SUMMARY
AND
CONCLUSION
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The experiment “Development of Modified Atmospheric Packaging System for Extended Storage of Tomato” was conducted with following objectives:

1. To study the effect of post harvest treatments on the quality and shelf life of tomato.
2. To study various parameters affecting respiration of tomato and to develop optimum gaseous concentration for Modified Atmosphere Packaging of Tomato.
3. To study objective and Subjective performances of modified atmosphere packages and to evaluate their performance at various storage temperature.
4. To assess the economic viability of post harvest treatments and MAP system for tomato storage.

For performance evaluation, packages were stored at 8, 15 and 30°C. The performance of various packages was evaluated firstly for their ability to establish equilibrium at target level and secondly, their ability to extend shelf-life of packaged fruit. Variation of Y and Z levels in various MA packages with time was determined experimentally and compared with predicted values. The variation in different quality attributes such as weight, density, texture, colour, total soluble solids, titrabe acidity and ascorbic acid content of MA packaged and as well as unpackaged were determined at 8,15 and 30°C.

The respiration model suggests good agreement between predicted and experimental values. The model suggested that the effect of variation in O₂ concentration on Ry and Rz was significant whereas the effect of variation in CO₂ concentration on Ry and Rz was significant only when it was combined with the effect of variation in O₂ concentration and temperature. Examination of respiration profiles suggested that the lowering of O₂ concentration reduced Ry and Rz. The reductions were found to be larger at O₂ concentration level below 5%. The effect of lowering O₂ concentration was more pronounced on Ry than on Rz. The increase in CO₂ concentration also reduced Ry and Rz although by small amounts. However the effect of increase in CO₂ concentration was more pronounced on Rz than on Ry. The O₂ concentration levels below 1% and CO₂ concentration level above 5% were found to be deleterious particularly at higher temperatures.
The different post harvest treated samples and Modified Atmospheric (MA) packages were evaluated for physical attributes (Physiological loss of weight, Density), organoleptic attributes (Colour and Texture) and Chemical attributes (Titratable acidity, total soluble solids, Ascorbic acid and Reducing sugar) at different time interval i.e. 0, 8, 16, 24, 32 and 40 days

Data obtained on these aspects were statistically analyzed by using ANOVA one way & ANOVA 4 way and critical difference (C.D.) technique. The summary and conclusion of result obtained after analysis of stored tomatoes are as follows:

5.1 POST HARVEST TREATMENT OF TOMATO:

Post-harvest heat treatment is a non-contaminating physical treatment that delays the ripening process, reduces chilling injury and controls the activity of pathogens. Due to these beneficial effects, heat treatments are currently used commercially for quality controls of fresh products. The role of calcium in the physiology of plant tissue is well established. Addition of calcium rigidifies cell wall and obstructs enzymes such as polygalacturonase from reaching active sites. Calcium compounds have shown promising results in the quality retention of fruits and vegetables through maintenance of firmness and reducing the respiration rates. Considering the importance of these post harvest treatments and storage conditions, the present investigations were undertaken to find out the effective post harvest method for extension of shelf life in tomato. The results obtained from this investigation are discussed below.

5.1.1 PHYSIOLOGICAL LOSS IN WEIGHT

From the Fig. 4.2, it can be concluded that highest percent physiological loss in weight (%PLW) was found in t0/d5-(25.84) followed by t4/d5- (25.22), the lowest %PLW was observed in case of CaCl2 treated tomato t2/d5 after 40 days of storage. The highest percent physiological loss in weight (%PLW) was found in t0/d4-(24.98) followed by t4/d4- (24.21), the lowest %PLW was observed in case of CaCl2 treated tomato t2/d5 after 32 days of storage. However, highest percent physiological loss in weight (%PLW) was found in t0/d3-(24.98) followed by t4/d3- (24.21), the lowest %PLW was observed in case of CaCl2 treated tomato t2/d3-(16.55) after 24 days of storage. Differences in %PLW were attributed due to different post-harvest treatments and days of storage. From Table 4.2, it can be concluded that treated tomatoes differs significantly from the control samples at all the days of storage. The
%PLW was lowest in CaCl₂ treated tomato at 8th day and remains lowest in all the days of storage and significantly different from the all other treatments and control tomato hence considered best amongst all the other post-harvest treatments. The weight loss of fresh tomatoes is primarily due to transpiration and respiration. Transpiration is a mechanism in which water is lost due to differences in vapour pressure of water in the atmosphere and the transpiring surface. Respiration causes a weight reduction because a carbon atom is lost from the fruit each time a carbon-dioxide molecule is produced from an absorbed oxygen molecule and evolved into atmosphere (Bhowmik and Pan, 1992). Low temperature stored fruits had a low weight loss due to temperature effects on vapour pressure difference and increased water retention (Tasdelen and Bayindirli, 1998). Similar results were reported by Bussel and Kenigsberger (1975) in green bell pepper and Efiuvwevwere et al. (1991) in oranges.

5.1.2 DENSITY:

From the Fig. 4.2b, it can be concluded that highest average scores of density was found in t3/d5-(0.935) followed by t4/d5 and t2/d5- (0.932), the lowest density was observed at the end of storage period of treated tomato after 40 days of storage was t1/d5. The highest density was found in t1/d4-(0.943) followed by t2/d4 & t3/d4- (0.939), the lowest score of density among treated tomato was observed in t4/d4 after 32 days of storage. The scores of density was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.

5.1.3 TEXTURE:

From the Fig. 4.2C, it can be concluded that among the treatments, fruits stored in hot air and hot water treatments were firmer followed by CaCl₂ and paper packaging treatments under ambient conditions. While, the control fruits were very soft at during the advancement of storage period and recorded 1.2 score. However, the fruits receiving hot air and hot water treatments did not vary in their texture till 32 days. The scores of texture was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.

5.1.4 COLOURS:

From the Fig. 4.2D, it can be concluded that significant differences were present in colour development between the treatments. Hot water and Hot Air
delayed the colour development both at 24 and 32 days under ambient storage conditions followed by CaCl₂ which differed significantly with each other at 32 days but were on par at 40 days of storage. Colour development was significantly higher in control fruits over all other treatments at ambient storage. The scores of colour was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.

5.1.5 TITRATABLE ACIDITY:

From the Fig. 4.3A, it can be concluded that among the treatments, significantly higher titratable acidity was recorded in hot water over all other treatments at 24 days and 32 days of storage. The next best treatment was hot water which was on par with CaCl₂ at all the days of observation. Significantly lower titratable acidity was recorded in control fruits which were on par with paper packaging at 24 and 32 days. The value of titratable acidity was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.

5.1.6 TOTAL SOLUBLE SOLIDS (°Brix):

From the Fig. 4.3B, it can be concluded that there were no significant differences during 16 and 24 days of storage under ambient conditions among all the treatments. The control fruits recorded significantly higher TSS at all the stages, but was on par with CaCl₂ treatment at 24 days Hot water and hot air treatments were on par with each other at 16 and 24 days of storage. The control fruits recorded significantly higher TSS but were on par with hot air treatment at 32 days of storage. The value of TSS was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.

5.1.7 REDUCING SUGAR:

From the Fig. 4.3C, it can be concluded that there were a general trend during storage for reducing sugar (RS) content of tomato was an initial increase followed by a decrease during the later stage of storage. Among the treatment the best treatment was hot air treatment in which the reducing sugar content was found to be remaining high in compare to the other treatments during end of the storage period. The value of reducing sugar was found to be best in hot water treated tomato after 40 days of storage period and found to be best among all the storage.
5.1.8 ASCORBIC ACID:

From the Fig. 4.3D, it can be concluded that among the treatments, significantly higher ascorbic acid content was recorded in paper packaging in all the days of observation. The next best treatment was CaCl$_2$ in terms of higher ascorbic acid content. Significantly lower ascorbic acid content was recorded in control fruits in all the storage days past harvest. The second best treatment was hot water which was at par with the paper packaging. The value of ascorbic acid was found to be best in CaCl$_2$ treated tomato after 40 days of storage period and found to be best among all the storage.

5.2 MODIFIED ATMOSPHERIC TREATMENT OF TOMATO:

In MA packaging system, fresh fruits are sealed in permselective polymeric film packages. Due to respiration, O$_2$ start depleting and CO$_2$ starts accumulating within the package. Consequently, respiration begins to decrease while O$_2$ and CO$_2$ concentration gradient between package and ambient atmosphere begins to develop. The development of concentration gradients induces ingress of O$_2$ and egress of CO$_2$. The decrease in respiration and increase in gas permeation continue till equilibrium is reached where O$_2$ consumption and CO$_2$ evolution of the packaged fruit become equal to the O$_2$ ingress and CO$_2$ egress of the package respectively. The package is then said to be in dynamic equilibrium with the surrounding atmosphere.

In a properly designed MAP, it is expected that the equilibrium establishes at the recommended levels of O$_2$ and CO$_2$ concentration in the package and the time required for establishing equilibrium (i.e. transient period) be as small as practical. For designing a package which satisfies these conditions, it becomes imperative to study the dynamics of respiration permeation interaction of MAP. Since, during transient period, O$_2$ and CO$_2$ concentration of package air continues to vary, the respiration as well as permeation profiles of the transient period becomes indispensable for designing MAP.

Thus, keeping in view the above perspectives, the present investigation on MA packaging of Tomato was undertaken with the objectives of optimizing MA package parameters by employing gaseous exchange model of MAP storage system; developing various film laminates for MA packaging of tomato storage, to find out the effective gaseous concentration for CO$_2$ and O$_2$ for extension of shelf life
in tomato and assessing the economic viability of MAP system of tomato storage. The results obtained from this investigation are discussed below:

5.3 RESPIRATION CHARACTERISTICS OF TOMATO:

Preliminary investigation suggested that the respiration rates under steady state air compositions were different from those of transient state. Thus, in the first part of respiration study, the respiration profile under simulated transient state of MAP was determined at 8, 15 and 30°C. Gas chromatograph was used to analyzing gas samples. Incorporating \(O_2\) concentration \((Y)\), \(CO_2\) concentration \((Z)\) and temperature \((T)\), an empirical model of respiration was developed for transient state of MAP. The model was used for calculating predictive values of \(O_2\) consumption rate \((R_y)\) and \(CO_2\) evolution rate \((R_z)\) of MA packaged tomato under transient state.

In the second part of respiration study, variation in respiration rate with time \((t)\) were determined at 8, 15 and 30°C under various steady state air composition \((i.e. 3\% \ O_2 + 3\% \ CO_2 ; 5\% \ O_2 + 3\% \ CO_2 ; 5\% \ O_2 + 5\% \ CO_2 ; 7\% \ O_2 + 5\% \ CO_2 \) in \(N_2\)). The objective was to assess the variation in respiration rates under normal and modified air compositions with storage time.

Several investigations have attempted to study the dynamics of respiration-permeation in MAP. Various MAP design approaches have been developed. In the present study, based on a mass balance of respiratory gases, the gaseous exchange in MAP was simulated mathematically. Through subsidiary experiment, the optimal ranges of \(O_2\) and \(CO_2\) concentrations for shelf-life extension of tomato in CA storage were ascertained to 1-3% and 3-5% respectively. However, for designing MAP, sub optimal concentrations of 3-7% \(O_2\) and 3-5% \(CO_2\) were considered appropriate particularly with a view to provide some factor of safety against anaerobiosis and \(CO_2\) injury. Thus, MA package were designed for target levels of 5% \(O_2\) and 3% \(CO_2\). The sub optimal concentration of \(O_2\) and \(CO_2\) were considered for MAP since in MAP system, the external means are not provided for controlling \(O_2\) and \(CO_2\) concentration precisely.

On the basis of preliminary investigations, a suitable shape and size of the packet for accommodating two or four medium sized tomato was selected \((i.e. 10 \times 10 \ cm)\). Based on the fill weights of loosely packed and tightly packed packages, an adequately wide range of fill weight was considered for the study \((0.4 \ to \ 0.5 \ kg)\). The entire fill weight range was divided into four equal sections. For establishing equilibrium at target levels of \(O_2\) and \(CO_2\), the gas transmission requirements of
MAP are calculated from mass balance equations by incorporating average fill weight values of the section. Thus, each types of laminated films was designed to accommodate any value of fill weight between 0.4 and 0.5 kg safely. Since the effect of O₂ concentration on respiration was more pronounced than that of CO₂ concentration. It was preferred to tailor the laminated films to meet OTR requirement of MAP as precisely as practical instead of CTR requirement. However, in comparison with individual films, the TR values of laminated films were found to be far closer to the TR requirement of MAP. Considering four different types of laminated films, four types of MA packages (i.e. MA₁, MA₂, MA₃ and MA₄,) was designed for storage at 15°C. Various package design parameters were optimized with the objective of developing a MA package which would accommodate variation of fill weights between 0.4 and 0.5 Kg as well as that of temperature between 7 and 30°C without causing unaffordable deviation in package equilibrium conditions for the target levels. The empirical model of respiration and permeation as well as theoretical model of gaseous exchange of MAP were incorporated on equation to calculate predictive values of equilibrium O₂ concentration (Yeq) and equilibrium CO₂ concentration (Zeq) of MAP for various fill weight and temperature levels.

5.3.1 VARIATION IN STEADY STATE RATE OF RESPIRATION (ml CO₂ kg h) OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT POLYMERIC FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

5.3.1.1 VARIATION IN STEADY STATE RATE OF RESPIRATION (ml CO₂ kg h) OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALY ORIENTED POLYPROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.7a, it can be concluded that rate of respiration under steady state of unpackaged and MA packaged tomato packed with biaxially oriented polypropylene (BOPP) films was highest in P₁/D₁/ t₀-(23.84) at 32 days of storage followed by P₁/D₁/ t₀-(21.45) at 40 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in P₁/D₂/ t₀-(24.14) and P₁/D₁/ t₀-(21.94) which is more higher at storage temperature of 30°C which was (24.87) for P₁/D₃/ t''₄ and (23.12) P₁/D₃/ t''₅. Among the modified atmospheric treated tomato the highest rate of respiration was found in case of MA₄ (7% O₂ + 5% CO₂) i.e P₁/D₁/ t₅-(13.66) and lowest rate of respiration (13.54) was observed in MA₃ (5% O₂ + 5% CO₂) i.e P₁/D₁/ t₄ at 8°C at 40 days of storage time. The similar results were found in the case to MA packaged tomato kept in 15°C and 30°C. The modified atmospheric package MA₃
(5% O₂ + 5% CO₂) has lower respiration rate at the end of 40 days of storage at the different temperature levels of 8°C, 15°C and 30°C.

5.3.1.2 VARIATION IN STEADY STATE RATE OF RESPIRATION (ml CO₂ kg h) OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C and 30°C

From the Fig. 4.4.7b, it can be concluded that rate of respiration under steady state of unpackaged and MA packaged tomato packed with SARAN™ films was highest in P₂/D₁/ t₀-(23.84) at 32 days of storage followed by P₂/D₁/ t₀-(21.45) at 40 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in P₂/D₂/ t₀-(24.21) and P₂/D₁/ t₀-(21.85) which is more higher at storage temperature of 30°C which was (24.25) for P₂/D₂/ t''₀ and (22.11) P₂/D₃/ t''₁. Among the modified atmospheric treated tomato the highest rate of respiration was found in case of MA₁ (3% O₂ + 3% CO₂) & MA₂ (5% O₂ + 3% CO₂) i.e P₂/D₁/ t₂ & P₂/D₁/ t₃ -(14.54) respectively and lowest rate of respiration (13.54) was observed in MA₄ (5% O₂ + 5% CO₂) i.e P₂/D₃/ t₄ at 8°C at 40 days of storage time. At 15°C highest rate of respiration was found in case of MA₂ (5% O₂ + 3% CO₂) i.e P₂/D₁/ t₃ (14.94) while lowest rate of respiration was found in MA₂ (5% O₂ + 3% CO₂) i.e P₂/D₄/ t₄(13.24) in 40 days of storage time. The similar results were found in the case to MA packaged tomato 30°C. Thus, The modified atmospheric package MA₃ (5% O₂ + 5% CO₂) has lower respiration rate at the end of 40 days of storage at the different temperature levels of 8°C, 15°C and 30°C.

5.3.1.3 VARIATION IN STEADY STATE RATE OF RESPIRATION (ml CO₂ kg h) OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY ETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C and 30°C

From the Fig. 4.4.7c, it can be concluded that rate of respiration under steady state of unpackaged and MA packaged tomato packed with polyethylene films was highest in P₃/D₁/ t₀-(22.54) at 40 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in P₃/D₂/ t₀-(22.94) and which is more higher at storage temperature of 30°C which is (24.24) for P₃/D₃/ t''₀. Among the modified atmospheric treated tomato the highest rate of respiration was found in case of MA₁ (3% O₂ + 3% CO₂) & MA₂ (5% O₂ + 3% CO₂) i.e P₃/D₁/ t₂ & P₃/D₁/ t₃ -(14.54) respectively and lowest rate of respiration (13.54) was observed in MA₄ (5% O₂ + 5% CO₂) i.e P₃/D₄/ t₄ at 8°C at 40 days of storage time. At 15°C highest rate of respiration was found in case of MA₁ (3% O₂ + 3% CO₂) i.e P₃/D₂/ t₃ (14.94) while lowest rate of respiration was found in MA₃ (5% O₂ + 3% CO₂) i.e P₃/D₂/ t₃(13.24) in
40 days of storage time. The similar results were found in the case to MA packaged tomato 30°C. Thus, The modified atmospheric package MA3 (5% O₂ + 5% CO₂) has lower respiration rate at the end of 40 days of storage at the different temperature levels of 8°C, 15°C and 30°C and considered to be best for diminishing the rate of respiration for MA packaged tomato.

5.3.1.4 VARIATION IN STEADY STATE RATE OF RESPIRATION (ml CO₂ kg h⁻¹) OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C and 30°C

From the Fig. 4.4.7d, it can be concluded that rate of respiration under steady state of unpackaged and MA packaged tomato packed with Poly Vinyl Chloride (PVC) films was highest in P₄/D₁/t₀-(23.84) at 32 days of storage followed by P₄/D₁/t₀-(21.45) at 40 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in P₄/D₂/t₀-(24.21) and P₄/D₁/t₀-(24.56) however rate of respiration was less in comparison of both 32 and 42 days at storage temperature of 30°C. Among the modified atmospheric treated tomato the highest rate of respiration was found in case of MA₁ (3% O₂ + 3% CO₂) & MA₂ (5% O₂ + 3% CO₂) i.e. P₃/D₁/t₂ & P₃/D₁/t₃-(14.54) respectively and lowest rate of respiration (13.54) was observed in MA₄ (5% O₂ + 5% CO₂) i.e. P₃/D₁/t₄ at 8°C at 40 days of storage time. At 15°C highest rate of respiration was found in case of MA₁ (3% O₂ + 3% CO₂) i.e. P₄/D₂/t₃ (14.78) while lowest rate of respiration was found in MA₃ (5% O₂ + 3% CO₂) i.e. P₄/D₂/t₃ (13.94) in 40 days of storage time. The similar results were found in the case to MA packaged tomato 30°C. Thus, The modified atmospheric package MA₃ (5% O₂ + 5% CO₂) has lower respiration rate at the end of 40 days of storage at the different temperature levels of 8°C, 15°C and 30°C and considered to be best for diminishing the rate of respiration for MA packaged tomato.

Tomato being climacteric fruit ripens during storage with an onset of respiratory climacteric using the stored starch sugar and it gradually declines as the produce begins to deteriorate over storage period. Respiration rate depends on the supply of oxygen. Curtailment of this oxygen supply can drastically reduce the respiration rates and hence delaying the ripening process. The results of the present investigation showed that modified atmosphere packaging of tomatoes significantly delayed the rise in climacteric respiration at storage temperatures of 8°C, 15°C and 30°C due to their differential permeabilities of the packaging material to these gases. The films used for modified atmosphere packaging are more permeable to CO₂ than
O2. Hence, the rate of diffusion of O2 from the atmosphere through the outer layer of the fruit is reduced and thus, reducing the number of glucose molecules oxidized per unit time. Elevated CO2 concentration inhibits the activity of phosphofructokinase, which is an important regulatory enzyme in glycolytic pathway. Also accumulation of fructose-6-phosphate and reduction in fructose, 1-6 – bisphosphate suggested an inhibitory effect of CO2 upon phosphofructokinase activity (Kerbel et al., 1988). Low oxygen atmosphere reduced the respiration rates in avocado, bell pepper and tomatoes (Kanellis et al., 1991; Rahman et al., 1993; Artes et al., 1999; Bhowmik and Pan, 1992).

5.3.2 VARIATION IN QUALITY ATTRIBUTES OF MA PACKAGED TOMATO:

5.3.2.1 VARIATION IN %PHYSIOLOGICAL LOSS IN WEIGHT OF UNPACKAGED MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.1.1 VARIATION IN %PHYSIOLOGICAL LOSS IN WEIGHT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED POLY PROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.5.1.1A, it can be concluded that rate of % Physiological loss of weight of unpackaged and MA packaged tomato packed with Biaxially Oriented Poly Propylene (BOPP) films was highest in P1/D1/ t0-(12.22) at 40 days of storage followed by P1/D1/ t0-(11.26) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P1/D2/ t0-(12.81) and P1/D2/ t0-(11.72) however rate of respiration was higher in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the highest % Physiological loss of weight was found in case of MA1 (3% O2 + 3% CO2) i.e P1/D1/ t1-(2.06) followed by MA2 (5% O2 + 3% CO2) P1/D2/ t2-(1.98) and lowest % Physiological loss of weight (1.90) was observed in MA3 (5% O2 + 5% CO2) i.e.P1/D3/ t3 at 8°C at 40 days of storage time. At 15°C highest % Physiological loss of weight was found in case of MA2 (5% O2 + 3% CO2) i.e.P1/D2/ t’2 (14.78) while lowest % Physiological loss of weight was found in MA1 (3% O2 + 3% CO2) i.e.P1/D2/ t’1-(1.84) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C highest % Physiological loss of weight was found in case of MA2 (5% O2 + 3% CO2) i.e.P1/D3/ t’’2 (2.11) while lowest % Physiological loss of weight was found in MA3 (5% O2 + 5% CO2) i.e.P1/D3/ t’’3(1.89) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has lower % Physiological loss of weight at the end of 40 days of
storage at temperature levels of 8°C and 30°C and considered to be best for resisting the % Physiological loss of weight for MA packaged tomato.

5.3.2.1.2 VARIATION IN %PHYSIOLOGICAL LOSS IN WEIGHT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C:

From the Fig. 4.5.1.1B, it can be concluded that rate of % Physiological loss of weight of unpackaged and MA packaged tomato packed with SARAN™ films was highest in P2/D1/ t0-(12.34) at 40 days of storage followed by P2/D1/ t0-(11.24) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P2/D2/t0'-(12.97) and P2/D2/t0'-(11.98) however rate of respiration was significantly higher in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the highest % Physiological loss of weight was found in case of MA4 (7% O2 + 5% CO2) i.e. P2/D1/ t4-(2.06) followed by MA2 (5% O2 + 3% CO2) P2/D1/ t2 - (1.94) and lowest % Physiological loss of weight (1.91) was observed in MA3 (5% O2 + 5% CO2) i.e. P2/D1/ t3 at 8°C at 40 days of storage time. At 15°C highest % Physiological loss of weight was found in case of MA2 (5% O2 + 3% CO2) i.e.P2/D2/ t'2 (2.21) while lowest % Physiological loss of weight was found in MA3 (5% O2 + 5% CO2) i.e.P2/D2/ t'3(1.95) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C highest % Physiological loss of weight was found in case of MA2 (5% O2 + 3% CO2) i.e.P2/D3/ t''2 (2.11) while lowest % Physiological loss of weight was found in MA3 (5% O2 + 5% CO2) i.e.P1/D3/ t''3(1.89) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has lower % Physiological loss of weight at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for resisting the loss of weight for MA packaged tomato.

5.3.2.1.3 VARIATION IN %PHYSIOLOGICAL LOSS IN WEIGHT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.5.1.1C, it can be concluded that rate of % Physiological loss of weight of unpackaged and MA packaged tomato packed with Polyethylene films was highest in P3/D1/ t0-(12.22) at 40 days of storage followed by P3/D1/ t0-(11.26) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P3/D2/t0'-(12.72) and P3/D2/t0'-(11.62), however % Physiological loss of weight was significantly higher in comparison to all the storage days as the temperature
increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the highest % Physiological loss of weight was found in case of MA1 (3% O₂ + 3% CO₂) i.e. P₃/D₁/ t₁-(2.06) followed by MA₂ (5% O₂ + 3% CO₂) P₂/D₁/ t₂ -(1.98) and lowest % Physiological loss of weight (1.90) was observed in MA₃ (5% O₂ + 5% CO₂) i.e.P₃/D₃/ t₃ at 8°C at 40 days of storage time. At 15°C highest % Physiological loss of weight was found in case of MA₄ (7% O₂ + 5% CO₂) i.e. P₃/D₂/ t₄ (1.98) while lowest % Physiological loss of weight was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₃/D₂/ t₃(1.95) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C highest % Physiological loss of weight was found in case of MA₄ (7% O₂ + 5% CO₂) i.e.P₃/D₃/ t''₄ (2.24) while lowest % Physiological loss of weight was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₃/D₃/ t''₃(1.95) in 40 days of storage time. Thus, The modified atmospheric package MA₃ (5% O₂ + 5% CO₂) has lower % Physiological loss of weight at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.1.4 VARIATION IN %PHYSIOLOGICAL LOSS IN WEIGHT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.5.1.1D, it can be concluded that rate of % Physiological loss of weight of unpackaged and MA packaged toma to packed with Poly Vinyl Chloride (PVC) films was highest in P₄/D₁/t₀-(12.88) at 40 days of storage followed by P₄/D₁/t₀-(11.98) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P₄/D₂/t'₀-(12.98) and P₄/D₂/t'₀-(11.96), while % Physiological loss of weight was significantly higher in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the highest % Physiological loss of weight was found in case of MA₄ (7% O₂ + 5% CO₂) i.e. P₄/D₁/ t₄-(2.16) followed by MA₂ (5% O₂ + 3% CO₂) P₄/D₁/ t₂ -(1.96) and lowest % Physiological loss of weight (1.96) was observed in MA₃ (5% O₂ + 5% CO₂) i.e.P₄/D₇/ t₃ at 8°C at 40 days of storage time. At 15°C highest % Physiological loss of weight was found in case of MA₄ (7% O₂ + 5% CO₂) i.e.P₄/D₇/ t₄ (2.24) while lowest % Physiological loss of weight was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₄/D₇/ t₃(1.93) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C highest % Physiological loss of weight was found in case of MA₂ (5% O₂ + 3% CO₂) i.e.P₄/D₇/ t''₄ (2.21) while lowest % Physiological loss of weight was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₄/D₇/
"3(1.98) in 40 days of storage time. Thus, The modified atmospheric package MA₃ (5% O₂ + 5% CO₂) has lower % Physiological loss of weight at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.2 VARIATION IN DENSITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.2.1 VARIATION IN DENSITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAxiaLLY ORIENTED POLY PROPYLene FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.1.2 A, it can be concluded that density of unpackaged and MA packaged tomato packed with Biaxially Oriented Poly Propylene (BOPP) films was lowest in P₁/D₁/ t₀-(0.852) at 40 days of storage followed by P₁/D₁/ t₀-(0.912) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P₁/D₂/ t₀-(0.862) and P₁/D₂/ t'₀-(0.916), density was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest density was found in case of MA₁ (3% O₂ + 3% CO₂) i.e. P₁/D₁/ t₁-(0.912) followed by MA₂ (5% O₂ + 3% CO₂) i.e. P₁/D₁/ t₂-(0.932) and highest density(0.935) was observed in MA₃ (5% O₂ + 5% CO₂) i.e.P₁/D₁/ t₃ at 8°C at 40 days of storage time. At 15°C lowest density was found in case of MA₁ (3% O₂ + 3% CO₂) i.e.P₁/D₂/ t₁-(0.919) while highest density was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₁/D₂/ t'₁(0.941) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest density was found in case of MA₄ (7% O₂ + 5% CO₂) i.e.P₁/D₃/ t''₃ (0.913) while highest density was found in MA₃ (5% O₂ + 5% CO₂) i.e.P₁/D₃/ t''₃ (0.947) in 40 days of storage time. Thus, The modified atmospheric package MA₃ (5% O₂ + 5% CO₂) has retained density effectively at the end of 40 days of storage at temperature levels of 8°C and 15°C and considered to be best for MA packaged tomato.

5.3.2.2.2 VARIATION IN DENSITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.1.2 B, it can be concluded that density of unpackaged and MA packaged tomato packed with SARAN™ was lowest in P₂/D₁/ t₀-(0.842) at 40 days of storage followed by P₂/D₁/ t₄-(0.912) at 32 days of storage at 8°C, compared
to the rate of respiration at 15°C at similar days in by $P_{2/D_2/ t_0}$(0.862) and $P_{2/D_2/ t_0'}$(0.910), density was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest density was found in case of MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e. $P_{2/D_1/ t_4}$(0.892) followed by MA$_2$ (5% O$_2$ + 3% CO$_2$) i.e. $P_{2/D_1/ t_2}$(0.898) and highest density(0.940) was observed in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e.$P_{2/D_1/ t_3}$ at 8°C at 40 days of storage time. At 15°C lowest density was found in case of MA$_1$ (3% O$_2$ + 3% CO$_2$) i.e.$P_{2/D_2/ t_1}$(0.882) while highest density was found in MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e.$P_{2/D_2/ t_1'}$(0.921) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest density was found in case of MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e.$P_{2/D_3/ t_3}$(0.894) while highest density was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e.$P_{2/D_3/ t_3'}$(0.940) in 40 days of storage time. Thus, The modified atmospheric package MA$_3$ (5% O$_2$ + 5% CO$_2$) has retained density effectively at the end of 40 days of storage at temperature levels of 8°C and 30°C and considered to be best for MA packaged tomato.

**5.3.2.2.3 VARIATION IN DENSITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C**

From the Fig. 4.4.1.2C, it can be concluded that density of unpackaged and MA packaged tomato packed with Polyethylene film was lowest in $P_{3/D_1/ t_0}$(0.852) at 40 days of storage followed by $P_{3/D_1/ t_4}$(0.910) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by $P_{3/D_2/ t_0}$(0.858) and $P_{3/D_2/ t_0'}$(0.914), density was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest density was found in case of MA$_2$ (5% O$_2$ + 3% CO$_2$) i.e. $P_{3/D_1/ t_4ind}$ (0.896) followed by MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e. $P_{3/D_1/ t_4}$ (0.910) and highest density(0.928) was observed in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e.$P_{3/D_1/ t_3}$ at 8°C at 40 days of storage time. At 15°C lowest density was found in case of MA$_2$ (5% O$_2$ + 3% CO$_2$) i.e.$P_{3/D_2/ t_2}$ (0.984) while highest density was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e.$P_{3/D_2/ t_3}$ (0.922) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest density was found in case of MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e.$P_{3/D_3/ t_3}$ (0.864) while highest density was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e.$P_{3/D_3/ t_3'}$ (0.941) in 40 days of storage time. Thus, modified atmospheric package MA$_3$ (5% O$_2$ + 5% CO$_2$) has retained density
effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.2.4 VARIATION IN DENSITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.1.2D, it can be concluded that density of unpackaged and MA packaged tomato packed with PVC film was lowest in P4/D1/ t0-(0.862) at 40 days of storage followed by P4/D1/ t4-(0.898) at 32 days of storage at 8°C, compared to the rate of respiration at 15°C at similar days in by P4/D2/ t0-(0.862) and P4/D2/ t'0-(0.916), density was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato, the lowest density was found in case of MA1 (3% O2 + 3% CO2) i.e. P4/D1/ t1-(0.868) followed by MA4 (7% O2 + 5% CO2) i.e. P4/D1/ t4-(0.884) and highest density(0.896) was observed in MA3 (5% O2 + 5% CO2) i.e. P4/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest density was found in case of MA4 (7% O2 + 5% CO2) i.e.P4/D2/ t'4 (0.864) while highest density was found in MA3 (5% O2 + 5% CO2) i.e.P4/D2/ t'3(0.942) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest density was found in case of MA4 (7% O2 + 5% CO2) i.e.P4/D3/ t''3 (0.896) while highest density was found in MA3 (5% O2 + 5% CO2) i.e.P4/D3/ t''3 (0.941) in 40 days of storage time. Thus, modified atmospheric package MA3 (5% O2 + 5% CO2) has retained density effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.2 VARIATION IN TEXTURE OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.2.1 VARIATION IN TEXTURE OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED POLY PROPYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.1A, it can be concluded that scores of texture of unpackaged and MA packaged tomato packed with Biaxially Oriented Poly Propylene (BOPP) films was lowest in P1/D1/ t0-(1.2) at 40 days of storage followed by P1/D1/ t0-(1.4) at 32 days of storage at 8°C, compared to the score of texture at 15°C at similar days in by P1/D2/ t0(1.2) and P1/D2/ t0-(1.4), scores of texture was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric
treated tomato the lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P1/D1/ t2-(2.0) followed by MA1 (3% O2 + 3% CO2) i.e. P1/D1/ t1 -(2.1) and highest scores of texture(2.4) was observed in MA3 (5% O2 + 5% CO2) i.e.P1/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e.P1/D2/ t2 (0.919) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P1/D2/ t1(2.5) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of texture was found in case of MA4 (7% O2 + 5% CO2) i.e.P1/D3/ t3 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P1/D3/ t3 (2.4) in 40 days of storage time. Thus, the modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of texture effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.2.2 VARIATION IN TEXTURE OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.1B, it can be concluded that scores of texture of unpackaged and MA packaged tomato packed with SARAN™ films was lowest in P2/D1/t0-(1.2) at 40 days of storage followed by P2/D1/ t0-(1.4) at 32 days of storage at 8°C, compared to the score of texture at 15°C at similar days i.e. P2/D2/ t0(1.2) and P2/D2/ t0-(1.4), scores of texture was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P2/D1/ t2-(2.0) followed by MA1 (3% O2 + 3% CO2) i.e. P2/D1/ t1 -(2.1) and highest scores of texture(2.4) was observed in MA3 (5% O2 + 5% CO2) i.e.P2/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e.P2/D2/ t2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P2/D2/ t1(2.4) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e.P2/D3/ t2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P2/D3/ t3 (2.5) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of texture effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.
5.3.2.2.3 VARIATION IN TEXTURE OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.1C, it can be concluded that scores of texture of unpackaged and MA packaged tomato packed with polyethylene films was lowest in P3/D1/t0-(1.2) at 40 days of storage followed by P3/D1/ t0-(1.4) at 32 days of storage at 8°C, compared to the score of texture at 15°C at similar days i.e. P3/D2/ t0(1.2) and P3/D2/ t0-(1.4), scores of texture was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P3/D1/ t2-(2.0) followed by MA1 (3% O2 + 3% CO2) i.e. P3/D1/ t1 -(2.1) and highest scores of texture(2.8) was observed in MA3 (5% O2 + 5% CO2) i.e.P3/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e.P3/D2/ t2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P3/D2/ t1(2.8) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e.P3/D3/ t2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e.P3/D3/ t3 (2.9) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of texture effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.2.4 VARIATION IN TEXTURE OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.1D, it can be concluded that scores of texture of unpackaged and MA packaged tomato packed with polyethylene films was lowest in P3/D1/t0-(1.2) at 40 days of storage followed by P3/D1/ t0-(1.4) at 32 days of storage at 8°C, compared to the score of texture at 15°C at similar days i.e. P3/D2/ t0(1.2) and P3/D2/ t0-(1.4), scores of texture was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P3/D1/ t2-(2.0) followed by MA1 (3% O2 + 3% CO2) i.e. P3/D1/ t1 -(2.1) and highest scores of texture(2.6) was observed in MA3 (5% O2 + 5% CO2) i.e.P3/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest
scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P4/D2/ t’2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e. P4/D2/ t’1(2.6) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of texture was found in case of MA2 (5% O2 + 3% CO2) i.e. P4/D3/ t’’2 (2.0) while highest scores of texture was found in MA3 (5% O2 + 5% CO2) i.e. P4/D3/ t’’3 (2.6) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of texture effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.3 VARIATION IN COLOURS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.3.1 VARIATION IN COLOURS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED POLYPROPYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.2A, it can be concluded that scores of colours of unpackaged and MA packaged tomato packed with Biaxially Oriented Polypropylene (BOPP) films was lowest in P1/D1/t0-(1.2) at 40 days of storage followed by P1/D1/ t0-(1.6) at 32 days of storage at 8°C, compared to the score of colours at 15°C at similar days i.e. P1/D2/t0(1.2) and P1/D2/ t’0-(1.6), scores of colours was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest scores of colours was found in case of MA1 (3% O2 + 3% CO2) i.e. P1/D1/ t1-(1.4) followed by MA2 (5% O2 + 3% CO2) i.e. P1/D1/ t2 -(2.1) and highest scores of colours (2.4) was observed in MA3 (5% O2 + 5% CO2) i.e. P1/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest scores of colours was found in case of MA1 (5% O2 + 3% CO2) i.e. P1/D2/ t’2 (1.4) while highest scores of colours was found in MA3 (5% O2 + 5% CO2) i.e. P1/D2/ t’3(2.3) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of colours was found in case of MA1 (3% O2 + 3% CO2) i.e. P1/D3/ t’’1 (1.4) while highest scores of colours was found in MA3 (5% O2 + 5% CO2) i.e. P1/D3/ t’’3 (2.5) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of colours effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.
5.3.2.3.2 VARIATION IN COLOURS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From the Fig. 4.4.2.2B, it can be concluded that scores of colours of unpackaged and MA packaged tomato packed with SARAN™ films was lowest in P2/D1/t0-(1.2) at 40 days of storage followed by P2/D1/ t0-(1.6) at 32 days of storage at 8°C, compared to the score of colours at 15°C at similar days i.e. P2/D2/t0(1.2) and P2/D2/ t'0-(1.6), scores of colours was lower in comparison to all the storage days as the temperature increases as similar pattern was found in storage temperature of 30°C. Among the modified atmospheric treated tomato the lowest scores of colours was found in case of MA1 (3% O2 + 3% CO2) i.e. P2/D1/ t1--(1.4) followed by MA2 (5% O2 + 3% CO2) i.e. P2/D1/ t2 -(2.1) and highest scores of colours (2.4) was observed in MA3 (5% O2 + 5% CO2) i.e.P2/D1/ t3 at 8°C at 40 days of storage time. At 15°C lowest scores of colours was found in case of MA1 (5% O2 + 3% CO2) i.e.P2/D2/ t2 (1.4) while highest scores of colours was found in MA3 (5% O2 + 5% CO2) i.e.P2/D2/ t'3(2.3) in 40 days of storage time. While, in case of MA packaged tomato stored at 30°C lowest scores of colours was found in case of MA1 (3% O2 + 3% CO2) i.e.P2/D3/ t''1 (1.4) while highest scores of colours was found in MA3 (5% O2 + 5% CO2) i.e.P2/D3/ t''3 (2.5) in 40 days of storage time. Thus, The modified atmospheric package MA3 (5% O2 + 5% CO2) has retained scores of colours effectively at the end of 40 days of storage at temperature levels of 8°C, 15°C and 30°C and considered to be best for MA packaged tomato.

5.3.2.4 VARIATION IN TITRATABLE ACIDITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.4.1 VARIATION IN TITRATABLE ACIDITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXially ORIENTED POLY PROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.3a, it can be concluded that titratable acidity is lowest in P1/D1/t0- (0.214) after 40 days of storage period followed by P1/D1/ t0- (0.224) after 32 days of storage period at 8°C compared to the titratable acidity at 15°C in similar days where values of titratable acidity did not changes. While, at the temperature of 30°C, the values of titratable acidity were P1/D3/t''0- (0.224) and P1/D3/t''0- (0.226) for the storage time of 40 and 32 days respectively, which showed the titratable acidity of unpackaged tomato was declining as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of titratable acidity was found
in MA3 (5% O2 + 5% CO2) i.e. P1/D1/t4- (0.301) and lowest titratable acidity was found
in MA2 (5% O2 + 3% CO2) i.e. P1/D1/t2- (0.249) after 40 days of storage at 8°C. At
15°C the highest value of titratable acidity was found in MA1 (3% O2 + 3% CO2) i.e. 
P1/D2/t1- (0.297) and lowest titratable acidity was found in MA2 (5% O2 + 3% CO2)
i.e. P1/D2/t2- (0.249) after 40 days of storage, while at the temperature of 30°C, the
highest values of titratable acidity was found in MA3 (5% O2 + 5% CO2) i.e. P1/D3/t''3-
(0.298) and lowest value was of MA2 (5% O2 + 3% CO2) i.e. P1/D3/t''2- (0.244).
Therefore, it can be concluded that gaseous concentration of MA3 (5% O2 + 5% CO2)
is best for retaining the titratable acidity in MA packaged tomato as it retained the
titratable acidity more effectively at temperature of 8°C and 30°C.

5.3.2.4.2 VARIATION IN TITRATABLE ACIDITY OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.3B, it can be concluded that titratable acidity is lowest in
P2/D1/t0- (0.214) after 40 days of storage period followed by P2/D1/t0- (0.232) after 32
days of storage period at 8°C compared to the titratable acidity at 15°C in similar
days where values of titratable acidity for P2/D1/t0- (0.214) after 40 days of storage
period followed by P2/D1/t0- (0.224) after 32 days of storage period. While, at the
temperature of 30°C, the values of titratable acidity were P2/D3/t''0- (0.204) and
P2/D3/t''0- (0.220) for the storage time of 40 and 32 days respectively, which showed
the titratable acidity of unpackaged tomato was declining as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of
titratable acidity was found in MA3 (5% O2 + 5% CO2) i.e. P2/D1/t4- (0.389) and lowest
titratable acidity was found in MA2 (5% O2 + 3% CO2) i.e. P2/D1/t2- (0.289) after 40
days of storage at 8°C. At 15°C the highest value of titratable acidity was found in
MA1 (3% O2 + 3% CO2) i.e. P2/D2/t1- (0.297) and lowest titratable acidity was found
in MA2 (5% O2 + 3% CO2) i.e. P2/D2/t2- (0.249) after 40 days of storage, while at the
temperature of 30°C, the highest values of titratable acidity was found in MA1 (3% O2
+ 3% CO2) i.e. P2/D3/t''1- (0.249) and lowest value was of MA2 (5% O2 + 3% CO2)
i.e. P2/D3/t''2- (0.235). Therefore, it can be concluded that gaseous concentration of
MA1 (3% O2 + 3% CO2) is best for retaining the titratable acidity in MA packaged
tomato as it retained the titratable acidity more effectively at temperature of 8°C,
15°C and 30°C.
5.3.2.4.3 VARIATION IN TITRATABLE ACIDITY OF UNPACKAGED AND MA
PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS
WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.3c, it can be concluded that titratable acidity is lowest in
P3/D1/t0- (0.212) after 40 days of storage period followed by P3/D1/t0- (0.234) after 32
days of storage period at 8°C compared to the titratable acidity at 15°C in similar
days where values of titratable acidity for P3/D1/t0- (0.204) after 40 days of storage
period followed by P3/D1/t0- (0.264) after 32 days of storage period. While, at the
temperature of 30°C, the values of titratable acidity were P3/D3/t''0- (0.218) and
P3/D3/t''0- (0.226) for the storage time of 40 and 32 days respectively, which showed
the titratable acidity of unpackaged tomato was declining as the storage time
progresses in POLYETHYLENE FILMS. Among the modified atmospheric treated
tomato, the highest value of titratable acidity was found in MA1 (3% O2 + 3% CO2) i.e.
P3/D1/t1- (0.386) and lowest titratable acidity was found in MA4 (7% O2 + 5% CO2) i.e.
P3/D1/t4- (0.288) after 40 days of storage at 8°C. At 15°C the highest value of
titratable acidity was found in MA3 (5% O2 + 5% CO2) i.e. P3/D2/t'3- (0.289) and
lowest titratable acidity was found in MA2 (5% O2 + 3% CO2) i.e. P3/D2/t'2- (0.249)
after 40 days of storage, while at the temperature of 30°C, the highest values of
titratable acidity was found in MA3 (5% O2 + 5% CO2) i.e. P3/D3/t''3- (0.386) and
lowest value was of MA2 (5% O2 + 3% CO2) i.e. P3/D3/t''2- (0.316). Therefore, it can
be concluded that gaseous concentration of MA3 (5% O2 + 5% CO2) is best for
retaining the titratable acidity in MA packaged tomato as it retained the titratable
acidity more effectively at temperature of 15°C and 30°C.

5.3.2.4.4 VARIATION IN TITRATABLE ACIDITY OF UNPACKAGED AND MA
PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE
(PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.3D, it can be concluded that titratable acidity is lowest in
P4/D1/t0- (0.212) after 40 days of storage period followed by P4/D1/t0- (0.226) after 32
days of storage period at 8°C compared to the titratable acidity at 15°C in similar
days where values of titratable acidity for P4/D2/t0- (0.216) after 40 days of storage
period followed by P4/D2/t0- (0.234) after 32 days of storage period. While, at the
temperature of 30°C, the values of titratable acidity were P4/D3/t''0- (0.210) and
P4/D3/t''0- (0.226) for the storage time of 40 and 32 days respectively, which showed
the titratable acidity of unpackaged tomato was declining as the storage time
progresses in PVC films. Among the modified atmospheric treated tomato, the
highest value of titratable acidity was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e. P$_4$/D$_1$/t$_1$- (0.389) and lowest titratable acidity was found in MA$_1$ (3% O$_2$ + 3% CO$_2$) i.e. P$_4$/D$_1$/t$_4$- (0.295) after 40 days of storage at 8°C. At 15°C the highest value of titratable acidity was found in MA$_1$ (3% O$_2$ + 3% CO$_2$) i.e. P$_4$/D$_2$/t'$_1$- (0.298) and lowest titratable acidity was found in MA$_2$ (5% O$_2$ + 3% CO$_2$) i.e. P$_4$/D$_2$/t'$_2$- (0.269) after 40 days of storage, while at the temperature of 30°C, the highest values of titratable acidity was found in MA$_1$ (3% O$_2$ + 3% CO$_2$) i.e. P$_4$/D$_3$/t''$_1$- (0.340) and lowest value was of MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e. P$_4$/D$_3$/t''$_4$- (0.265). Therefore, it can be concluded that gaseous concentration of MA$_1$ (3% O$_2$ + 3% CO$_2$) is best for retaining the titratable acidity in MA packaged tomato as it retained the titratable acidity more effectively at temperature of 15°C and 30°C.
5.3.2.4 VARIATION IN TOTAL SOLUBLE SOLIDS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.4.1 VARIATION IN TOTAL SOLUBLE SOLIDS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED POLY PROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.4 A, it can be concluded that total soluble solids content is highest in P1/D3/t0- (5.79) after 40 days of storage period followed by P1/D1/t0- (5.68) after 32 days of storage period at 8°C compared to the total soluble solids content at 15°C in similar days where values of total soluble solids content did not change. While, at the temperature of 30°C, the values of total soluble solids content were P1/D3/t0- (5.98) and P1/D3/t0- (5.78) for the storage time of 40 and 32 days respectively, which showed the total soluble solids content of unpackaged tomato was increasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of total soluble solids was found in MA3 (5% O2 + 5% CO2) i.e. P1/D1/t4- (5.42) and lowest total soluble solids was found in MA1 (3% O2 + 3% CO2) i.e. P1/D1/t1- (5.32) after 40 days of storage at 8°C. At 15°C the highest value of total soluble solids was found in MA4 (7% O2 + 5% CO2) i.e. P1/D2/t4- (5.49) and lowest total soluble solids was found in MA1 (3% O2 + 3% CO2) i.e. P1/D2/t1- (5.32) after 40 days of storage, while at the temperature of 30°C, the highest values of total soluble solids was found in MA1 (3% O2 + 3% CO2) i.e. P1/D3/t1- (5.78) and lowest was of MA2 (5% O2 + 3% CO2) i.e. P1/D3/t2- (5.42). Therefore, it can be concluded that gaseous concentration of MA1 (3% O2 + 3% CO2) is best for retaining the total soluble solids in MA packaged tomato as it retained the total soluble solids more effectively at temperature of 8°C and 15°C.

5.3.2.4.2 VARIATION IN TOTAL SOLUBLE SOLIDS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.4 B, it can be concluded that total soluble solids content is highest in P2/D1/t0- (6.69) after 40 days of storage period followed by P2/D1/t0- (6.12) after 32 days of storage period at 8°C compared to the total soluble solids content at 15°C in similar days where values of P2/D2/t0- (5.79) and P2/D2/t0- (5.68) respectively. While, at the temperature of 30°C, the values of total soluble solids were P2/D3/t0- (6.24) and P2/D3/t0- (6.08) for the storage time of 40 and 32 days respectively, which showed the total soluble solids content of unpackaged tomato was increasing
as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of total soluble solids was found in MA4 (7% O2 + 5% CO2) i.e. P2/D1/t4- (5.48) and lowest total soluble solids was found in MA3 (5% O2 + 5% CO2) i.e. P2/D1/t3- (5.16) after 40 days of storage at 8°C. At 15°C the highest value of total soluble solids was found in MA4 (7% O2 + 5% CO2) i.e. P2/D2/t4- (5.49) and lowest total soluble solids was found in MA1 (3% O2 + 3% CO2) i.e. P2/D2/t1- (5.32) after 40 days of storage, while at the temperature of 30°C, the highest values of total soluble solids was found in MA2 (5% O2 + 3% CO2) i.e. P2/D3/t2- (5.52) and lowest value was of MA3 (5% O2 + 5% CO2) i.e. P2/D3/t3- (5.36). Therefore, it can be concluded that gaseous concentration of MA3 (5% O2 + 5% CO2) is best for retaining the total soluble solids in MA packaged tomato as it retained the total soluble solids more effectively at temperature of 8°C and 30°C.

5.3.2.4.3 VARIATION IN TOTAL SOLUBLE SOLIDS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.4 C, it can be concluded that total soluble solids content is highest in P3/D1/t0- (5.79) after 40 days of storage period followed by P3/D1/t0- (5.68) after 32 days of storage period at 8°C compared to the total soluble solids content at 15°C in similar days where values of P3/D2/t0- (5.98) and P3/D2/t0- (5.78) respectively. While, at the temperature of 30°C, the values of total soluble solids were P3/D3/t2- (5.78) and P3/D3/t3- (5.84) for the storage time of 40 and 32 days respectively, which showed the total soluble solids content of unpackaged tomato was increasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of total soluble solids was found in MA2 (5% O2 + 3% CO2) i.e. P3/D1/t2- (5.58) and lowest total soluble solids was found in MA3 (5% O2 + 5% CO2) i.e. P3/D1/t3- (5.32) after 40 days of storage at 8°C. At 15°C the highest value of total soluble solids was found in MA4 (7% O2 + 5% CO2) i.e. P3/D2/t4- (5.78) and lowest total soluble solids was found in MA3 (5% O2 + 5% CO2) i.e. P3/D2/t3- (5.42) after 40 days of storage, while at the temperature of 30°C, the highest values of total soluble solids was found in MA4 (7% O2 + 5% CO2) i.e. P3/D3/t4- (5.49) and lowest value was of MA2 (5% O2 + 3% CO2) i.e. P3/D3/t2- (5.38). Therefore, it can be concluded that gaseous concentration of MA3 (5% O2 + 5% CO2) is best for retaining the total soluble solids in MA packaged tomato as it retained the total soluble solids more effectively at temperature of 8°C and 15°C.
5.3.2.4 VARIATION IN TOTAL SOLUBLE SOLIDS OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.4 D, it can be concluded that total soluble solids content is highest in $P_4/D_1/t_0^-$ (6.20) after 40 days of storage period followed by $P_4/D_1/t_0^-$ (5.92) after 32 days of storage period at 8°C compared to the total soluble solids content at 15°C in similar days where values of $P_4/D_2/t_0^-$ (6.29) and $P_4/D_2/t_0^-$ (5.98) respectively. While, at the temperature of 30°C, the values of total soluble solids were $P_4/D_3/t'_0^-$ (6.89) and $P_4/D_3/t''0^-$ (6.58) for the storage time of 40 and 32 days respectively, which showed the total soluble solids content of unpackaged tomato was increasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of total soluble solids was found in MA$_1$ (3% O$_2$ + 3% CO$_2$) i.e. $P_4/D_1/t_1^-$ (5.78) and lowest total soluble solids was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e. $P_4/D_1/t_3^-$ (5.38) after 40 days of storage at 8°C. At 15°C the highest value of total soluble solids was found in MA$_2$ (5% O$_2$ + 3% CO$_2$) i.e. $P_4/D_2/t_2^-$ (5.78) and lowest total soluble solids was found in MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e. $P_4/D_2/t_3^-$ (5.38) after 40 days of storage, while at the temperature of 30°C, the highest values of total soluble solids was found in MA$_4$ (7% O$_2$ + 5% CO$_2$) i.e. $P_4/D_3/t_4^-$ (5.85) and lowest value was of MA$_3$ (5% O$_2$ + 5% CO$_2$) i.e. $P_4/D_3/t''3^-$ (5.38). Therefore, it can be concluded that gaseous concentration of MA$_3$ (5% O$_2$ + 5% CO$_2$) is best for retaining the total soluble solids in MA packaged tomato as it retained the total soluble solids more effectively at temperature of 8°C, 15°C and 30°C.

The total soluble solids acts as a rough index of the amount of sugars present in fruits. It is the amount of sugar and soluble minerals present in fruits and vegetables. Sugars constitute 80-85 per cent of soluble solids. The total soluble solids increased during the ripening due to degradation of polysaccharides to simple sugars thereby causing a rise in TSS (Naik et al., 1993). However, in the present study, MAP significantly delayed the change in total soluble solids indicating a delay in ripening. Similar results were reported by Nakhasi et al. (1991) in tomatoes sealed in MAP bags. Similarly, controlled atmosphere storage of ginger gold apples for several months maintained the total soluble solids.
5.3.2.5 VARIATION IN REDUCING SUGAR OF UNPACKAGED AND MA
PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH
STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.5.1 VARIATION IN REDUCING SUGAR OF UNPACKAGED AND MA
PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED
POLY PROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C,
15°C AND 30°C

From Fig. 4.4.2.5 A, it can be concluded that reducing sugar content is high in
P1/D1/t0- (4.450) thereafter, it increases after on the 8th day of storage (4.460), then
there was a constant decrease in the reducing sugar content in tomato packed in
BOPP films during all the storage days. After 32 days of storage, the reducing sugar
content was highest in P1/D1/t0- (3.280) at 8°C, compared to the reducing sugar
content at 15°C in similar days where the values of reducing sugar content did not
change. While, at the temperature of 30°C, the values of reducing sugar content
were P1/D3/t0- (4.460) and P1/D3/t0- (3.284) for the storage time of 0 and 32 days
respectively, which showed the reducing sugar content of unpackaged tomato was
increasing during the 8th day and decreases further as the storage time progresses.
Among the modified atmospheric treated tomato, the highest value of reducing sugar
was found in MA2(5% O2 + 3% CO2) i.e. P1/D1/t2- (3.260) and lowest reducing sugar
was found in MA3 (5% O2 + 5% CO2) i.e. P1/D1/t2- (3.240) after 32 days of storage at
8°C. However, the value of reducing sugar was identical in all the modified
atmospheric treatment at 8°C. At 15°C the values of reducing sugar were similar to
the values at 8°C, while at the temperature of 30°C, the highest values of reducing
sugar was found in MA4 (7% O2 + 5% CO2) i.e. P1/D3/t4- (3.280) and lowest value
was of MA3 (5% O2 + 5% CO2) i.e. P1/D3/t3- (3.140) after 32 days of storage.
Therefore, it can be concluded that the gaseous concentration of MA2 (5% O2 + 3%
CO2) is best for retaining the reducing sugar in MA packaged tomato as it retained
the reducing sugar more effectively at temperature of 8°C and 15°C.
5.3.2.5.2 VARIATION IN REDUCING SUGAR OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.5 B, it can be concluded that reducing sugar content is high in P2/D1/t0- (4.650) thereafter, it increases after on the 8th day of storage (4.680), then there was a constant decrease in the reducing sugar content in tomato packed SARAN™ films during all the storage days. After 40 days of storage, the value for reducing sugar was highest in P2/D1/t0- (3.280) at 8°C, compared to the reducing sugar content at 15°C in similar days where the values of reducing sugar content did not change. While, at the temperature of 30°C, the values of reducing sugar content were P2/D3/t''0- (2.960) and P2/D3/t''0- (3.270) for the storage time of 40 and 32 days respectively, which showed the reducing sugar content of unpackaged tomato was increasing during the 8th day and decreases further as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of reducing sugar was found in MA1(3% O2 + 3% CO2) i.e. P2/D1/t1- (2.980) and identical values of reducing sugar was found in all other modified atmospheric treatments after 40 days of storage at 8°C. At 15°C the values of reducing sugar were similar to the in all the modified packaging treatment with the unpackaged tomato. While at the temperature of 30°C, the highest values of reducing sugar was found in MA4 (7% O2 + 5% CO2) i.e. P2/D3/t''4- (2.980) and lowest value was of MA2 (5% O2 + 3% CO2) i.e. P2/D3/t''2- (2.960) after 40 days of storage. Therefore, it can be concluded that the gaseous concentration of MA1 (3% O2 + 3% CO2) is best for retaining the reducing sugar in MA packaged tomato as it retained the reducing sugar more effectively at temperature of 8°C and 15°C.

5.3.2.5.3 VARIATION IN REDUCING SUGAR OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.5 C, it can be concluded that reducing sugar content is high in P3/D1/t0- (4.465) thereafter, it increases after on the 8th day of storage (4.480), then there was a constant decrease in the reducing sugar content in tomato packed polyethylene films during all the storage days. After 40 days of storage, the value for reducing sugar was in P3/D1/t0- (2.960) at 8°C, compared to the reducing sugar content at 15°C in similar days where the values of reducing sugar showed similar trend. While, at the temperature of 30°C, the values of reducing sugar content were P3/D3/t''0- (2.970) and P3/D3/t''0- (3.280) for the storage time of 40 and 32 days.
respectively, which showed the reducing sugar content of unpackaged tomato was increasing during the 8th day and decreases further as the storage time progresses at all three temperature levels. Among the modified atmospheric treated tomato, the highest value of reducing sugar was found in MA1 (3% O\(_2\) + 3% CO\(_2\)) i.e. P\(_3/D_1/t_1\) (2.970) and lowest value of reducing sugar was found in MA2 (5% O\(_2\) + 3% CO\(_2\)) i.e. P\(_3/D_1/t_1\) (2.960) after 40 days of storage at 8°C. At 15°C the highest value of reducing sugar was found in MA1 (3% O\(_2\) +3% CO\(_2\)) i.e. P\(_3/D_2/t'_1\) (2.980) and lowest value of reducing sugar was found in MA3 (5% O\(_2\) + 5% CO\(_2\)) i.e. P\(_3/D_2/t'1\) (2.970) after 40 days of storage. While at the temperature of 30°C, the values of reducing sugar were similar to the in all the modified packaging treatment with the unpackaged tomato after 40 days of storage. Therefore, it can be concluded that the gaseous concentration of MA1 (3% O\(_2\) + 3% CO\(_2\)) is best for retaining the reducing sugar in MA packaged tomato as it retained the reducing sugar more effectively at temperature of 8°C and 15°C.

### VARIATION IN REDUCING SUGAR OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.5 D, it can be concluded that reducing sugar content is high in P\(_4/D_1/t_0\) (4.482) thereafter, it increases after on the 8th day of storage (4.490), then there was a constant decrease in the reducing sugar content in tomato packed polyethylene films during all the storage days. After 40 days of storage, the value for reducing sugar was was in P\(_4/D_1/t_0\) (2.976) at 8°C, compared to the reducing sugar content at 15°C in similar days where the values of reducing sugar showed similar trend. While, at the temperature of 30°C, the values of reducing sugar content were P\(_4/D_3/t''0\) (2.980) and P\(_4/D_3/t''0\) (3.260) for the storage time of 40 and 32 days respectively, which showed the reducing sugar content of unpackaged tomato was increasing during the 8th day and decreases further as the storage time progresses at all three temperature levels. Among the modified atmospheric treated tomato, the highest value of reducing sugar was found in MA2 (5% O\(_2\) + 3% CO\(_2\)) i.e. P\(_4/D_1/t_2\) (2.990) and lowest value of reducing sugar was found in MA3 (5% O\(_2\) + 5% CO\(_2\)) i.e. P\(_4/D_1/t_3\) (2.970) and MA4 (7% O\(_2\) + 5% CO\(_2\)) i.e. P\(_4/D_1/t_4\) (2.970) after 40 days of storage at 8°C. At 15°C the values of reducing sugar were identical in all the modified packaging treatment after 40 days of storage. While at the temperature of 30°C, the values of reducing sugar were similar to the in all the modified packaging treatment with the unpackaged tomato after 40 days of storage. Therefore, it can be
concluded that the gaseous concentration of MA2 (5% O₂ + 3% CO₂) is best for retaining the reducing sugar in MA packaged tomato as it retained the reducing sugar more effectively at temperature of 8°C and 15°C.

5.3.2.6 VARIATION IN ASCORBIC ACID CONTENT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH DIFFERENT FILMS WITH STORAGE TIME AT DIFFERENT TEMPERATURES

5.3.2.6.1 VARIATION IN ASCORBIC ACID CONTENT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH BIAXIALLY ORIENTED POLY PROPYLENE (BOPP) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.6 A, it can be concluded that ascorbic acid content is lowest in P₁/D₁/t₀⁻ (11.20) after 40 days of storage period followed by P₁/D₁/t₀⁻ (13.60) after 32 days of storage period at 8°C compared to the ascorbic acid content at 15°C in similar days where values of ascorbic acid content did not changes. While, at the temperature of 30°C, the values of ascorbic acid content were P₁/D₃/t'''₀⁻ (11.21) and P₁/D₃/t'''₀⁻ (15.82) for the storage time of 40 and 32 days respectively, which showed the ascorbic acid content of unpackaged tomato was increasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of ascorbic acid was found in MA₂ (5% O₂ + 3% CO₂) i.e. P₁/D₁/t₂⁻ (19.88) and lowest ascorbic acid was found in MA₃ (5% O₂ + 5% CO₂) i.e. P₁/D₁/t₃⁻ (16.25) after 40 days of storage at 8°C. At 15°C the values of ascorbic acid did not change after 40 days of storage, while at the temperature of 30°C, the highest values of ascorbic acid was found in MA₂ (5% O₂ + 3% CO₂) i.e. P₁/D₃/t''₂⁻ (19.86) and lowest value was of MA₃ (5% O₂ + 5% CO₂) i.e. P₁/D₃/t''₃⁻ (17.25). Therefore, it can be concluded that gaseous concentration of MA₂ (5% O₂ + 3% CO₂) is best for retaining the ascorbic acid in MA packaged tomato as it retained the ascorbic acid more effectively at temperature of 8°C, 15°C and 30°C.

5.3.2.6.2 VARIATION IN ASCORBIC ACID CONTENT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH SARAN™ FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.6 B, it can be concluded that ascorbic acid content is lowest in P₂/D₁/t₀⁻ (11.30) after 40 days of storage period followed by P₂/D₁/t₀⁻ (13.60) after 32 days of storage period at 8°C compared to the ascorbic acid content at 15°C in similar days where values of ascorbic acid content did not changes. While, at the temperature of 30°C, the values of ascorbic acid content were P₂/D₃/t'''₀⁻ (11.68) and P₂/D₃/t'''₀⁻ (13.98) for the storage time of 40 and 32 days respectively, which showed
the ascorbic acid content of unpackaged tomato was increasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of ascorbic acid was found in MA2 (5% O2 + 3% CO2) i.e. P2/D1/t2- (19.68) and lowest ascorbic acid was found in MA4 (7% O2 + 5% CO2) i.e. P2/D1/t3- (17.36) after 40 days of storage at 8°C. At 15°C the highest value of ascorbic acid was found in MA2 (5% O2 + 3% CO2) i.e. P2/D1/t2- (19.88) and lowest ascorbic acid was found in MA3 (5% O2 + 5% CO2) i.e. P2/D1/t3- (16.25) after 40 days of storage, while at the temperature of 30°C, the highest values of ascorbic acid was found in MA3 (5% O2 + 5% CO2) i.e. P2/D3/t2- (20.14) and lowest value was of MA2 (5% O2 + 3% CO2) i.e. P3/D3/t2- (17.12). Therefore, it can be concluded that gaseous concentration of MA2 (5% O2 + 3% CO2) is best for retaining the ascorbic acid in MA packaged tomato as it retained the ascorbic acid more effectively at temperature of 8°C, and 15°C.

5.3.2.6.3 VARIATION IN ASCORBIC ACID CONTENT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLYETHYLENE FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.6 C, it can be concluded that ascorbic acid content is lowest in P3/D1/t0- (11.20) after 40 days of storage period followed by P3/D1/t0- (13.60) after 32 days of storage period at 8°C compared to the ascorbic acid content at 15°C in similar days where values of ascorbic acid were P3/D2/t0- (11.46) and P3/D2/t0- (13.95) for the storage time of 40 and 32 days respectively. While, at the temperature of 30°C, the values of ascorbic acid content were P3/D3/t0- (11.78) and P3/D3/t0- (13.84) for the storage time of 40 and 32 days respectively, which showed the ascorbic acid content of unpackaged tomato was decreasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of ascorbic acid was found in MA2 (5% O2 + 3% CO2) i.e. P3/D1/t2- (19.88) and lowest ascorbic acid was found in MA2 (5% O2 + 3% CO2) i.e. P3/D1/t2- (16.25) after 40 days of storage at 8°C. At 15°C the highest value of ascorbic acid was found in MA2 (5% O2 + 3% CO2) i.e. P3/D1/t2- (19.82) and lowest ascorbic acid was found in MA4 (7% O2 + 5% CO2) i.e. P3/D1/t4- (17.65) after 40 days of storage, while at the temperature of 30°C, the highest values of ascorbic acid was found in MA3 (5% O2 + 5% CO2) i.e. P3/D3/t2- (19.88) and lowest value was of MA2 (5% O2 + 3% CO2) i.e. P3/D3/t2- (16.25). Therefore, it can be concluded that gaseous concentration of MA2 (5% O2 + 3% CO2) is best for retaining the ascorbic acid in MA packaged tomato as it retained the ascorbic acid more effectively at temperature of 8°C, and 15°C.
5.3.2.6.4 VARIATION IN ASCORBIC ACID CONTENT OF UNPACKAGED AND MA PACKAGED TOMATO PACKED WITH POLY VINYL CHLORIDE (PVC) FILMS WITH STORAGE TIME AT 8°C, 15°C AND 30°C

From Fig. 4.4.2.6 D, it can be concluded that ascorbic acid content is lowest in $P_4/D_1/l''0- (11.26)$ after 40 days of storage period followed by $P_4/D_1/l''0- (13.68)$ after 32 days of storage period at 8°C compared to the ascorbic acid content at 15°C in similar days where values of ascorbic acid were $P_4/D_2/l''0- (11.38)$ and $P_4/D_2/l''0- (13.36)$ for the storage time of 40 and 32 days respectively. While, at the temperature of 30°C, the values of ascorbic acid content were $P_4/D_3/l''0- (11.54)$ and $P_4/D_3/l''0- (13.74)$ for the storage time of 40 and 32 days respectively, which showed the ascorbic acid content of unpackaged tomato was decreasing as the storage time progresses. Among the modified atmospheric treated tomato, the highest value of ascorbic acid was found in MA2 (5% O₂ + 3% CO₂) i.e. $P_4/D_1/l''2- (19.74)$ and lowest ascorbic acid was found in MA4 (7% O₂ + 5% CO₂) i.e. $P_4/D_1/l''2- (17.46)$ after 40 days of storage at 8°C. At 15°C the highest value of ascorbic acid was found in MA2 (5% O₂ + 3% CO₂) i.e. $P_4/D_1/l''2- (19.88)$ and lowest ascorbic acid was found in MA4 (7% O₂ + 5% CO₂) i.e. $P_4/D_1/l''4- (17.86)$ after 40 days of storage, while at the temperature of 30°C, the highest values of ascorbic acid was found in MA2 (5% O₂ + 3% CO₂) i.e. $P_4/D_3/l''2- (19.88)$ and lowest value was of MA1 (3% O₂ + 3% CO₂) i.e. $P_4/D_3/l''1- (17.84)$. Therefore, it can be concluded that gaseous concentration of MA2 (5% O₂ + 3% CO₂) is best for retaining the ascorbic acid in MA packaged tomato as it retained the ascorbic acid more effectively at temperature of 8°C, 15°C and 30°C.

In MA packaged as well as unpackaged tomatoes, the titratable acidity, reducing sugar content, ascorbic acid content and density decreases with time whereas total soluble solids, physiological loss in weight were found to have increased. The loss of various quality attributes with storage time was slow in MA packaged tomatoes in comparison with unpackaged tomato. Tomatos in some packages were found to be have suffered from discolouration and flesh softening, probably due to high CO₂ levels. Statistical analysis indicated that in MA packaged tomato, the variation in quality attributes such as TA, TSS and density with storage time was not significantly different from that of unpackaged tomato whereas variation in weight and density of unpackaged tomato was significantly different from MA packaged tomato.
Sensory evaluation during initial period of storage suggested that the MA packaged tomatoes were less aromatic, more acid and firmer. Hence, they were rated slightly lower than the unpackaged tomatoes. However, towards later period MA packaged tomatoes were rated far above the unpackaged tomatoes. Sensory ratings were found to be an agreement with the objective test values. In MA$_3$ packages of various polymeric film packages, the shelf life of tomatoes was found to have increased by 3 to 4 times that of unpackaged tomatoes between 8 to 15°C. It was educed that the MA packaging of Tomatoes, the films having extremely low water vapour transmission rates should not be employed.
CONCLUSIONS

In the present investigation, it was concluded that the shelf-life of tomato can be extended by post harvest treatments but significant extension of shelf-life can be achieved by using Modified Atmospheric Packaging technique. First, the investigation was carried out to study the influence of various post harvest treatments and storage conditions on physico-chemical changes associated with ripening during the storage of tomato. The post harvest treatment experiment was laid out in factorial randomized design with three replications. The treatments consisted of Untreated tomato (control) Paper packaging (T1), 1% CaCl2 (T2), Hot water (T3) and Hot Air (T4). Significant differences were observed among the physico-chemical parameters due to various post harvest treatments at ambient storage conditions. The tomato fruits kept in paper packaging had a significantly low physiological loss in weight and better density however scores of Colour, Texture and titratable acidity were found to be best in hot water treatment, whereas 1% CaCl2 treatment was found to be best in retaining Total Soluble Solids and Ascorbic acid content. For modified atmospheric experiment, Fresh Tomatoes (Var. Avinash) were sorted out and packed aseptically in different polymer packaging films (P1-BOPP film, P2-SARAN™, P3-Polyethylene and P4-PVC film) at different concentrations of CO2 and O2 (t0 - unpackaged tomato, t1 - 3% O2 + 3% CO2, t2 - 5% O2 + 3% CO2, t3 - 5% O2 + 5% CO2) and t4 - 7% O2 + 5% CO2, stored at three different temperatures (T1-8°C, T2-15°C and T3-30°C). The respiration rate of fruits differed significantly among the treatments; respiratory climacteric was significantly delayed in fruits stored in modified atmosphere packaging. Similarly, significantly lower respiration rate was recorded in cold stored fruits (8°C). Modified atmosphere packages under cold storage (8°C) significantly reduced the respiration rates over the storage period. The physiological loss in weight was significantly lower in modified atmosphere packed fruits over all other treatments. Cold storage also significantly reduced the weight loss over ambient storage. Modified atmosphere packages recorded significantly higher organoleptic scoring in terms of colour and texture. Fruits kept under 8°C storage recorded a higher organoleptic scoring, but, symptoms of chilling injury were observed at the end of storage period. Cold storage of modified atmosphere packed fruits significantly delayed the colour development and maintained a better texture. Modified atmosphere packaging maintained significantly higher titratable acidity over the storage period.
storage had a higher titratable acidity. Significantly lower total soluble solids were recorded in fruits sealed in modified atmosphere packages. However, storage conditions did not have much influence on the TSS although cold storage (8°C) had a lower TSS. Ascorbic acid content was significantly higher in the fruits stored in modified atmosphere packages. Among the storage conditions, cold storage (8°C) maintained significantly higher ascorbic acid content. The shelf life of fruits stored in modified atmosphere packaging was significantly extended. However, no significant differences were observed among the storage conditions. Modified atmosphere packaging under cold storage significantly extended the shelf life of fruits. Among the polymeric films the biaxially oriented poly propylene (BOPP) film extended the shelf life of tomato as well as retained the physical, organoleptic and chemical properties of tomato as compared to the other polymeric films at the gaseous concentration of MA₃ (5% O₂ + 5% CO₂).