. In MAP-CBM0, CO_2 decreased nearly by 2% and N_2 increased by nearly 2%. Kot Vel Lawecka *et al*. (2019) reported that in MAP-CBM (80%O_2+13%CO_2+7%N_2) stored at 2°C for 7 days, oxygen decreased by 10%, carbon dioxide increased by 2.5%, the concentration of nitrogen increased more than double the initial value.

Microbiological evaluation

Standard plate count (SPC)

The standard plate counts of all the groups were significantly (p<0.05) increased with storage time (Table.3). The use of vacuum packaging delayed the time taken for SPC to attain 8 log10 CFU g^{-1} by 2-3 days, while 30% CO2 + 70% N2 packs delayed it by 4 days, similarly, 70% CO2 + 30% N2 samples reached that value at about 12-13 days of storage (Jinemez *et al*., 1997). At the time of rejection, SPC had reached the level of 7.5 and 7 log CFU/g for sea bass stored under air and MAP (80% CO2 + 20% N2) respectively (Rajamaki *et al*., 2006).

The SPC of the AP-CBM and MAP-CBM groups differed significantly (p<0.05) during 9 days of the refrigerated storage period. Similar results were found by Ariff *et al*., (2011) after 28 days of storage, samples of roasted spicy chicken in MAP-(30% CO2 + 70% N2) & MAP-(40% CO2 + 60% N2) packages had a significantly lower SPC than the control (normal air) samples. Rathod *et al*., (2017) found that the SPC of chicken meat were increased with storage period during refrigeration.

As per FSSAI (2020), a chilled meat sample should be rejected when the SPC is above 7.70 log cfu/g. In the current study, SPC was above 7.70 log cfu/g on day 21 in MAP-CBM groups.

Sensory evaluation

The appearance, color, odor, and sliminess score of all the modified atmosphere groups was significantly (p<0.05) decreased with storage time. The appearence scores of MAP packaged chicken meat caruncles were higher compared to aerobic packaged samples (Singh *et. al*., 2014). The decrease in color score might be because of the formation of surface metmyoglobin. The appearance score of the AP-CBM group was significantly (p<0.05) lower compared to MAP-CBM groups on day 6 of the refrigerated storage period (Fig.2). MAP-CBM0 had a significantly higher (p<0.05) score on day 6. MAP-CBM20 had a significantly higher (p<0.05) score on day 12. Among all packages, MAP-CBM20 showed a better appearance which may be due to high oxygen concentration, which leads to the formation of oxymyoglobin. Hence it can be correlated to oxymyoglobin content, in comparison to others MAP-CBM20 had more amount of oxymyoglobin on day 21 which imparts bright red color.
The color score of the AP-CBM group was significantly (p<0.05) lower compared to MAP-CBM groups on days 6 and 9 of the refrigerated storage period (Fig.3). MAP-CBM20 had a significantly (p<0.05) higher color score within MAP-CBM groups on days 15 and 18. The odor score of the AP-CBM group was significantly (p<0.05) lower compared to MAP-CBM groups on day 6 of the refrigerated storage period (Fig.4). The MAP-CBM20 group had a significantly (p<0.05) higher odor score on day 18 within MAP-CBM groups. MAP-CBM0 had a significantly (p<0.05) lower odor score on day 6. The slightly strange odor started from day 9 in AP-CBM group day 15 in MAP-CBM groups.

Table 3: Microbial changes in aerobic and modified atmospheric packaged chicken breast meat during refrigeration storage (4±1°C)

Groups	**Days**							
Standard plate count	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**
AP-CBM	$5.03±0.02^{bD}$	$5.31±0.02^{bC}$	$5.73±0.08^{bB}$	$6.30±0.01^{bA}$	ND	ND	ND	ND
MAP-CBM20	$5.65±0.19^{aE}$	$5.88±0.09^{aE}$	$6.80±0.15^{aD}$	$6.82±0.17^{aD}$	$6.94±0.17^{aCD}$	$7.27±0.01^{aBC}$	$7.44±0.05^{aB}$	$7.83±0.14^{aA}$
MAP-CBM10	$5.58±0.17^{aE}$	$5.74±0.15^{aE}$	$6.65±0.23^{aD}$	$6.92±0.17^{aCD}$	$6.83±0.14^{aCD}$	$7.24±0.01^{aBC}$	$7.48±0.06^{aAB}$	$7.84±0.14^{aA}$
MAP-CBM0	$5.63±0.18^{aD}$	$5.85±0.08^{aD}$	$6.94±0.19^{aC}$	$6.82±0.14^{aC}$	$6.99±0.13^{aBC}$	$7.20±0.06^{aBC}$	$7.38±0.06^{aB}$	$7.84±0.15^{aA}$

n=6; Means with different superscripts in the same column (small letters) and same row (capital letters) differ significantly (p<0.05); AP-CBM= Aerobic packaged chicken breast meat; MAP-CBM20= Modified atmosphere packaged chicken breast meat (20%O2+30% CO2+50%N2); MAP-CBM10= MAP breast meat (10%O2+ 40% CO2+50%N2); MAP-CBM0= MAP breast meat (0% O2 + 20% CO2+80% N2) packaged at 4±1°C.

The sliminess score of the AP-CBM was significantly (p<0.05) lower compared to MAP-CBM groups on day 9 of the refrigerated storage period (Fig.5). MAP-CBM20 had a significantly (p<0.05) higher sliminess score on day 18. MAP-CBM0 had a significantly (p<0.05) lower sliminess score on day 15. The sliminess started in the AP-CBM group from day 9 and day 15 in MAP-CBM groups in current studies. The beginning of surface slime on chicken meat was recorded from day 12 of the storage in the oxygen-modified atmosphere, whereas in argon- modified atmosphere group, it showed from day 16 of storage (Tomankova *et al.*, 2012).

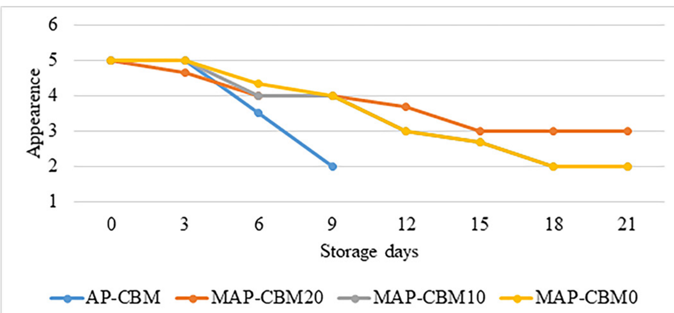

Fig. 2: Change in the Appearance values of chicken breast meat with aerobic and modified atmospheric packaging during refrigeration storage (Mean±SE)

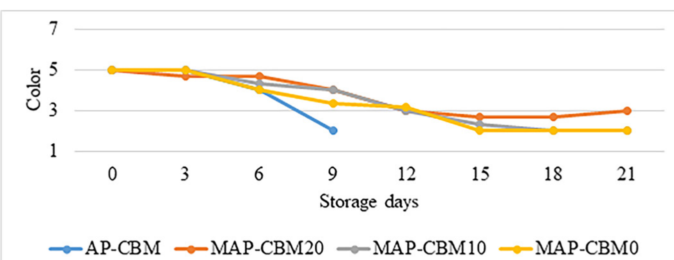

Fig. 3: Change in the Color values of chicken breast meat with aerobic and modified atmospheric packaging during refrigeration storage (Mean±SE)

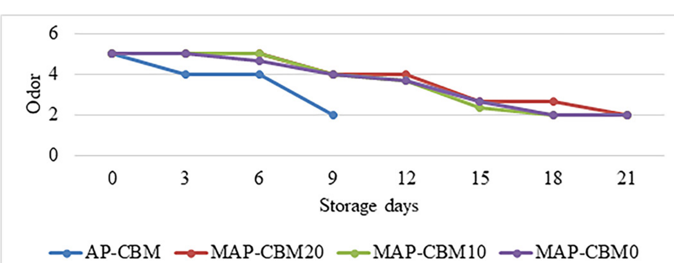

Fig. 4: Change in the Odor values of chicken breast meat with aerobic and modified atmospheric packaging during refrigeration storage (Mean±SE)

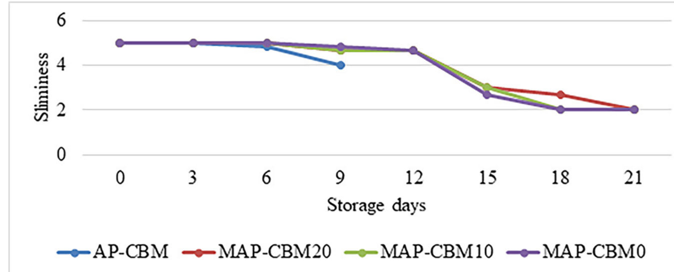

Fig. 5: Change in the Sliminess values of chicken breast meat with aerobic and modified atmospheric packaging during refrigeration storage (Mean±SE)

CONCLUSION

Chicken breast meat with MAP of 0-20% oxygen significantly (p<0.05) decreased TBARS, deoxymyoglobin, metmyoglobin, L* value, b* value, oxygen, and nitrogen values but increased the pH, oxymyoglobin, total meat pigment, a* value, carbon dioxide, nitrogen, standard plate count and sensory attributes compared to chicekn breast meat with AP at refrigerated conditions (4±1°C) . The MAP increased shelf-life of CBM upto 12 days irrespective of different gaseous concentrations. However, the shelf-life of CBM packaged in AP was found to be only 6 days. Thus, it can be concluded that MAP is effective to prolong the shelf-life of CBM in comparison to AP by at least 6 days under refrigeration storage. Hence, oxygen at the rate of 0-20% and carbon dioxide at the rate of 20-40% along with nitrogen gas at the rate of 50-80% are recommended in MAP to improve the shelf-life of CBM in refrigerated storage.

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COMPETING INTERESTS

The authors do not have any competing interests among themselves or others related to this research work.

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