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Development of edible coating for fresh fig fruit (*Ficus carica* L.)

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Abstract
Edible coating acts as a barrier to environmental factors and thus increases the shelf life of food by protecting them from undesirable changes like color, taste flavor and auto-oxidation. To keep this view in mind, edible coating material has been developed using a combination of chitosan (shrimp shell) and guar gum (Guar pods). A perishable food with health benefits often ends up being wasted due to their susceptibility towards microbial spoilage causing organism. Developed coating material was applied on fig as they are highly perishable in nature and was stored at 4±1˚C. Without any treating the shelf life of fig is 2 days after that it becomes unhealthy/unfit for consumption due to the yeast and mold growth on the surface of produce.

Keywords: edible coating, guar gum, chitosan, fig, shelf life, antimicrobial properties

Introduction

Edible coating is an ideal technique used by numerous sectors of different industries which are aimed at fulfilling different marketing needs by providing safe, healthy and high quality foods. It exhibit many potential benefits like reduction in weight, firmness, respiration rate, chlorophyll, metabolism and oxidation (Gennadios *et al*., 1999) [4]. Instead of packaging material, utilization of coating materials will reduce environmental problem (Han, 2014) [11] also it can be reduce the complexity and thus it improve the recyclability of packaging material. Edible coatings have been designed by utilizing a variety of bio-compounds which enrobed (i.e., coating or wrapping) various food to extend shelf life of the product that may be eaten together with food with or without further removal is considered an edible film or coating. A thin layer of wax adheres tightly to the surface which reduces respiration rate and sealing the moisture inside the produce, thereby helping to maintain the crispiness, firmness, and juiciness of the fruits and vegetables (Ladaniya *et al*., 2008) [13].

Galactomannan (Gaur gum), is derived from guar kernels which belong to *Leguminosae* family. It is soluble in water, where as it is insoluble in hydrocarbons, fats, oils, esters and ketones in general. Guar gum has the unique ability to produce highly viscous and pseudo-plastic aqueous solution even at lower concentration, this happens due to higher molecular weight of guar gum and also due to the presence of some extended repeating units formed due to hydrogen. This special feature of guar gum makes it easy to soluble and form gel. It is stable at wide range of pH (1.0-10.5) as it exhibits non-ionic and uncharged behavior. Due to the guar gum's capability to imbibe large quantities of water resulting in highly viscous dispersions makes it the most applicable polymer in various industries. Guar gum is been used in processed cheese, bakery industry, dairy products, processed meats, salads and tomatoes, sauces etc. (sheikh *et al*., 2014) [15].

Chitosan is a potentially active bio-based coating material used for storage and nutritional enhancement of fruits and vegetables (Duran *et al*., 2016) [8]. Chitosan coatings applied to papaya fruits, it helped to prolong the shelf-life of fruit and prevented from microbial spoilage. When chitosan coating materials were incorporated with antimicrobial agents and applied on fruits and vegetables it acts as a barrier which restricted the exchange of gases and thus prolonged the shelf-life of these products. Several studies revealed that spraying of chitosan on tomatoes, capsicum and brinjal delayed the signs of aging, formation of wrinkles, skin texture softening, and reduction in weight and also some changes in color were also minimized (Xing *et al*., 2016) [23].

Materials and Methods

1. Raw and packing material

As fig is seasonal fruit it was been purchased from local market of Pune. To store the final product, packaging materials were used like polyethylene zip lock bags were purchased from local market of Pune.

2. Optimization of coating material

Table 1: Composition of guar gum and chitosan.

	Guar gum			
	0.25%	**0.50%**	**0.75%**	**1%**
Chitosan	0.25%	0.25%	0.25%	0.25%
Glycerol	0.3ml	0.3ml	0.3ml	0.3ml
Acetic Acid	1%	1%	1%	1%
Distilled Water	100ml	100ml	100ml	100ml
Heating Temperature	30°C	30°C	30°C	30°C
Stirring Time	12hrs	12hrs	12hrs	12hrs

Table 2: Variation in composition of chitosan

	Chitosan			
	0.2%	**0.3%**	**0.4%**	**0.5%**
Guar gum	1%	1%	1%	1%
Glycerol	0.3ml	0.3ml	0.3ml	0.3ml
Acetic Acid	1%	1%	1%	1%
Distilled Water	100ml	100ml	100ml	100ml
Heating Temperature	30°C	30°C	30°C	30°C
Stirring Time	12hrs	12hrs	12hrs	12hrs

3. Guar gum treatment

Different concentrations of gaur gum were used and stirred at 800 rpm for 30 min and used for treatments (Chacon *et al*., 2017) [5].

4. Chitosan treatment

After optimizing the concentration of guar gum, chitosan concentration were also optimized by varying its ration and rpm provided for overnight at room temperature. (Souza *et al.,* 2018) [20]**.**

5. Method of coating

Method of dipping refers to the immersion of a substrate into a coating material and allows keeping it for drain followed by drying at room temperature. The dipping of fruits for 5 minutes, allow for draining for 1 minute, drying at 40-50°C and stored at refrigerated temperature for 4±1°C.

6. Sensory evaluation

Sensory evaluation of product was done by semi-trained panelist consist of 10 members using 'Nine Point Hedonic Scale'. Sensory score sheet was prepared and quality parameters like color, appearance, flavor, taste, texture and overall acceptability (Ranganna, 2015) [17] of product were evaluated.

Mechanical characteristics

1. Penetration

The firmness of fig fruits were measured by using penetrations method with manual Penetrometer.

Chemical analysis

1. Determination of TSS

Total soluble solids of the fig sample was measured with the help of digital refractometer (Atago RX-34 1000). Percent soluble solids (Brix) noted as described in (AOAC (2005)) [3].

2. Titratable acidity

The titrable acidity estimated by (Ranganna, 2015) [17].

Biochemical analysis

1. Estimation of total phenolic content

The estimation of total phenolic content was carried by using method of Thimmaiah, 2016 [21]. Total phenol content was expressed in mg of GAE/100g.

2. Determination of antioxidant activity

Determination of antioxidant activity conducted by using DDPH method given by Kumar, 2018 [12].

Microbial analysis of samples

Determination of yeast and mold count: To check the yeast and mould count standard pour plate technique were used. And following yeast and mould count was counted by using formula given by Aneja, 2003 [1].

The material is developed by using chitosan, guar gum, acetic acid, glycerol and distilled water. Several combinations of guar gum and chitosan were tried to optimize coating material. The prepared coating material applied on fig (Ficuscarica L.) and stored it at refrigeration temperature for optimization of ratio of chitosan and guar gum. Chemical, bio-chemical and microbial analyses were carried out for the optimization of ratio.

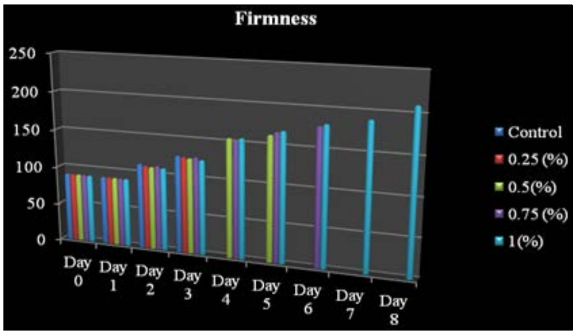
Results and Discussion

Present investigation was carried out to develop an edible coating material to avoid surface drying and protect it from microbial spoilage leads to extension of shelf life by maintaining all quality parameters. For the development of coating material, parameters like concentration of gaur gum and chitosan, storage temperature were varied to obtained best combination of this. Coated product were packed and stored in plastic containers called as punnets during storage study.

1. Optimization of guar gum concentration

The study was carried out with four different concentrations of gaur gum (0.25, 0.50, 0.75, and 1.0 %) whereas the concentration of chitosan kept constant at 0.25 %. The study was further proceeded to check the potential of guar gum and chitosan (combine) for preservation of fig fruits. The results were compared with control samples and compiled in tables given below. The coating composition consists of 0.25% chitosan, 0.3 ml glycerol, 1 ml acetic acid and 100ml water. Processing was done at 30°C temperature, 12hrs stirring time and the storage temperature was 4±2°C.

2. Effect of gaur gum on firmness of fig fruits

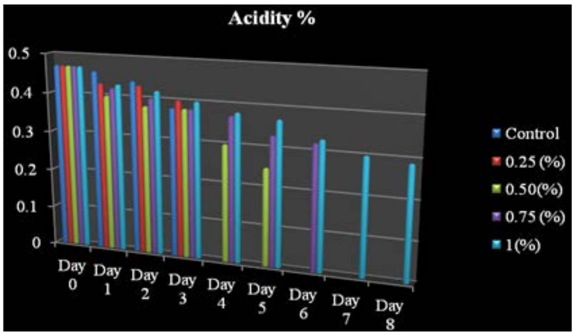


[Data are expressed as mean ± standard deviation of triplicate experiments (n=3)].

Graph 1: Analysis of firmness of fig fruits

It can be observed from graph 3.1 that the penetration value of fruits increased with increase in storage time. On 0th day of storage, the values of fruit firmness were 90 ± 2 same for all the samples whereas the firmness of fruit was changed over a period of time. Comparative study were carried out and observed that coated sample extended the shelf life of fruit when compared with a control. Control sample can be last up to 3 days whereas coated sample (1% guar gum) extended storage period up to 7 days, can be seen from graph. Statistical analysis were carried out to check the difference between the treatments and the significant difference were observed between 0.75% and 1% gaur gum treated sample and therefore 1% concentration of gaur gum were optimized for further studies.

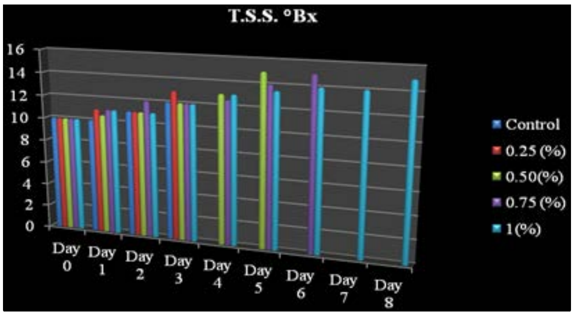
Effect of edible coating on acidity of fig fruit



[Data are expressed as mean± standard deviation of triplicate experiments (n=3)].

Graph 2: Analysis of titratable acidity of fig fruits

Effect of guar gum on TSS of fig fruits

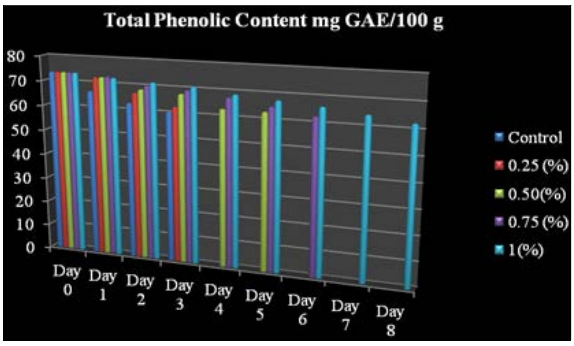


[Data are expressed as mean ± standard deviation of triplicate experiments (n=3)].

Graph 3: Analysis TSS of fig fruits (°Bx)

The positive correlation between TSS and acidity were observed and can be very well seen from graph 3.2 and 3.3. This can be understood from the ripening phenomenon of fruits, where the acidity of fruit decreases with increase in TSS or sweetness of fruit. Initial value of acidity (0.47 ± 0.01 %) and TSS (10 ± 1.00 °Bx) was same for all the samples but has changed with respect to time and coating concentration. Remarkable changes observed in coated samples where the respiration rate (judge on the basis of ripening of fruit) of fruits reduced with increase in concentration of coating material from 3 days to 8 days of storage time compared with control sample. Later the TSS of samples evaluated and found that it was increased with storage time from 10 ± 1°Bx to 12 ± 1°Bx on the 3rd day of storage for all the samples. Whereas the 15 ± 1°Bx obtained for 1 % of gaur gum concentration on the 8th day of storage. The reason behind this may be coating delays the process of ripening by reducing the rate of respiration and it avoid drastic reduction in the levels of soluble solids of coated sample which implies changes in TSS in coated fruit, was observed slower than control (Saha *et. al.* 2016) [18]. T-TEST ($P<0.05$) were carried out between 0.75% and 1% concentration of guar gum coating, the obtained value were 0.71% for acidity and 0.72°Bx for T.S.S., indicates that there is a significant difference between two treatments and therefore 1% concentration of gaur gum were optimized for further studies.

Effect of guar gum on total phenolic content of fig fruits

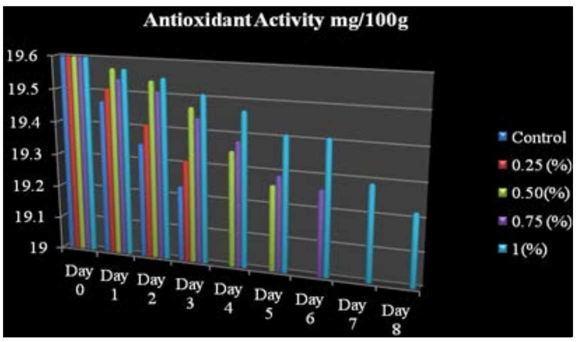


[Data are expressed as mean± standard deviation of triplicate experiments (n=3)].

Graph 4: Analysis of total phenolic content of fig fruits (mg GAE/100 g)

Along with proximate analysis fruit samples were analyzed for its chemical constituents to check the effect of coating material on the sample. Positive correlation between TPC and antioxidant activity were observed (graph 3.4) and was decreased over a period of time. On the 0th day of storage the TPC value of sample was 73.58 mg GAE/100 g and decreased up to 60.44 mg GAE/100 g after 3 days for control, whereas in treated sample the rate of reduction is same in all treated samples only the shelf life of treated sample were varied with different concentration of coating material and 1 % concentration of gaur gum extended the shelf life of fruit from 3 days to 8 days. Similar reports were observed by Gosh *et. al.* 2014 [9], he revealed that the total phenolic content was declined in fruits due to the higher rate of respiration. It might also be due to senescence and breakdown of cell structure during storage of fruits. Similar trend were observed with antioxidant activity as well. Obtained results indicated positive correlation between TPC and antioxidant activity. T-TEST ($P<0.05$) were carried out between 0.75% and 1% concentration of guar gum coating, the obtained value was 0.95 mg GAE/100 g, indicates that there is a significant difference between two treatments and therefore 1% concentration of gaur gum were optimized for further studies.

Effect of guar gum on antioxidant activity of fig fruits

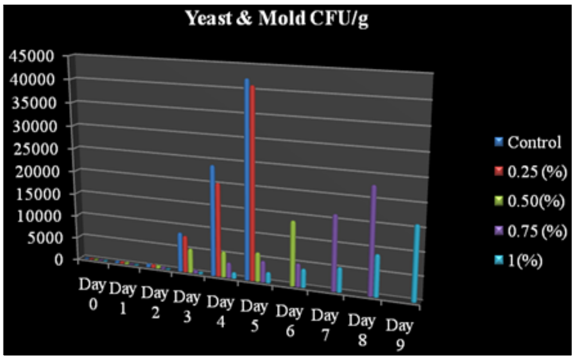


[Data are expressed as mean ± standard deviation of triplicate experiments (n=3)].

Graph 5: Analysis of antioxidant activity of fig fruits (mg/100g)

There are several reports available which states that phenolic content and antioxidant activity are relative terminology. As the content of phenols decreases the associated effect of antioxidant activity is also decreases and vice-a-versa. The increase in phenol content is related with enhancement of antioxidant capacity (Gosh *et. al.* 2014) [9]. From graph 3.5 we can observe that on 0th day of storage the antioxidant activity was 19.60 ± 0.19 mg/100g. Decrement in antioxidant activity was observed in coated and uncoated samples. It is reported in graph 3.5 that the rate of degradation was more for uncoated fig as compared to coated fig sample. From graph 3.5 we can observed that the 1% guar gum coated samples showed the best results among all the samples and was suitable for fig fruits to increase its shelf life. Obtained results are in coordination with Ptekova *et.,al.* 2019 [16], observed 21±1.2 mg/100g antioxidant content in fresh fig fruits. T-TEST (P<0.05) were carried out between 0.75% and 1% concentration of guar gum coating, the obtained value is 0.98 mg/100g, the value indicates significant difference between two treatments and therefore 1% concentration of gaur gum were optimized for further studies.

Effect of guar gum on yeast and mold count of fig fruits



[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

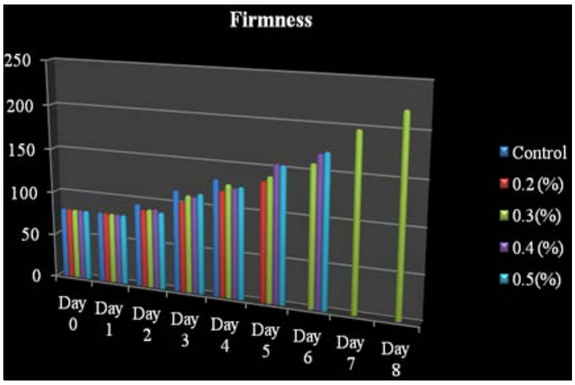
Graph 6: Analysis of yeast and mold count of fig fruits (CFU/g)

Microbial studies were carried out during storage and observed yeast and mold growth on the surface of fruits, results were indicated in graph 3.6. Obtained results indicated that the reduced microbial growth in treated samples when compared with untreated and reduction rate was increase with increase in concentration of coating material. This may be due to the coating helps to prevent damages during storage and it act as barrier for the same, so the coated sample can last for long time. At 0th day of storage the CFU count for control sample is 3.3 × 10^2 CFU/g and for treated sample the CFU count is 3 ×10^1 CFU/g, 3 ×10^1 CFU/g, 3 ×10^1 CFU/g and 3 ×10^1 CFU/g for 0.25%, 0.50%, for 0.75 % and 1% respectively. On 4th day of storage the microbial count of control sample was 2.4 ×10^4 CFU/g. This indicates that the uncoated samples shows less shelf life as compare to coated samples. This may be due to the metabolic changes which could not stop during storage as no barrier between fruit and environmental conditions. Comparison between all other coated fruits shows that the 1% has obtained the best results as it prevent the growth of yeast and mold till 8th day of storage the 8th count was 9 ×10^3 CFU/g. As per the FSSAI notification the acceptable limit of microbial growth for yeast and mold should be below 1×10^4 CFU/g. As indicated in the graph 3.6, 1% coated fruit showed less growth of microorganism and therefore 1% concentration of gaur gum was selected (graph 3.6), it may act as a preservative for the fruits.

Optimization of chitosan concentration

For this study four different concentrations of chitosan (0.2%, 0.3%, 0.4% and 0.5%) were selected whereas the concentration of guar gum was 1 % was kept constant. The study was further carried out to check the potential of combination of guar gum and chitosan for preservation of fig fruits. The results were compared with control samples and compiled in graphs given below. The coating composition consists of 1% guar gum, 0.3 ml glycerol, 1 ml acetic acid, 100ml water. Processing was one at 30°C temperature, 12hrs stirring time and the storage temperature is 4±2°C

Effect of chitosan on firmness of fig fruits

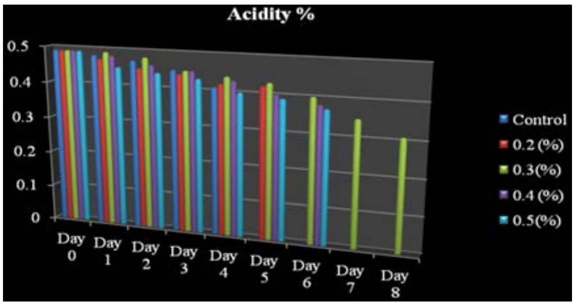


[Data are expressed as mean±standard deviation of triplicate experiments (n=3).]

Graph 7: Analysis of firmness of fig fruits

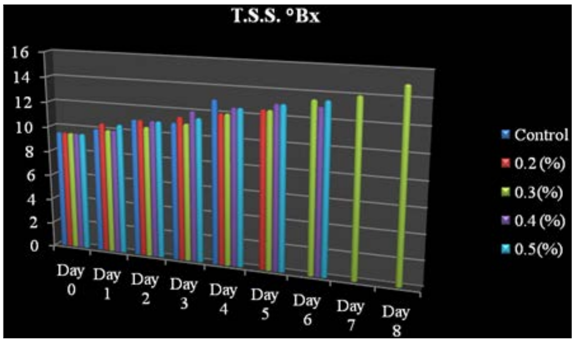
To optimize concentration of chitosan for development of coating material, four different concentrations of chitosan were selected, on the other hand the concentration of guar gum was kept constant (1% gaur gum). On the 0th day of storage, firmness (80 ± 2.5) of all the samples was same and it was decreased with increase in storage time. As indicated in graph 3.7 the firmness of coated sample was declined slowly as compared to control one. It can also be observed from the results that the concentration of chitosan plays very important role in preserving the quality of produce. Among all concentrations, 0.3% concentration of chitosan was extended its shelf life up to 8 days. Rate of change in penetration value for uncoated fruit was faster than that coated sample. It can be very well observed that the firmness value of fruit decreases due to the ripening of fruits which makes fruits softer. Ripening of fruits is associated with increase in juiciness and decrease in thickness of the epicarp. Decrease in firmness of fruits and retention of higher firmness of coated fruits was observed by Gundewadi *et al.* (2017) [10]. With this context Saha *et al.* (2016) [18] also reported that the firmness retention is an indicator of freshness of fruits and vegetables with higher turgor pressure in cells responsible for structural integrity during storage. Turgidity being directly affected by retention of moisture on the fruits skin is understandably higher in case of coated fruits. Thus, coating found effective in retaining fruit moisture which leads better quality retention during storage. The effectiveness of thick layer of coating clearly attributed to its viscosity which forms an effective coating on the surface of fig fruits. Therefore the combination of 1% guar gum and 0.3% chitosan were optimized because it slowed down the rate of ripening and can extend the shelf life of fruit up to 8 days (graph 3.7). To achieve more accurate results T-TEST were carried out for 0.3% and 0.4 % concentrations, obtained T-TEST ($P<0.05$) value is 0.93 which indicates significant difference between two treatments.

Effect of chitosan on acidity and T.S.S. of fig fruits



[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 8: Analysis of acidity of fig fruits (%)

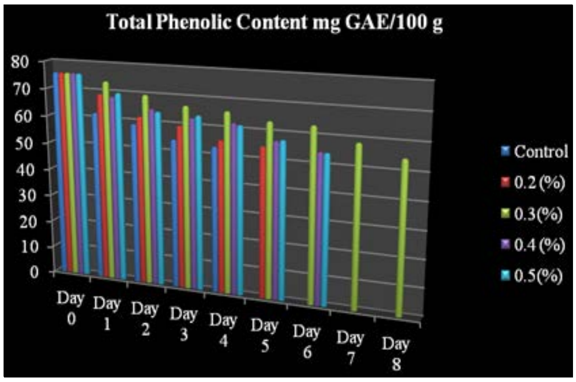


[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 9: Analysis of TSS of fig fruits (°Bx)

To check the potential of coating material, total soluble solid and acidity of samples were analyzed. With respect to storage time, the TSS was increased with decrease in acidity content this may be due to the ripening of horticultural produce. The present study shows that the total acidity of fig fruits decreases and the TSS increases. The change in the value of total acidity is due to ripening of fig fruits. As fruit gets ripened, the citric acid concentration increases. Guar gum coating slowed down the synthesis of citric acid during ripening by providing barrier against oxygen uptake around the fruits (chacon *et. al.* 2017) [5]. Gradual increase in TSS of fruits has been occurred. Edible coating delays this process as coating slows down the metabolism by reducing internal respiration rate and thus, avoiding drastic reduction in the levels of soluble solids of coated as compared to control which implies changes in TSS in coated fruit was slower than control (saha *et. al.* 2016) [18]. The trend of obtained results can be seen from the graph 3.8 and 3.9. The acidity of fruits on 0^{th} day of storage was 0.49 ± 0.01% (graph 3.8) and T.S.S. was found 9.5 ± 1.00°Bx (graph 3.9). Reduced ripening rate was observed and the acidity of 0.3% sample on 8^{th} day of storage was 0.31 ± 0.03% and T.S.S. was 15 ± 1.00°Bx. However, once fruit reach the full ripe stage, citric acid content starts to decline. Overall findings of these results are in accordance with findings reported by chacon *et al.* 2017 [5] and saha *et al.* 2016 [18]. The observations of acidity and T.S.S. resulted that the 1g guar gum and 0.3g chitsoan coating is suitable for fig fruits to prolong its shelf life. T-TEST ($P<0.05$) were carried out between 0.3% and 0.4% concentration of chitosan coating, the obtained value is 0.63% for acidity and 0.48°Bx for T.S.S., the value indicates significant difference between two treatments.

Effect of chitosan on total phenolic content of fig fruits

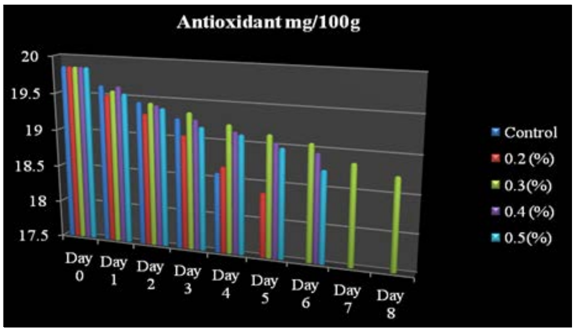


[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 10: Analysis of total phenolic content of fig fruits (mg GAE/100 g)

Initial concentration of phenolic compound present in fig was found to be 75.82 ± 0.25 mg GAE/100 g and decreased with increase in storage time. Reduction in phenolic content over the period of time was observed in present study. A comparative study indicate the difference between coated and uncoated samples and signifies that application of coating delays ripening stage as it limits respiration process during storage. On 0^{th} day of storage the phenolic content was 75.82 ± 0.25 mg GAE/100 g. There was drastic change observed during storage of uncoated fig fruits as on 4^{th} day of storage the content was 53.22 ± 0.17 mg GAE/100 g; for coated samples the degradation in phenolic content was less as compare to uncoated samples, on 8^{th} day of storage the content of 0.3 % sample was 54.62 ± 0.16 mg GAE/100 g which is very similar to the value of 4^{th} day content of control sample. Gosh *et. al.* 2014 [9] revealed that the decline of phenol content in fruits is due to the higher rate of respiration. It might also be due to senescence and breakdown of cell structure during storage. So due to the exposure of fruits phenolic content may decreases; the total phenolic content (TPC) decreased by ripening stages is reported by Shahdadi *et al.* 2013[19]. The obtained results are very well correlated with each other and it proved from its analysis. T-TEST ($P<0.05$) were carried out between 0.3% and 0.4% concentration of chitosan coating, the obtained value is 0.48 mg GAE/100 g, the value indicates significant difference between two treatments. Amongst all 0.3 % of chitosan gives best result in acceptability point of view.

Effect of chitosan on antioxidant activity of fig fruits

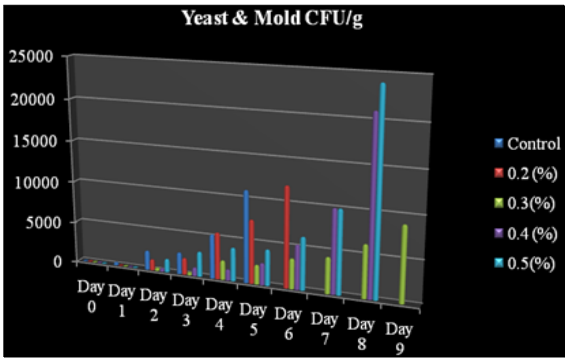


[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 11: Analysis of antioxidant activity of fig fruits (mg/100g)

The increase in phenol content is related with enhancement of antioxidant capacity (Gosh *et. al.* 2014) [9]. Antioxidant content is directly proportional to phenolic content and it decrease with decrease in antioxidant activity (graph 3.11). As we can observe that the 19.86 ± 0.31 mg/100g content was found on initial day but it decreased with storage time. Loss in antioxidant activity is more in uncoated fig compared to coated sample. As we can see that on 4th day of storage the antioxidant activity of uncoated fruit was 18.58 ± 0.16 mg/100g and for coated 18.74 ± 0.19 mg/100g on the 8th day of storage for 0.3% treated fig fruits. By observing all the responses of antioxidant content in graph 3.11 we can conclude that 0.3 % of chitosan got the best results and it increases the shelf life of fig for 8 days. Anton *et. al.* (2017) [2], stated that the antioxidant content decreased with increase in storage time. Our findings are in accordance with these results. T-TEST ($P<0.05$) were carried out between 0.3% and 0.4% concentration of chitosan coating, the obtained value is 0.42 mg/100g, the value indicates significant difference between two treatments.

Effect of chitosan on yeast and mold count of fig fruits



[Data are expressed as mean±standard deviation of triplicate experiments (n=3]

Graph 12: Analysis of yeast and mold count of fig fruits (CFU/g)

From graph 3. 12 it can be observe that on 0th day of storage uncoated fig fruit has count 3.3×10^2 CFU/g. Uncoated sample last till 5th day of storage with 1.1×10^4 CFU/g storage. The effectiveness of coating enhances the shelf life of fruits till 8 days. As per FSSAI the acceptable limit of yeast and mold should be below 1×10^4 CFU/g. During storage the TPC results are observed below the FSSAI limits i.e. 6.3×10^3 CFU/g and on 9th day it was found 9×10^3 CFU/g for 0.3 % chitosan. It is well-known phenomenon that the respiration rate of the fruits increases; it starts deterioration of the fruits, due to the nutrient availability for the microorganisms to grow. The protective effect provided by the edible coating seems to reduce the rate of development of microorganisms that affect quality of fig fruits (Chacon *et. al*., 2017) [5]. Comparisons of results in graph 3.12 shows that coated samples inhibit the growth of yeast and mold till the 8th day storage and uncoated fruits deteriorated on 5th day of storage. Chitosan is coating material as well as it is antimicrobial agent itself. Obtained results demonstrates that the 1% guar gum and 0.3% chitosan gives the best results for inhibition of growth of yeast and mold and this combination was suitable for fig fruits to prolong its shelf life

Optimized coating material concentration for fig fruits

Table 3: Optimized coating material concentration

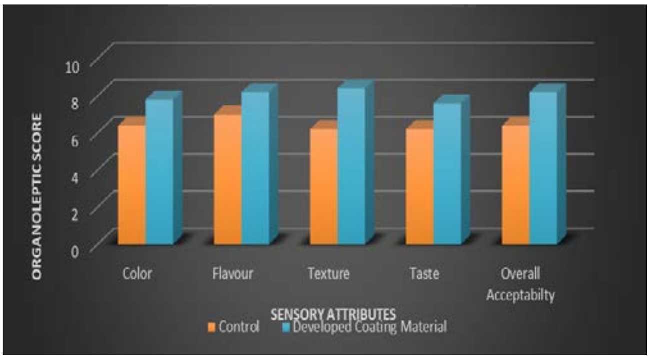
Components of edible coating material	Concentration
Guar gum	1 %
Chitosan	0.30 %
Glycerol	0.3 ml
Acetic Acid	1 ml
Distilled Water	100 ml
Heating Temperature	30°C
Stirring Time	12 hrs

Sensory evaluation of the fig fruits

From the above study the concentration of the coating material and all other parameters were optimized and indicated in table 3.1. As we can see in the pictures the change in color of coating materials is due to increase in concentration of chitosan and guar gum. When the concentration of chitosan increases the viscosity of coating material increases. Chitosan works as an antimicrobial agent but if we use high concentration it binds with guar gum and shows high viscous nature, probably that affects on fig fruits which could not gave good results at high concentrations like 0.4 % and 0.5 % of chitosan.

Table 4: Sensory evaluation of fig fruits

Sensory attributes of fig fruits	Colour	Flavour	Texture	Taste	Overall Acceptability
Control	6.40	7.00	6.20	6.20	6.40
Developed coating material	7.80	8.20	8.40	7.60	8.20



Graph 13: sensory evaluations of fig fruits

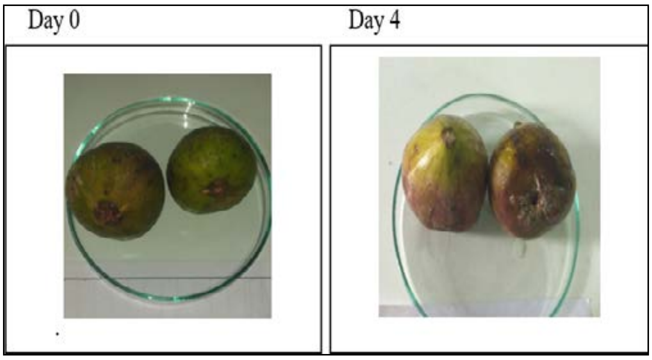


Fig 1: Uncoated Figs

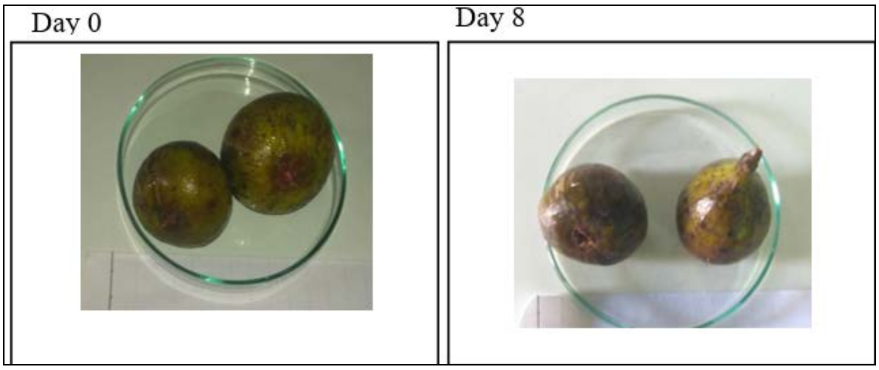
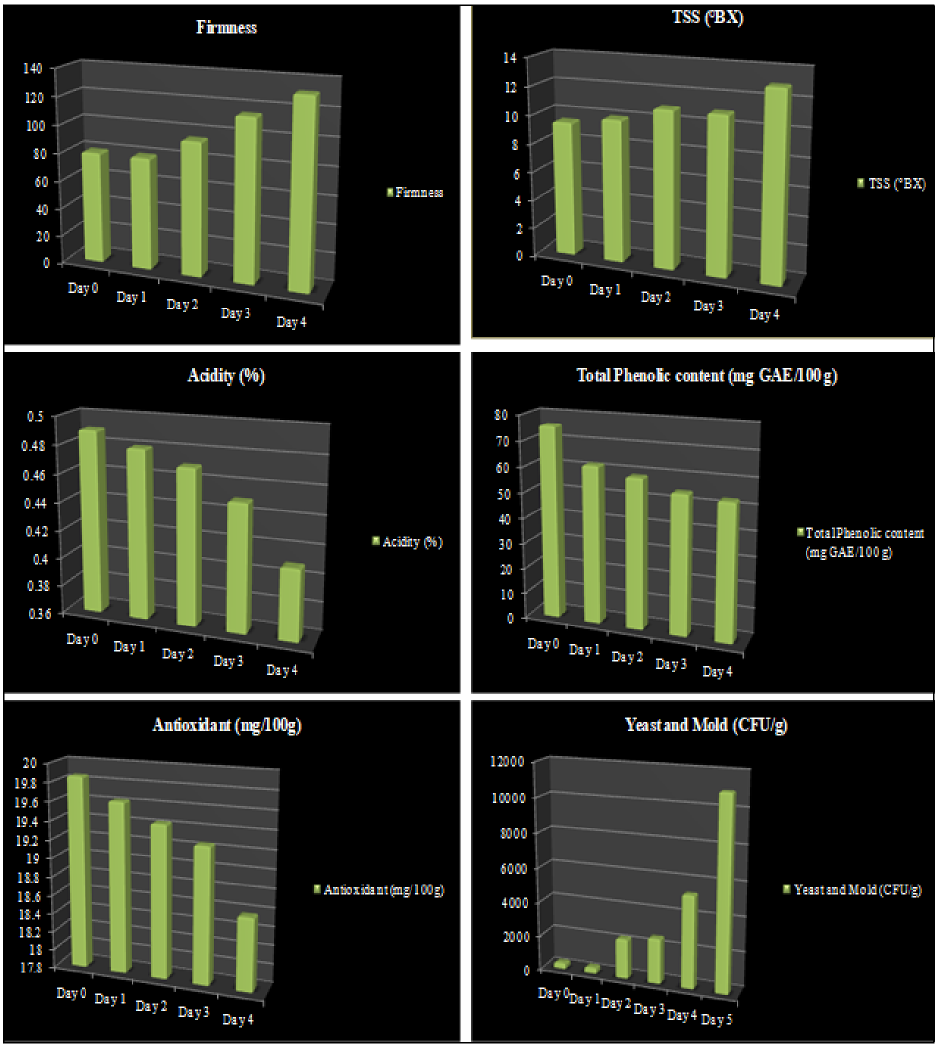
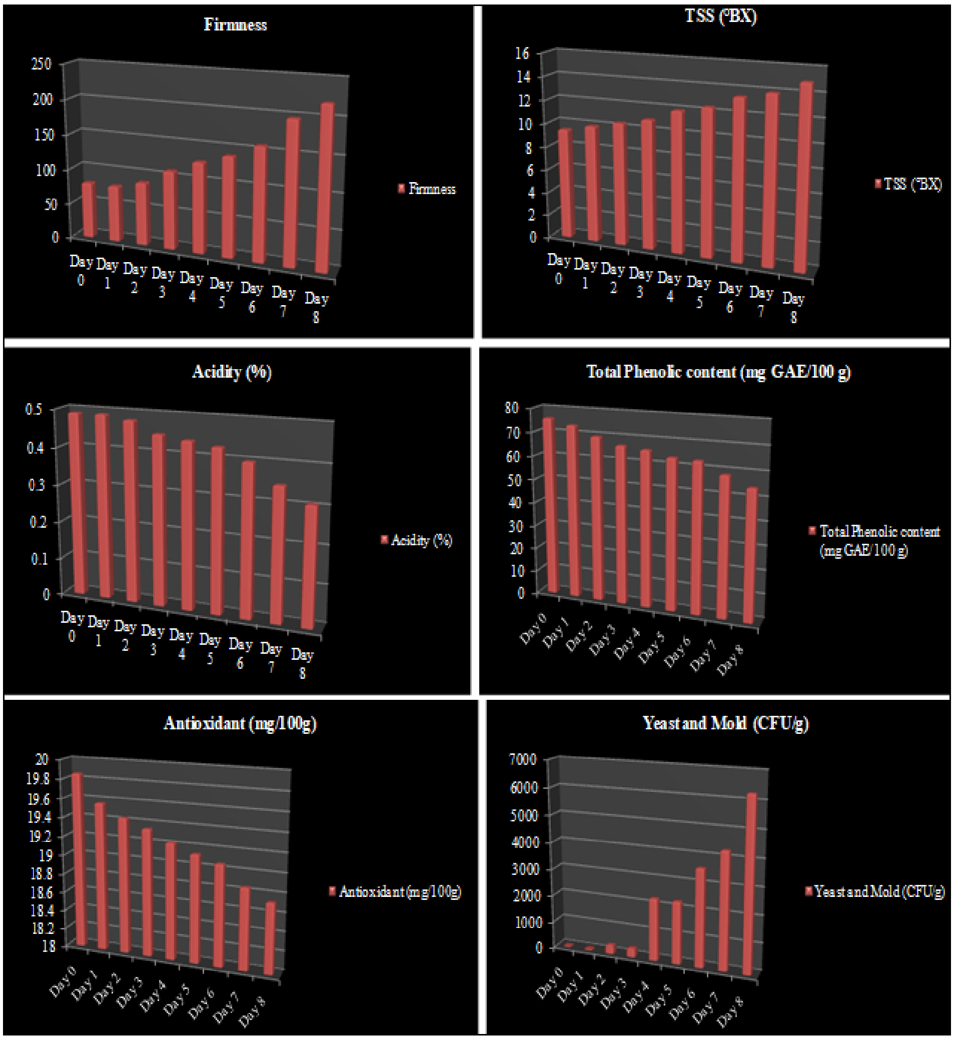


Fig 2: Coated Figs



[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 14: Analysis of uncoated figs



[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Graph 15: Analysis of coated figs

Graph 3.14 and 3.15 depicts that the shelf life of coated fig fruits is more than uncoated samples at refrigeration temperature 4 ± 2°C. The uncoated sample has 4 days shelf life, on the 5th day of storage the yeast and mold count was 1.1 $\times 10^4$ CFU/g. The count of for coated sample was 6.3 $\times 10^3$ CFU/g on the 8th day of storage. Coating material inhibits the growth of yeast and mold. Graph 3.15 shows that the coating material successfully maintains the all parameters of fig fruits till the 8th day of storage. From graph 3.14 and 3.15 we can conclude that the 1 % guar gum and 0.30 % chitosan concentration is suitable for fig fruits to prolong its shelf life for 8 days. The changes in color over the period of time were observed. The change in color for uncoated figs were observed as it changes light yellow to dark brown rapidly as compare to coated figs. From the pictures we can observe that the some figs have not changed their color drastically but microbial growth was found. It is because of the coating material, the combination of guar gum and chitosan coating delayed the ripening process by inhibiting the respiration rate of this fruits. This concluded that the coating not only maintained the quality parameters of fruits but also improved the postharvest quality of fruits during storage (Chacon *et. al.* 2017) [5].

Antimicrobial studies of coating material

Antimicrobial activities of developed coating material were analyzed against gram positive and gram negative bacterial to check it potential. For this study well diffusion assay was done and obtained results were indicated in table 3.3. The results indicate that the coating material is effective against gram negative bacteria.

Table 5: Antimicrobial activity of developed edible coating

	Salmonella	Bacillus	E. Coli
Coating Material (1% gaur gum and 0.3% Chitosan)	16 mm	11.5 mm	14 mm

[Data are expressed as mean±standard deviation of triplicate experiments (n=3)].

Table 3.3 depicts the antimicrobial inhibition zone of coating material, which shows that the coating material efficiency. As it is well known that the salmonella and *E.Coli* is gram negative and *Bacillus* is a gram positive bacteria. The antimicrobial effect of edible coating was observed during the well diffusion assay. The most prevalent proposed antibacterial activity of chitosan is by binding to the negatively charged bacterial cell wall causing disruption of the cell, thus altering the membrane permeability, followed by attachment to DNA causing inhibition of DNA replication and subsequently cell death (Nagy *et al.* 2011) [6]. Another possible mechanism is that chitosan acts as a chelating agent that electively binds to trace metal elements causing toxin production and inhibiting microbial growth (Divya *et al*. 2017) [7].

Viscosity of coating material

Viscosity plays an important role in formation of edible coating and therefore it has checked for edible coating (4.59Pa/sec). High viscosity of coating solution becomes very thick and low viscous becomes thin coating material. The viscosity of coating material maintains the turgidity of fruits and kept them fresh for long time. The maximum viscosities of guar gum dispersions are achieved at temperatures of about 25-40°C (Whistler *et. al.,* 1979) [22].

Summary

The present investigation was carried out to develop coating material for food application ex. Fruit and vegetable (Fig). Different concentration of gaur gum and chitosan were selected and optimized on the sensory basis. 1% guar gum and 0.3% chitosan concentration was found to be suitable for fig fruits. Higher concentration of gaur gum increases its viscosity and made difficult for coating. Different factors like firmness, acidity, T.S.S., total phenolic content, antioxidant content and microbial (yeast and mold CFU/g) studies were carried out during storage. Water holding capacity of guar gum maintained the turgidity of fig fruits. Obtained results and antimicrobial studies of developed edible coating material reveals that it possesses antimicrobial activity thus increase a shelf life of coated fig fruits up to 8 days.

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