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# Development of tulsi impregnated starch-based edible coating to extend the shelf-life of tomatoes

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## Abstract
An investigation study was undertaken to identify the optimum formulation of starch based edible coating and determine the effect of addition of Tulsi extract to optimized formulation of starch based edible coating on storage quality of tomatoes. The coating solutions were prepared by completely gelatinizing 1, 1.25, 1.5, 1.75 and 2 g/100 mL starch slurry in water at 95ºC for 30 minutes and adding glycerol (0.4, 0.5 and 0.6 mL) as plasticizer. The moisture loss, percent solubility of the coated film, TA and TSS of tomatoes after 10 days of coating were determined. Non-dominated sorting technique was applied to identify the optimum levels of starch and glycerol in the coating solution that minimized all the four storage attributes. The solution containing 1.5% starch and 0.5 mL glycerol was found to be best formulation for coating of tomatoes. The extract of Tulsi at 1%, 2% and 3% by volume was added to the optimized formulation and the effect of coating on weight loss, TSS, TA, pH and moisture content of tomatoes in every five days interval upto 20 days were studied. The weight loss, TSS and TA increased with increase in storage period for both coated and uncoated tomatoes. The moisture content and pH of tomato decreased with increase in storage period. The rate of increase and decrease of these parameters was found to be lowest for the optimized coating solution added with 3% Tulsi extract. Therefore, in order to increase the shelf life of tomatoes, coating using the starch based edible coating of 1.5% starch and 0.5 mL glycerol added with Tulsi extract upto 3% may be recommended.

**Keywords:** Starch, edible coating, tomatoes, tulsi, shelf-life

## Introduction
Starch is a central component of human diet which is the major dietary source of carbohydrates and is the most abundant storage polysaccharide in plants. Starch is a polymeric carbohydrate composed of anhydroglucose units. Starch is composed of glucose polymers: a linear chain molecule termed amylose and a branched polymer of glucose termed amylopectin which is linked together by α-D-(1-4) and/or α-D-(1-6) glycosidic bonds. Starch is the predominant food reserve substance in plants. Edible coating and/or film is a thin layer not exceeding 0.3 mm in thickness, made-up of eatable material covering any food item to extend their shelf-life and to introduce additional value to the item. Edible Coating can also be used on the surface of food to control the diffusion rate of preservative substances from the surface to the interior of the food [1, 2]. Edible coatings may be composed of polysaccharides, proteins, lipids or a blend of these compounds [2, 3, 4, 5]. Coating can act as a barrier to moisture and oxygen during processing handling and storage [6]. Additionally, edible coating can act as carriers of functional ingredients such as antimicrobial and antioxidant agents, nutraceuticals and color and flavor ingredients [7]. Food products are usually coated by dipping or spraying, forming a thin layer on the food surface that acts as a semi-permeable membrane, which in turn control the moisture loss and/or suppress the gas transfer [8]. The coatings also function as carriers for antimicrobial and antioxidant agents [9].
Edible coating can also be safely eaten as part of the product and do not add unfavourable properties to the foodstuff [10]. Starch-based coatings or films exhibit physical characteristics similar to plastic films in that they are odorless, tasteless, colorless, non-toxic, biologically absorbable, semi-permeable to carbon dioxide, and resistant to passage of oxygen. Since the water activity is critical for microbial, chemical, and enzymatic activities, edible starch based films can retard microbial growth by lowering the water activity within the package. Amylose is responsible for the film-forming capacity of starch [9]. Glycerol is a plasticizer and is included in the edible coating formulation with the purpose of modifying the mechanical properties of the base edible components producing more flexible coatings [11, 12].

Tomato (*Lycospersicon esculentum*) is one of the most important and widely distributed horticultural vegetable crops of Assam. Tomato is a seasonal vegetable which is a rich source of lycopene, various vitamins, minerals, antioxidants and fiber which produces huge health benefits to the consumers [13, 14]. Tomatoes have a limited shelf life at ambient condition and are highly perishable, which is a serious post-harvest problem for traders. Tulsi leaves have been reported to show strong antifungal activities against the Aspergillus species [15]. *Ocimum kilimandscharicum* and most of the other species of Tulsi due to abundant presence of flavanoids have great potential to be exploited as antioxidant that can lower down the respiration rate and prevent the oxidation of its surrounding cells by limiting down the oxygen availability [16].

## 2. Materials and Methods

In this section, we discuss the different materials used in the process of coating. Also, we further put forward the methodology employed in the process of coating the tomatoes.

### 2.1 Materials

Tomatoes of equal maturity and ripening stage were purchased from a local market of Silchar, Cachar (Assam). The tomatoes were carefully selected to be uniform in appearance (weight, shape and colour) and free from any defect. They were then disinfected with sodium hypochlorite (0.01% v/v), washed and allowed to dry and made ready for coating.

Starch (medium molecular weight), glycerol (87%) and other chemicals and reagents are of analytical grade (A.R.) and all are from Hi-media and Merck, Germany make. All glasswares used are sterilisable and borosilicate.

### 2.2 Methodology

#### 2.2.1 Preparation of Coating Solution and Coating of Tomato

The coating solutions were prepared by completely gelatinizing 1, 1.25, 1.5, 1.75 and 2 g/100 mL starch slurry in water at 95ºC for 30 min on a heating plate while stirring with a magnetic stirrer, followed by addition of glycerol (0.4, 0.5 and 0.6 mL) as plasticizer and further heating and mixing for 10 min for cross-linking to occur. Thus 15 coating solutions were prepared. The pH of the solutions was adjusted to pH 5.6 with 0.1 M sodium hydroxide. Tomatoes were dipped into the prepared coating emulsions for 1 min and then drained. Uncoated tomatoes as control samples were immersed in a 0.5% glacial acetic acid solution at pH 5.6 for the same duration of time. The treated and control tomato samples were dried in ambient conditions (26±2°C and 50-70% relative humidity) for 2 hours. After setting a thin layer of edible coating on the surface of treated samples, control and coated tomatoes samples were stored at ambient conditions in the laboratory for experimental study.

#### 2.2.2 Physico-chemical Analysis of Uncoated Tomato

**A. Total Soluble Solid (TSS)**

The TSS content of the fruit was determined by using refractrometer (Atago Co., Tokyo, Japan). Homogenous sample was prepared by blending the tomato flesh in blender. The sample was thoroughly mixed and a few drops were taken on prism of refractrometer and direct reading was taken by reading the scale [17].

**B. Titratable Acidity (TA)**

Titratable acidity was estimated by method described by [18]. Organic acids are weak acids. When titrated with a strong base, the equivalence point is not neutral (pH 7) but slightly basic, because the salt of a weak acid (Formed during the titration) is slightly basic. Total acidity can be determined by the [17], which uses 0.1N NaOH.

**C. pH Value**

pH of the ground tomatoes was determined with the help of a pH meter (Sartorius, PB-11, Germany).

**D. Moisture Content**

Moisture content of the sample was determined by keeping the samples in a thermostatically controlled electric oven at 105±1°C for 16 h until the constant weight is achieved (AOAC, 1992).

**E. Weight Loss**

For determining weight loss, coated tomatoes were weighed individually using an electronic balance (Sartorius CP2245, Switzerland). Losses in weights were calculated and the results were expressed as percentage weight loss.

**F. Percentage Solubility**

Percentage Solubility of the coated film was determined by soaking and gently stirring about 1 g of coated film strip in 10 mL of water for 0.5 h. After the removal of water by centrifugation, the residue of the film strips was recovered and dried in an oven. Solubility was calculated as the percent weight loss of the film strips from the soaking.

#### 2.2.3 Optimization of Coating Formulation

The best combination of percent starch and glycerol content in the coating solution was determined for coating of tomatoes considering weight loss, percent solubility, TA and TSS on the 10$^{th}$ day after coating. The best combination of percent starch and glycerol content in the coating solution is the one that results in minimum weight loss, minimum percent solubility, minimum TA and minimum TSS on the 10$^{th}$ day after coating. This is a multi-objective optimization problem. The objectives conflict with each other in the sense that different treatments resulted in minimum weight loss, minimum percent solubility, minimum TA and minimum TSS on the 10$^{th}$ day after coating. No one treatment had all these values minimum. Hence, it is impossible to obtain a single set of values of the design variables (percent starch and glycerol content) that corresponds to the best of all the objectives.

In this situation, an optimal solution represents a certain level of trade-offs among all of the objectives, and a set of trade-off solutions exists for a multi-objective optimization problem. The set containing all the trade-off solutions is called the Pareto front [19], and the solutions on the Pareto front are also called non-dominated solutions. Therefore, solving a multi-objective optimization problem refers to obtaining a subset of the solutions on the Pareto front instead of getting each objective's optimum.

**A. Pareto Dominance**

In a minimization problem of *m* objectives, solution *x* dominates solution *y* is defined by

$$x \prec y \mid \forall_i : f_i(x) \le f_i(y) \text{ and } \exists_j : f_j(x) < f_j(y)$$

where $f_i$ ($x$) and $f_i$ ($y$) are the values of the $i$-th objective corresponding to $x$ and $y$, respectively. The meaning of above definition is that all the objectives corresponding to solution $x$ are smaller than or equal to those corresponding to $y$, and there exists at least one objective whose value for $x$ is smaller than that for $y$. If $x$ does not dominate $y$ and vice versa, the two are said to be non-dominated. A set of non-dominated solutions is called a non-dominated front. For solutions of a given population, there may be multiple non-dominated fronts [20]. However, solutions in the first front have higher preference (fitness) in the selection process than those in other fronts, because the latter is dominated by the former.

In the present study, all the four objectives must be minimized. The pseudocode of non-dominated sorting is illustrated in Fig. 1. In Fig. 1, $P$ is the population containing 15 sets of combination of percent starch and glycerol content in the coating solution along with their values of weight loss, percent solubility, TA and TSS on the 10th day after coating. The individual solution containing one set of combination of percent starch and glycerol content along with its weight loss, percent solubility, TA and TSS values is represented by $p$ and $q$. $S_p$ is the set that contains all the individual solutions that is being dominated by $p$. $N_p$ is the number of individual solutions that dominate $p$. $F_1$ refers to the first non-dominated front.

```
Non-dominated sorting (P)
F1 = Φ
For each p ∈ P
Sp = Φ
Np = 0
For each q ∈ P
If (p ≺ q) Then Sp = Sp ∪ {q}
Else if (q ≺ p) Then Np = Np + 1
If Np = 0 Then F1 = F1 ∪ {p}
```

**Fig 1:** Pseudo code for non-dominated sorting

Steps involved in non-dominated sorting are given below:

(i) One individual solution ($p$) from the population ($P$) of solutions was taken up.

(ii) This solution was compared with other solutions ($q$) in $P$. A set ($S_p$) of solutions that $p$ dominated was generated as per the definition of Pareto dominance. The number of solutions ($N_p$) that dominated $p$ was determined.

(iii) Steps (i) and (ii) were repeated for each individual solution in the population.

(iv) The first non-dominated front ($F_1$) was developed with individual solutions that has $N_p$=0. The front $F_1$ was stored.

Any solution in the front $F_1$ containing the combination of percent starch and glycerol content in the coating solution could be selected as the best solution. However, the solution that dominates the maximum number of solutions is generally taken as the best among the solutions in the front.

### 2.2.4 Effect of Optimized Coating Formulation on Storage Quality of Tomato

With the optimized coating formulation identified, tomatoes were coated with the optimized formulation added with extract of Tulsi at 1%, 2% and 3% by volume. Both coated and uncoated (control) tomatoes were prepared as mentioned earlier and stored in ambient temperature without any packaging. Both coated and uncoated tomatoes were analyzed for weight loss, total soluble solid (TSS), titratable acidity (TA), pH and moisture content by following the same method as mention above in every five days interval upto 20 days to assess the effects of coating on changes in physic-chemical and nutritional quality of tomato during storage.

## 3. Results and Discussions

### 3.1 Physico-chemical Properties of Uncoated Tomato

The average values of various physico-chemical properties of selected tomatoes for coating are presented Table 1.

**Table 1**: Average Physico-chemical properties of selected tomatoes before coating.

| Sl. No. | Physico-chemical properties | Values |
|---|---|---|
| 1. | Moisture content, % d.b. | 86.90 |
| 2. | TSS, % | 3.90 |
| 3. | TA, % | 0.28 |
| 4. | pH | 4.06 |
| 5. | Fat content, % | 0.18 |
| 6. | Protein content | 0.23 |

### 3.2 Effect of Percent Starch and Glycerol Content in the Coating Solution on Physico-chemical Properties of Coated Tomatoes

The variations in moisture loss of tomatoes, percent solubility of the coated film, TA and TSS of tomatoes after 10 days of coating with coating solution containing various percentage of starch and glycerol content are shown in Fig. 2 to Fig. 5.

#### 3.2.1 Effect on Moisture Loss

Irrespective of percent starch in the coating solution, the moisture loss was highest when coated with the coating solution containing 0.4 mL glycerol and it was followed by solution containing 0.6 mL glycerol and 0.5 mL glycerol, respectively. Further, with increase in percent starch in the solution, moisture loss decreased initially and later increased with increase in percent starch in the solution. Figure 2 indicates that, coating solution containing 1.25 to 1.75% starch along with 0.5 mL glycerol is the best for coating tomatoes as it reduced the moisture loss from them in 10 days of coating. However, moisture loss was less than that observed for the uncoated tomatoes (9.8 %). This indicates that the coating of tomatoes reduced the moisture loss.

#### 3.2.2 Effect on Solubility of Coated Film

The percent solubility of the coated film increased with increase in percent starch in the coating solution. Further, the solubility of the coated film also increased with increase in glycerol content in the coating solution. Figure 3 reveals that the coating solution with 1% starch and 0.6 mL glycerol is highly resistant to solubility and maintains the film on the surface of tomatoes resulting in increase of shelf life.

#### 3.2.3 Effect on TA of Tomatoes

In the entire range of values of the percent starch in the coating solution, glycerol content of 0.6 mL resulted in the lower TA of coated tomatoes in 10 days of coating. The TA of coated tomatoes decreased with increase in percent starch in the coating solution and increased with decrease in glycerol content. Figure 4 indicates that the coating solution with 2%

starch added with 0.5 to 0.6 mL glycerol is the best for reducing TA of coated tomatoes. The TA of the uncoated tomatoes had increased to 0.46% (from 0.28% on first day) after 10 days and it was much higher than the coated tomatoes. This indicates that the coating helps in decreasing the rate of increase of TA of tomatoes during storage.

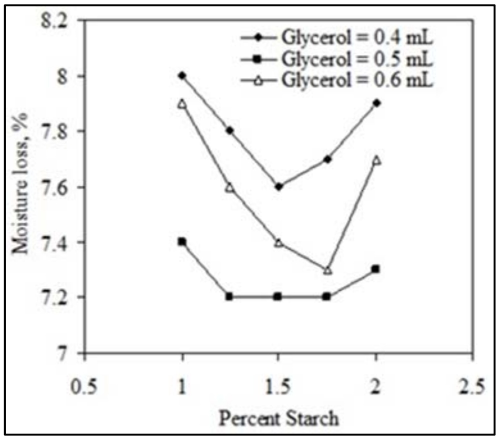


**Fig 2:** Variation in moisture loss of tomatoes after 10 days of coating with coating solution containing various percentage of starch and glycerol content.

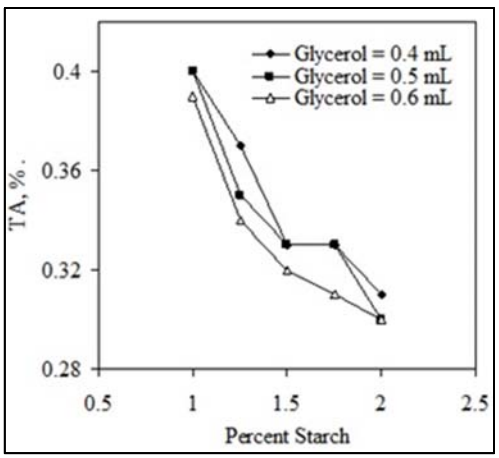


**Fig 3**: Variation in TA of tomatoes after 10 days of coating with coating solution containing various percentage of starch and glycerol content.

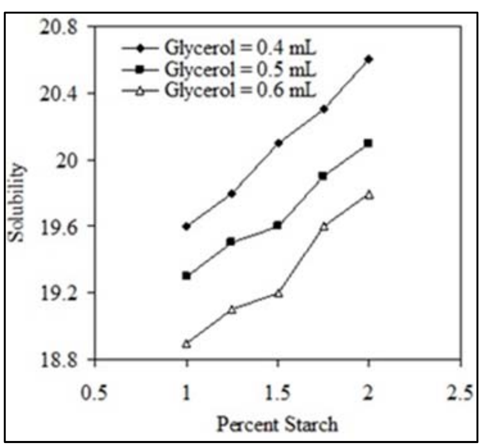


**Fig. 4:** Variation in solubility of coated film after 10 days of coating with coating solution containing various percentage of starch and glycerol content

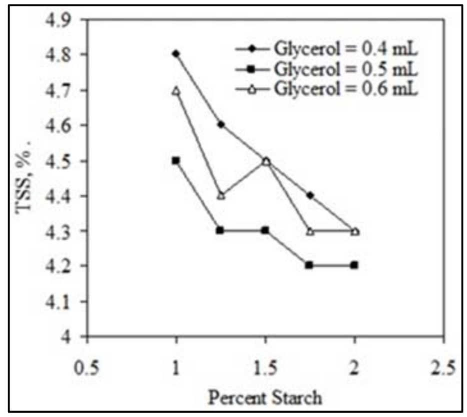


**Fig 5:** Variation in TSS of tomatoes after 10 days of coating with coating solution containing various percentage of starch and glycerol content.

### 3.2.4 Effect on TSS

The TSS of the coated tomatoes was lowest when the coating solution had 0.5 mL glycerol in it. The TSS of tomatoes decreased with increase in percent starch in the coating solution. It can be observed from Fig. 5 that, when tomatoes were coated with the solution containing 1.75 to 2 % starch and 0.5 mL glycerol, the rise in TSS during storage was lowest compared to when coated with other solutions. The uncoated tomatoes had the rise in TSS from 3.9 % to 5.4% in 10 days. The coating of starch on tomatoes has resulted in decrease in the rise of TSS during storage.

The results of the effect of starch based coating on tomatoes indicate that the coating helps in reducing the increase of moisture loss, TA and TSS of tomatoes as compared to uncoated tomatoes during storage. In addition, the coating also should have low solubility with time so that, the shelf life of tomatoes could be increased. However, it was observed that no one combination of treatment (starch and glycerol content in the solution) has resulted in the minimum increase of all these 4 properties at a time. If one coating solution is found best from certain considerations, the other seems to be best from certain other considerations. Hence, there exist a set of combination of coating solution, from which one has to be selected for meeting the requirement of the major considerations. The non-dominated sorting technique was therefore followed to identify the best coating solution.

### 3.3 Identification of Optimum Combination of Percent Starch and Glycerol Content in the Coating Solution

The non-dominated set of combination of percent starch and glycerol content in the coating solution along with values of weight loss, percent solubility, TA and TSS on the 10th day after coating are presented in Table 2. The first non-dominated front had 9 combinations of treatments.

Among the 9 coating solutions listed in Table 2, the solution containing 1.5% starch and 0.5 mL glycerol was selected as the values of the objectives from the minimum values desired were lowest for it (0.19). Therefore, the coating solution with 1.5% starch and 0.5 mL glycerol was used for further experiments. The extract of Tulsi was added to this coating solution to study the effect of coating on tomatoes.

### 3.4 Effect of Optimized Coating Formulation Added with Tulsi Extract on Physico-chemical Properties of Tomatoes During Storage

The effect of coating tomatoes using optimized coating formulation (1.5 % starch and 0.5 mL glycerol) added with 1%, 2% and 3% Tulsi extract on various physico-chemical properties are presented in Fig. 6 to 10.

### 3.4.1 Effect on Weight Loss
The weight loss increased with increase in storage period for both coated and uncoated tomatoes (Fig. 6). The increase in weight loss was substantially higher for the uncoated tomatoes. The addition of higher percentage of Tulsi extract reduced the rate of increase in weight loss over the period of storage as compared to the formulation without Tulsi extract. This indicates that the addition of Tulsi extract to the starch based coating improves the shelf life of tomatoes.

### 3.4.2 Effect on Moisture Content
The moisture content of tomatoes decreased with storage period (Fig. 7). However, the rate of decrease of moisture content of tomatoes was higher for the uncoated tomatoes followed by that coated with only starch based coating and coating with Tulsi extracts. The higher percentage addition of Tusli extract to the optimized starch based coating decreased the rate of loss of moisture from the tomatoes.

**Table 2:** Non-dominated set of combination of percent starch and glycerol content in the coating solutions

| % starch | Glycerol content | Moisture loss, % | Percent solubility of coated film | TA, % | TSS, % | Distance from the desired location |
|---|---|---|---|---|---|---|
| 1.00 | 0.6 | 7.9 | 18.9 | 0.39 | 4.7 | Infinity |
| 1.25 | 0.5 | 7.2 | 19.5 | 0.35 | 4.3 | Infinity |
| 1.25 | 0.6 | 7.6 | 19.1 | 0.34 | 4.4 | 1.30 |
| 1.50 | 0.5 | 7.2 | 19.6 | 0.33 | 4.3 | 0.19 |
| 1.50 | 0.6 | 7.4 | 19.2 | 0.32 | 4.5 | 1.58 |
| 1.75 | 0.5 | 7.2 | 19.9 | 0.33 | 4.2 | Infinity |
| 1.75 | 0.6 | 7.3 | 19.6 | 0.31 | 4.3 | 0.53 |
| 2.00 | 0.5 | 7.3 | 20.1 | 0.3 | 4.2 | Infinity |
| 2.00 | 0.6 | 7.7 | 19.8 | 0.3 | 4.3 | 0.99 |

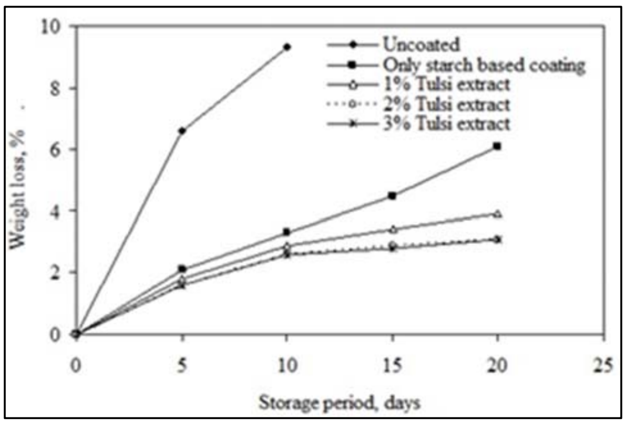


**Fig 6:** Variation in weight loss with storage period for tomatoes coated using only optimized starch based coating solution, optimum formulation added with 1%, 2% and 3% Tulsi extract and without coating.

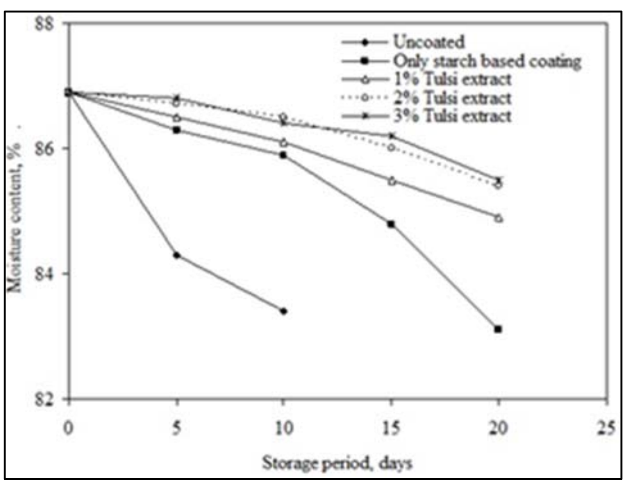


**Fig 7:** Variation in moisture content with storage period for tomatoes coated using only optimized starch based coating solution, optimum formulation added with 1%, 2% and 3% Tulsi extract and without coating.

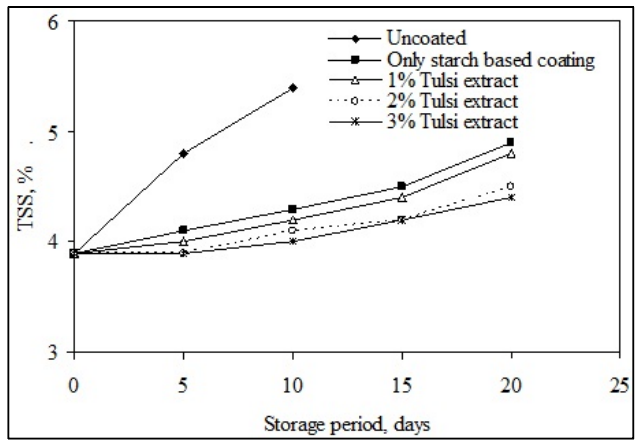


**Fig 8:** Variation in TSS with storage period for tomatoes coated using only optimized starch based coating solution, optimum formulation added with 1%, 2% and 3% Tulsi extract and without coating.

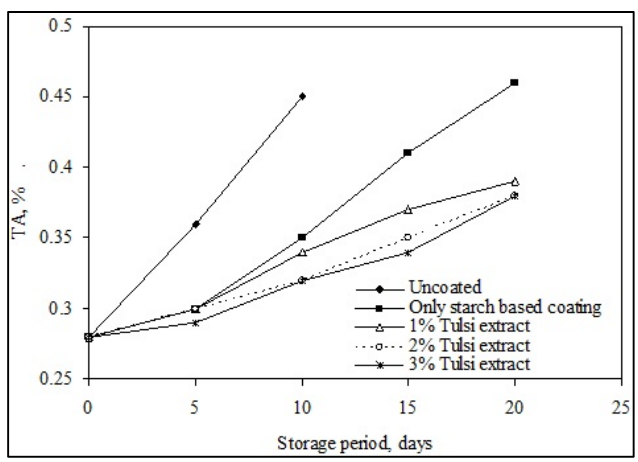


**Fig 9:** Variation in TA with storage period for tomatoes coated using only optimized starch based coating solution, optimum formulation added with 1%, 2% and 3% Tulsi extract and without coating.

### 3.4.3 Effect on TSS
Figure 8 indicates that the TSS of tomatoes increased with storage period and the rate of increase was higher for uncoated tomatoes than that of coated ones. The addition of Tulsi extract to optimized starch based coating solution resulted in reduction of rate of increase of TSS with storage period.

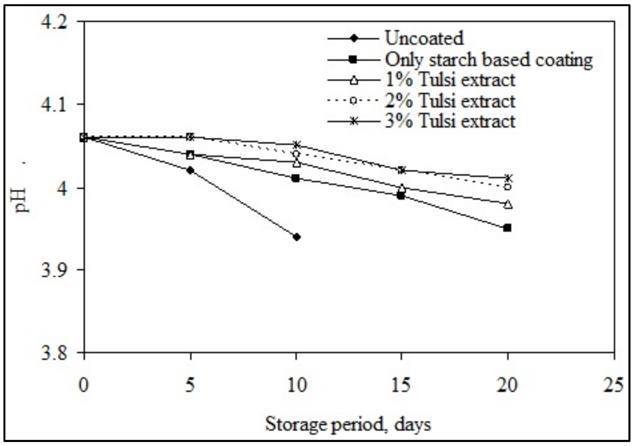


**Fig 10:** Variation in pH with storage period for tomatoes coated using only optimized starch based coating solution, optimum formulation added with 1%, 2% and 3% Tulsi extract and without coating.

### 3.4.4 Effect on TA
The trend of variation of TA of tomatoes was same as that of TSS, i.e., TA of tomatoes increased with increase in storage period and the rate of rise of TA was higher for uncoated tomatoes (Fig. 9). The starch based coating and addition of Tulsi extract to starch based coating reduced the rate of increase of TA with storage period.

### 3.4.5 Effect on pH
As TA increases with storage period, the pH decreases (Fig. 10). The trend of variation on pH was reverse to that observed for the variation in TA. The starch based coating and the addition of higher percentage of Tulsi extract to starch based coating helps in reducing the rate of decrease of pH over the storage period.

The results of the investigation reveal that there is a definite improvement in the storage quality of the tomatoes with the addition of Tulsi extract to starch based edible coating. The tomatoes without any coating got rotten within 10 days of storage under ambient atmospheric conditions whereas those coated with only starch based edible coating had the better shelf life. The coating of tomatoes with addition of Tulsi extract to starch based coating solution increased the shelf life as indicated by the high quality of the fruit during various stages of storage period.

Therefore, in order to increase the shelf life of tomatoes coating using the starch based edible coating of 1.5% starch and 0.5 mL glycerol added with Tulsi extract upto 3% may be recommended.

### 4. Conclusions
The following conclusions were drawn from the work:

1. The coating of tomatoes by dipping them in starch based coating solution was found to increase the storage attributes and hence, has the potential to increase the shelf life of tomatoes.
2. The coating solution with 1.5% starch by volume and 0.5 mL glycerol (plasticizer) was found to be the best formulation for coating tomatoes.
3. The addition of Tulsi extract to optimized formulation of coating solution was found to increase the storage attributes by acting as anti-microbial and anti-oxidant agent. Addition of Tulsi extract to optimized starch based coating solution has the potential to enhance the shelf-life of tomatoes.
4. The addition of Tulsi extract to optimized formulation of starch based coating solution to the extent of 3% was found to be the most suitable for coating of tomatoes.

### References
1. Bourtoom T. Edible films and coatings: characteristics and properties. International Food Research Journal 2008; 15(3):237-248.
2. Li P, Barth MM. Impact of edible coatings on nutritional and physiological changes in lightly processed carrots. Postharvest Biology and Technology. 1998; 14:51-60.
3. Park HJ, Chinnan MS, Shewfelt RL. Edible coating effects on storage life and quality of tomatoes. Journal of Food Science, 1994; 59(3):568-570.
4. Guilbert S, Gontard N, Gorris LGM. Prolongation of the shelf- life of perishable food products using biodegradable films and coatings. Lebensmittel-Wissenschaft und-Technologie, 1996; 29(1):10-17.
5. Mahmoud R, Savello PA. Mechanical properties of and water vapor transferability through whey protein films. Journal of Dairy Science, 1992; 75:942-946.
6. Cipolatti EP, Kupski L, Rocha MD, Oliveira MDS, Buffon JG, Furlong EB. Application of protein-phenolic based coating on tomatoes (Lycopersicum esculentum). Food Science and Technology (Campinas), 2012; 32(3):594-598.
7. Das DK, Dutta H, Mahanta CL. Development of a rice starch-based coating with antioxidant and microbe-barrier properties and study of its effect on tomatoes stored at room temperature. LWT-Food Science and Technology, 2013; 50(1):272-278.
8. Lin D, Zhao Y. Innovations in the development and application of edible coatings for fresh and minimally processed fruits and vegetables. Comprehensive Reviews in Food Science and Food Safety, 2007; 6(3):60-75.
9. Dhanapal A, Sasikala P, Rajamani L, Kavitha V, Yazhini G, Banu MS. Edible films from Polysaccharides. Food Science and Quality Management, 2012, 3.
10. Raghav PK, Agarwal N, Saini M. Edible Coating Of Fruits and vegetables: A Review. International Journal of Scientific Research and Modern Education, 2016; 1(1).
11. Chillo S, Flores S, Mastromatteo M, Conte A, Gerschenson L, Nobile MA. Influence of glycerol and chitosan on tapioca starch-based edible film properties. Journal of Food Engineering, 2008; 88(2):159-168
12. Rivero A, García MA, Pinotti A. Composite and bi-layer films based on gelatin and chitosan. Journal of Food Engineering, 2009; 90(4):531-539.
13. Causse M, Buret M, Robini K, Verschave P. Inheritance of nutritional and sensory quality traits in fresh market tomato and relation to consumer preferences. Journal of Food Science, 2003; 68:2342-2350.
14. Ellinger S, Ellinger J, Stehle P. Tomatoes, tomato products and lycopene in the prevention and treatment of prostate cancer: do we have the evidence from intervention studies? Current Opinion in Clinical Nutrition & Metabolic Care, 2006; 9(6):722-727.
15. Joglekar GV, Chaudhary NY, Aiman R. Effect of indigenous plant extracts on glucose-absorption in mice.

Indian Journal of Physiology and Pharmacology, 1959; 3:76.
16. Singh SK, Ankur A, Verma SK, Siddiqui SA, Mathur A, Saklani S. Analysis of phytochemical and antioxidant potential of Ocimum kilimandscharicumlinn. International journal of current pharmaceutical research 2011; 3:40-46.
17. Official Methods of Analysis of the AOAC. The Association of Official Analytical Chemists. 13th ed., Edited by Willliam Horwitz, Arlington, VA: 1038, 1980.
18. Ranganna. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2, Tata McGraw Hill, New Delhi, 2013, 9-10.
19. Coello CAC. A comprehensive survey of evolutionary-based multi-objective optimization techniques. Knowledge and Information systems, 1999; 1(3):129-156.
20. Deb K, Pratap A, Agarwal S, Meyarivan TA. A fast and elitist multi-objective genetic algorithm: NSGA-II. IEEE transactions on evolutionary computation, 2002; 6(2):182-197.