CHAPTER 5
SUMMARY AND CONCLUSIONS

This chapter deals with the summary of the present investigation with respect to various effects of composite edible coatings on shelf life of fresh commodities like tomato and papaya stored at ambient conditions and refrigerated conditions. It also brings out the conclusion that can be drawn on the basis of findings of current research project. The chapter is divided into the following headings:

5.1 Effect of composite edible coating on tomatoes stored at ambient conditions
5.2 Effect of composite edible coating on tomatoes stored at refrigerated conditions
5.3 Effect of composite edible coating on papaya stored at refrigerated conditions
5.4 Effect of formulation on properties of protein based edible film
5.5 Optimization of process parameters for edible film

5.1 Effect of Composite Edible Coating on Tomatoes Stored at Ambient Conditions

There was a significant change (p<0.05) in average titratable acidity of the uncoated samples as compared to coated samples of tomatoes at ambient conditions. The lowest average acidity value of 0.345% was shown by control sample followed by sample A, C and B with average acidity values of 0.455, 0.456 and 0.465% and there is no significant difference within coated samples. The maximum average acidity value of 0.552% was observed on 1st day of storage and lowest of 0.339% on 9th day of storage. The Vit C content of samples with treatment C was significantly higher as compared to other samples including control. The highest average Vit C value of 47.02 mg/100g
was found for samples of treatment C followed by treatment B, C and control with values of 35.25, 35.23 and 34.9 mg/100g respectively. Vit C content was decreased with the advancement of storage period of tomato fruits stored at ambient conditions.

The uncoated sample found to have significantly higher total sugar values as compared to coated samples. The average total sugar value was observed in control sample i.e. 4.53% followed by samples coated with coating C, B and A with values of 3.45, 3.22 and 3.10% respectively. In general both total and reducing sugar content goes on increasing up to 7th day of storage and then decreases slightly on 9th day of storage. The highest average total and reducing sugar content of 3.94 and 2.57 per cent respectively was found on 7th day of storage.

The highest average TSS value was shown by control sample i.e. 5.70 0Brix followed by samples treated with coating C, B and A showing the average values of 5.48, 5.42 and 5.30 0Brix. The average TSS values goes on increasing with the storage days and highest TSS value of 5.82 was observed on 9th day of storage. The effect of coating treatments on pH value is statistically insignificant (p<0.05). However, small difference in average pH value of control i.e 4.74 and coated samples A, B and C with values of 4.68, 4.68 and 4.62 respectively was recorded. The pH value go on increasing with storage period with maximum average value of 4.8 as compared to average value of 4.6 on 1st day of storage.

The highest average weight loss per cent i.e. 7.36 was observed in control (uncoated) sample followed by sample coated with coating C, A and B with average values of 6.50, 6.49 and 6.47 per cent. The storage period displayed rapid decrease in average weight loss per cent showing highest weight loss percentage of 10.02 on 2nd day of storage and lowest of 6.80 per cent at the end of storage period i.e. 9th day. The highest sugar to acid ratio of 19.30 was observed in control sample followed by samples coated with treatment C, A and B with the values of 12.28, 11.87 and 11.84 respectively. The highest average
sugar to acid ratio of 18.78 was found on 9th day of storage and lowest of 9.34 on 1st day of storage.

It can be observed that there is statistically significant effect of coatings on stiffness and cohesiveness of tomatoes stored at ambient conditions whereas the effect on chewiness is statistically insignificant. There was significant difference in stiffness, chewiness and cohesiveness values of tomatoes during all reported days of storage except for chewiness where there was insignificant difference between 7th and 9th day.

Microbial parameters i.e. SPC and YMC do not differ significantly between coated and uncoated (control) samples, however significant difference can be observed between samples of treatment B and other samples. Among various treatment samples of treatment B shown lowest value of 3.30 x 10^2 CFU/Cm^2 and 6.93 x 10^2 CFU/Cm^2 for SPC and YMC respectively. The highest value for SPC and YMC was shown on 9th day of storage with the values of 5.72 x 10^2 CFU/Cm^2 and 9.97 x 10^2 CFU/Cm^2 respectively.

**5.2 Effect of Composite Edible Coating on Tomatoes Stored at Refrigerated Conditions**

All coated samples have shown significant difference in average acidity values as compared to control sample. The lowest average acidity value of 0.348 per cent was shown by control sample followed by sample C, B and A with average acidity values of 0.413, 0.398 and 0.383 per cent. There was significant difference in average acidity values of tomatoes during each reported day of storage except 13th and 17th day. Vitamin C loss in coated samples is significantly lower as compared to control i.e. uncoated sample. The highest average vitamin C value of 39.08 mg/100g was found for sample of treatment C followed by treatment B, A and control with values of 31.45, 30.40 and 25.45 mg/100g respectively. The highest average vitamin C content was observed on 1st day of storage i.e. 57.13 mg/100g and
gradually decreased throughout storage and reached to a value of 11.78 mg/100g on 21st day of storage.

The uncoated sample found to have significantly higher total sugar values as compared to coated samples. The average total sugar value was observed in control sample i.e. 4.02 per cent followed by samples coated with coating A, B and C with values of 3.05, 2.95 and 2.87 per cent respectively. The highest average value of reducing sugar was found in control i.e. 2.60 per cent followed by sample treated with coating A, C and B, and the values are 2.44, 2.42 and 2.27 per cent respectively. There was statistically insignificant difference in reducing sugar content of samples with coating A and C all other treatment samples differs significantly. Average total sugar content goes on increasing up to 13th day and then decreases up to 21st day of storage while average reducing sugars content increases up to 17th day of storage and then decreased on last day of storage.

Within coated samples the TSS values were statistically insignificant between A and B, and B and C. Among all samples insignificant difference in TSS of sample with coating C and control was observed. The highest average pH value of 5.06 was recorded by control sample followed by samples treated with coating C, A and B with the values of 4.93, 4.86 and 4.85 respectively. Tomato sample stored at refrigerated conditions had significantly higher level of TSS value (i.e. 6.25 oBrix.) after 21 days of storage period. The pH value go on increasing with storage period with maximum average value of 5.30 as compared to average value of 4.6 on 1st day of storage.

The highest average weight loss per cent of 5.48 was observed in control (uncoated) sample followed by sample coated with coating C, A and B with average values of 4.87, 4.86 and 4.81 per cent. The highest sugar to acid ratio of 18.54 was observed in control sample followed by samples coated with treatment A, B and C with the values of 15.76, 14.86 and 14.32 respectively. Statistically significant difference was observed between each day of reported storage period
except between 13th and 17th day where the difference is not significant.

There was statistically significant effect of coatings on stiffness whereas the effect on cohesiveness and chewiness was statistically insignificant. The coating treatments exerted a beneficial effect on textural properties such that, by the end of the storage period, all the treatments gave rise to samples with higher stiffness and chewiness values and lower cohesiveness values than untreated samples. There was significant difference in stiffness, chewiness and cohesiveness values of tomatoes during all reported days of storage.

The comparison between coated and uncoated sample revealed that in general coated samples have shown higher values of both SPC and YMC, except treatment B. The highest value for SPC and YMC was shown on 21st day of storage with the values of 5.90 x 10^2 CFU/CM^2 and 9.77 x 10^2 CFU/CM^2 respectively.

5.3 Effect of Composite Edible Coating on Papaya Stored at Refrigerated Conditions

All coated samples have significantly low average acidity values as compared to control sample. Among various treatments the results for acidity values were statistically insignificant. The lowest average acidity value of 0.188 per cent was shown by control sample followed by sample C, A and B with average acidity values of 0.235, 0.226 and 0.224 per cent. There is significant difference in average acidity values of papaya cubes during each reported day of storage except 5th and 7th day. Vitamin C loss in coated samples is lower as compared to control i.e. uncoated sample. The highest average vitamin C value of 58.30 mg/100g was found for sample of treatment C followed by treatment B, A and control with values of 42.17, 41.98 and 37.78 mg/100g respectively. The highest vitamin C content was observed on 1st day of storage i.e. 58.39 mg/100g and gradually decreased throughout storage and reached to a value of 32.46 mg/100g on 7th day of storage.
The maximum average total sugar value was observed in control sample i.e. 6.04 per cent followed by samples coated with coating C, B and A with values of 5.58, 5.52 and 5.46 per cent respectively. The effect of various edible coatings on reducing sugar content of papaya cubes at refrigerated conditions was significant as compared to control. The highest average value of reducing sugar was found in control i.e. 3.39 per cent followed by sample treated with coating C, B and A, and the values are 2.80, 2.69 and 2.68 per cent respectively. Average total sugar content goes on increasing with the storage period. The similar trend was observed for reducing sugar content of papaya cubes stored at refrigerated conditions.

The highest average TSS value was shown by control sample i.e. 14 °Brix followed by samples treated with coating C, A and B showing the average values of 13.77, 13.42 and 13.15 °Brix. papaya cubes stored at refrigerated conditions had significantly higher level of TSS value (i.e. 14.95 °Brix.) after 7 days of storage period. There is no significant difference in pH of coated and uncoated samples of papaya cubes. The pH value go on increasing with storage period with maximum average value of 5.20 as compared to average value of 4.65 on 1st day of storage.

The highest average weight loss per cent of 4.79 was observed in control (uncoated) sample followed by sample coated with coating C, B and A with average values of 4.13, 4.02 and 4.01 per cent. The highest weight loss percentage of 6.47 was observed on 3rd day of storage and lowest of 4.81 on 7th day of storage. The non-significant effect of coating treatments was observed on sugar to acid ratio of papaya cubes stored at refrigerated conditions. Sugar to acid ratio increased with advances in storage period. The highest average sugar to acid ratio of 93.48 was found on 7th day of storage and lowest of 45.02 on 1st day of storage.

There was statistically non-significant effect of coatings on stiffness whereas the effect on cohesiveness and chewiness was
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Statistically significant. In case of stiffness and chewiness average lowest values of 0.067 kgf/mm and 0.021 Kgf.mm was shown by control sample. The highest values for stiffness, chewiness and cohesiveness were observed on 1st day of storage whereas lowest values was shown on 7th day of storage.

Among all, samples of treatment B have shown lowest value of 3.63 x 10^2 CFU/cm² and 6.20 x 10^2 CFU/cm² for SPC and YMC respectively. The storage period under consideration has a highly significant effect on SPC and YMC values of papaya cubes at refrigerated conditions.

5.4 Effect of Formulation on Properties of Protein Based Edible Film

As SPI concentration increases thickness of edible film also increases whereas as plasticizer concentration increases thickness of film decreases and similar trend was observed with respect to pH. The maximum thickness of 165 micron was observed at SPI concentration of 10 per cent and minimum thickness of 143 micron was observed with SPI concentration of 6 per cent.

As SPI concentration increases tensile strength of film increases rapidly whereas as pH increases tensile strength decreases slowly. At lower pH value tensile strength of film gradually increases and further decreases with increase in plasticizer concentration. The maximum and minimum tensile strength of 3.5 and 1.6 MPa was found at SPI concentration of 10 and 6% respectively. As plasticizer concentration increases tensile strength also increases slowly and again there is fall in tensile strength with increased plasticizer concentration.

As SPI concentration increases the young's modulus of edible film also increases rapidly whereas as plasticizer concentration increase it decreases linearly. The maximum and minimum value of 26.5 and 21.8 MPa for young's modulus was observed with plasticizer concentration of 33 and 67 per cent respectively. At lower plasticizer concentration the young's modulus increases with increase in pH and
at lower pH the young’s modulus decreases with increase in plasticizer concentration.

The elongation at break of edible film increases gradually with SPI concentration and then decreases slightly due to effect of plasticizer concentration. As plasticizer concentration increases the elongation values also increases. The maximum elongation at break value of 110 percent was obtained with plasticizer concentration of 67 per cent and minimum value of 73 per cent at plasticizer concentration of 40 per cent.

5.5 Optimization of Process Parameters For Edible Film

At optimum conditions of SPI concentration (8.39 per cent), pH (8.75) and plasticizer (60 per cent) the thickness of 149.95 ± 2.87 micron can be obtained. At optimum conditions of SPI concentration (8.65 per cent), pH (8.99) and plasticizer (60 per cent) the tensile strength of 2.72 ± 0.34 MPa can be obtained. At optimum conditions of SPI concentration (8.65 per cent), pH (8.99) and plasticizer (60 per cent) the Young’s modulus value of 23.38 ±0.47 MPa can be obtained. At optimum conditions of SPI concentration (8.39 per cent), pH (8.75) and plasticizer (60 per cent) the elongation at break value of 104.79 ± 7.16 per cent can be obtained.

The best combinations of process variables for response functions are found by keeping SPI concentration constant at 8.65 per cent. The process variables for best combination of response function are SPI concentration 8.65 per cent, plasticizer concentration 60 per cent, and pH 8.99. The response functions were calculated from the final polynomial and the response were thickness (151 micron), tensile strength (2.72MPa), Young’s modulus (23.4 MPa) and elongation at break (103.6 per cent).
5.6 Study of properties of optimized Protein Based Edible Film

There was a statistical significant difference in average moisture content values of edible films prepared from three different formulations i.e. A, B and C. The highest average moisture content value of 22.2 was found with formulation A followed by lowest value of 19.73 per cent with formulation C respectively.

The range of average WVP values of edible film was from 10.53 to 12.00 (g.mm m^{-2}h^{-2}kPa^{-1}). The highest and lowest value of WVP was recorded for formulation C and B respectively. The mean WVP values were statistically non significant between formulations A and B, B and C.

It can be observed that pH increases in formulation, the average oxygen permeability values go on decreasing. The highest and lowest average oxygen permeability values of 1.46 and 1.38 (cm³ µm/(m² d kPa) was recorded for formulation A and C respectively.

The present investigation leads to following conclusions

- The composite edible coatings can be formulated for fresh fruits and vegetables by using soy protein isolate, carboxy methyl cellulose and oleic acid as a source of protein, carbohydrate and lipid.

For tomatoes stored at ambient conditions

- There was a significant change (p<0.05) in average titratable acidity of the uncoated samples as compared to coated samples.
- The Vit C content of samples with treatment C was significantly higher as compared to other samples including control.
- The uncoated tomato sample found to have significantly higher total sugar values as compared to coated samples.
- Both total and reducing sugar content goes on increasing up to 7th day of storage and then decreases slightly on 9th day of storage.
Summary and Conclusions

- The average TSS values goes on increasing with the storage days and highest TSS value of 5.82 was observed on 9th day of storage.
- The effect of coating treatments on pH value is statistically insignificant (p<0.05).
- The highest average weight loss per cent i.e. 7.36 was observed in control (uncoated) sample followed by sample coated with coating C, A and B.
- The highest average sugar to acid ratio of 18.78 was found on 9th day of storage and lowest of 9.34 on 1st day of storage.
- There is statistically significant effect of coatings on stiffness and cohesiveness of samples whereas the effect on chewiness is statistically insignificant.
- Microbial parameters i.e. SPC and YMC do not differ significantly between coated and uncoated (control) samples, however significant difference can be observed between samples of treatment B and other samples.

For tomatoes stored at refrigerated conditions

- There was significant difference in average acidity values during each reported day of storage except 13th and 17th day.
- The highest average vitamin C content was observed on 1st day of storage i.e. 57.13 mg/100g and gradually decreased throughout storage and reached to a value of 11.78 mg/100g on 21st day of storage.
- The uncoated sample found to have significantly higher total sugar values as compared to coated samples.
- There was statistically insignificant difference in reducing sugar content of samples with coating A and C all other treatment samples differs significantly.
- Within coated tomato samples the TSS values were statistically insignificant between A and B, and B and C.
Summary and Conclusions

- The pH value go on increasing with storage period with maximum average value of 5.30 as compared to average value of 4.6 on 1st day of storage.
- The highest average weight loss per cent of 5.48 was observed in control (uncoated) sample followed by sample coated with coating C, A and B with average values of 4.87, 4.86 and 4.81 per cent.
- There was statistically significant effect of coatings on stiffness whereas the effect on cohesiveness and chewiness was statistically insignificant.
- With respect to microbial quality the comparison between coated and uncoated sample revealed that in general coated samples have shown higher values of both SPC and YMC, except treatment B.
- The papaya cube samples stored at ambient conditions and treated with different coating treatments were spoiled on 2nd day of storage including control.

For papaya cubes stored at refrigerated conditions.

- All coated samples have significantly low average acidity values as compared to control sample. Among various treatments the results for acidity values were statistically insignificant.
- The highest average vitamin C value of 58.30 mg/100g was found for sample of treatment C followed by treatment B, A and control with values of 42.17, 41.98 and 37.78 mg/100g respectively.
- The maximum average total sugar value was observed in control sample i.e. 6.04 per cent followed by samples coated with coating C, B and A.
- The total and reducing sugar content increased with storage period.
Summary and Conclusions

- Significantly higher level of TSS value (i.e. 14.95 °Brix.) after 7 days of storage period was observed.
- The pH value go on increasing with storage period with maximum average value of 5.20 as compared to average value of 4.65 on 1st day of storage.
- The highest average weight loss per cent of 4.79 was observed in control (uncoated) sample followed by sample coated with coating C, B and A.
- The non-significant effect of coating treatments was observed on sugar to acid ratio.
- There was statistically non-significant effect of coatings on stiffness whereas the effect on cohesiveness and chewiness was statistically significant.
- The storage period under consideration has a highly significant effect on SPC and YMC values.

Properties of protein based edible film during optimization using RSM

- As SPI concentration increases thickness of edible film also increases whereas as plasticizer concentration increases thickness of film decreases and similar trend was observed with respect to pH.
- As SPI concentration increases tensile strength of film increases rapidly whereas as pH increases tensile strength decreases slowly.
- As SPI concentration increases the young’s modulus of edible film also increases rapidly whereas as plasticizer concentration increase it decreases linearly.
- The elongation at break of edible film increases gradually with SPI concentration and then decreases slightly due to effect of plasticizer concentration.
Summary and Conclusions

Optimization of Process Parameters for edible film

- At optimum conditions of SPI concentration (8.39 per cent), pH (8.75) and plasticizer (60 per cent) the thickness of 149.95 ± 2.87 micron and the elongation at break value of 104.79 ± 7.16 per cent can be obtained.
- At optimum conditions of SPI concentration (8.65 per cent), pH (8.99) and plasticizer (60 per cent) the tensile strength of 2.72 ± 0.34 MPa and the Young’s modulus value of 23.38 ±0.47 MPa can be obtained.
- The process variables for best combination of response function are SPI concentration 8.65 per cent, plasticizer concentration 60 per cent, and pH 8.99.

Properties of optimized Protein Based Edible Film

- The highest average moisture content value of 22.2 was found with formulation A followed by lowest value of 19.73 per cent with formulation C respectively.
- The highest and lowest value of WVP was recorded for formulation C and B respectively.
- The highest and lowest average oxygen permeability values of 1.46 and 1.38 (cm³ μm/(m² d kPa) was recorded for formulation A and C respectively.