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An innovative approach of development of edible coating for fresh cut apple fruit for value addition of horticultural produce

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Abstract
In the current years the intake of fresh-cut fruits has been raising due to their numerous health benefits. Development of eatable coating on these minimally processed produce is considered as the recent alternative to reduce the quality deterioration and extend the shelf-life. The basic purpose of this research was to develop an edible coating and regulate the efficiency of this edible coating on the shelf-life of unprocessed apples. A range of solutions containing Sago, Oil, Lecithin and Glycerol were utilized as coating systems and Calcium chloride and Ascorbic acid solutions were used as pretreatment of the fresh cut apple so as to preserve the texture and delay the browning. Sensory evaluation and microbial analysis were done to determine quality and effectiveness of the coating. The overall analysis revealed that, the Sago-oil edible coating improved the shelf-life of fresh-cut apple, compared to the control.

Keywords: minimally processed food, edible coating, red delicious, shelf-life, value addition

1. Introduction
Owing to various advantages such as basic health food, freshness and low caloric content and consumers need for minimally processing food, gave rise to rapid development of the fresh-cut fruit and vegetables in the recent years (Raybaudi-Massilia *et al.*, 2007) [9]. This is mainly because of busy lifestyles, an upsurge in health awareness and increased procuring capacity of the customer (Watada *et al.*, 1996) [11].
Fresh cut fruits and vegetables are highly nutritious but highly perishable as well. Modifying the actual form leads to leakage of nutrients, weight loss and degraded standard of the product. Numerous methods have been explored so as to surpass these problems and lengthen the shelf life of fresh produce, for example, controlled and modified atmosphere packaging, excessive relative humidity and low temperature. Edible coating as an upcoming technique is a good alternative to lengthen the shelf-life of fresh-cut fruits, offering a semi-permeable hurdle against moisture, gases, aroma, and flavor compounds; thus maintaining the fruits quality properties during storage (Park, 1999) [8]. In addition, edible coatings can be utilized as carrier of active compounds, such as antimicrobial agents, to decrease the population of pathogenic and spoilage microorganisms (Glass and Johnson, 2004) [4].
Research has been conducted on these coatings and their significance on fresh whole produce, but little has been known about their application on fresh- cut fruits and vegetables and their consumer acceptance either uncoated or coated with an edible coating (Olivas *et al.*, 2007) [7]. The physical injury of the fresh-cut produce during the preparation (dicing, peeling, slicing and cutting) causes numerous physical and physiological responses (Brecht, 1995; Saltveit, 1999) [2, 10] The appearance, texture, and value of fresh cut fruit are altered which results in drop of commercial value (Braaksma *et al.*, 1999) [1]. The main changes occur after cutting fruits are enzymatic browning and non- enzymatic browning which reduces consumer acceptance (Espin *et al.*, 1999; Xie *et al.*, 2003) [3, 12]. In order to resolve these difficulties composite coatings of Sago, Soy oil, Glycerol and Lecithin was developed. The aim was to develop an edible coating and analyze its effectiveness on the shelf-life of fresh cut apple.

2. Materials and Methods
This study was executed in the Department of Post-Harvest Engineering and Technology, Aligarh Muslim University, Aligarh.

2.1 Raw materials
Apples (variety: Red Delicious) were obtained from the local market. Mature fruit of uniform size and shape were selected for the experiment. Sago pearl or *Sabudana* was procured from

the local market of Aligarh. This was then ground to form the powder, which was for the coating solution. Refined soybean oil was also obtained from the local market.

2.2 Chemicals
Glycerol (Moly Chemicals, Mumbai) and Lecithin (Acro organics, New Jersey, USA) were used for preparing edible coatings. Calcium chloride (Qualiken Fine Chemicals Pvt ltd, Delhi) and Ascorbic acid (Central Drug House, Delhi) were used in pretreatment process. Plastic trays and polythene wrapping material (20um thickness) was obtained from the local market.

2.3 Preparation of Coating Solutions
Sago and soy oil were the main components of the coating while glycerol was utilized as a plasticizer and lecithin as emulsifier, together developed nine different combinations of coating solutions. Based on the initial trails the concentration of sago was taken as 3%, 4% and 5% (w/v) while the concentration of oil was taken as 0%, 0.25% and 0.5% (w/v).The concentration of glycerol and lecithin in all the nine coating solutions were constant at 1.50% (w/v) and 0.50% (w/v), respectively. Coating solutions were produced by dissolving 30g; 40g and 50g sago powder in 3 containers each containing 1000 ml of distilled water and heating at about 70^{o}C with stirring till the solution becomes clear. Glycerol was mixed as plasticizer at rate of 1.5 % sago solution. Soy oil (0, 0.25, and 0.50%) and lecithin (0.50%) added to the solution and mixed properly using a Homogenizer (1/4hp, 10000 r.p.m, York Scientific Industries, Delhi). Mixing was done until the homogenous mixture of the solution is formed. The solution was brought down to the room temperature before the application as coating.

2.4 Preparation of apple pieces
'Red Delicious' Apples were appropriate for fresh-cut processing, mostly due to their firmness and texture. The apples free from external defects and with similar shape, size, color and firmness were selected. Apples were carefully cleaned with tap water to eliminate any surface impurities followed by final rinsing with sterile water. A disinfected knife was then used to cut each apple into equal sized pieces of approximately 2 cm. The pieces were initially dipped in 2% calcium chloride solution and then in 2% ascorbic acid solutions for 2 minute each. After this the pieces were immersed in the coating solution for about 3 minutes. They were then taken off and placed on a tray for another 3 minutes. About 180g fresh cut pieces were loaded in each sterile plastic container and marked following to the treatments and the storage days (0, 4, 8, and 12) of analysis. All the containers were stored in a refrigerator maintained at 4 ^{o}C. The 0th day sample was drawn after 2-3 h of keeping in refrigerator. Samples were evaluated after every 4 days during the study of 12 days in terms of Sensory evaluation and Microbial analysis.

3. Results and Discussion
3.1 Sensory analysis
Variations in sensory characteristics including aroma, color, taste, texture, juiciness of coated and uncoated fresh-cut fruits at 12th day of storage are shown in Table 3.1. All edible coating treatments lead to in prominent sensory scores than uncoated fruits for all standard aspects tested. The color of the apple slices is a vital segment of the sensory attributes. During the course of the study it was observed that the color of the coated slices was better with contrast to the uncoated. It was as a result of the treatment of ascorbic acid in addition to the composite coating. Taste and aroma was also very good in case of coated samples. Application of sago and oil coating had negative effect on the taste and aroma. In fact the natural taste and aroma of the apple remained same. It can be concluded that the coating utilized on the apples slices was almost tasteless and odorless. The juiciness and the texture of the apple pieces were also absolutely intact because of the treatment of Calcium Chloride solution and the sago-oil coating. The texture of the coated apple pieces was veritably intact even on the 12th day of study. In case of the overall acceptability, the outcomes displayed that the lower overall preference was given to the coating without oil and the best results were found in the coating containing 0.5% oil. Overall preference was given to the coating containing higher percentage of oil. Thus the coated specimen retained the sensory characteristic during the entire study better than the uncoated ones.

Table 3.1: Scores of sensory parameters of coated fresh-cut apples on 12th day

Oil (%)	Sago (%)	Aroma	Taste	Color	Juiciness	Texture
0.00	3	7.0	6.6	6.6	7.0	6.6
	4	7.0	7.0	7.0	7.6	7.0
	5	7.0	7.6	7.0	7.6	7.0
0.25	3	8.0	7.6	7.6	7.6	7.0
	4	8.0	8.0	7.0	8.0	8.0
	5	8.0	8.0	8.0	8.0	8.0
0.50	3	8.0	8.0	8.0	8.0	8.0
	4	8.0	8.0	8.0	8.0	8.0
	5	8.0	8.0	8.0	8.0	8.0
Control		7.0	6.3	5.6	7.0	6.0

3.2 Microbial analysis
The sago and oil coating was successful for inhibiting the molds and yeast growth in apple slices. 6 log CFU/g is regarded suitable as a maximum yeast count for non-thermal processed fruit. In this study, the yeast count remained within these levels throughout the storage. A noteworthy variation between the counts of molds and yeast of coated and uncoated fresh-cut apples was observed, thus confirming reduction of mold and yeast count on coated as compared to the uncoated slices. At the conclusion of the 12 days refrigerated storage, counts of coated samples was around 3log CFU/g for yeast and mold while uncoated apple wedges presented values as high as 4.484 log CFU/g showed in Table 3.2. The antimicrobial effect which was noticed might be owing to the antibrowning agent integrated in the coatings. Related observation for minimally processed apples was reported by Lee *et al*., (2003) [5] where citric acid, ascorbic acid and oxalic acid were utilized as antibrowning agents along with several kinds of whey protein concentrate and carbohydrate polymers. Coatings build up a modified atmosphere retarding the growth of spoilage microorganisms (Olivas and Barbosa-Canovas, 2005) [6]. Modified atmosphere may constrain the expansion of innocuous spoilage flora, thus study of these psychrophilic and mesophilic molds, bacteria and yeast is necessary in order to ensure microbial safety of the products.

Table 3.2: Effect of coating treatments on Yeast and mold count (log cfu/g) of coated fresh-cut apples

Oil (%)	Sago (%)	Storage Period (Days)			
		0	4	8	12
0.00	3	ND	ND	ND	3.977
	4	ND	ND	ND	3.851
	5	ND	ND	ND	3.568
0.25	3	ND	ND	ND	3.041
	4	ND	ND	ND	3.255
	5	ND	ND	ND	3.278
0.50	3	ND	ND	ND	3.230
	4	ND	ND	ND	3.041
	5	ND	ND	ND	3.079
Control		ND	ND	ND	4.484

4. Conclusion

The observations reported from this study indicate that the edible coating on fresh-cut fruits is a good alternative in lengthen their shelf-life and beneficial in maintaining the fruits quality properties during storage. It was observed that the texture (firmness) of the apple pieces throughout storage was highly improved by the sago-oil coating. During the storage control (uncoated) samples started to lose firmness while the coated specimen kept the same texture for longer which is attributed mainly to moisture content that was retained much in case of coated samples compared to control. All the sensory characteristics including color, taste, odor, juiciness and texture were better retained in coated samples. The general suitability exhibited that the sample coated with maximum quantity of oil were the utmost acceptable. The observations of the study also conclude that the coating was effective in controlling the mold and yeast development in the fresh-cut apple fruit. Overall, the best coatings were made of sago 5% and 0.5% oil. This particular treatment was the best alternative to maintain apple slices original standard attributes for longer, gained the best acceptability among panelists, and fulfilled the shelf-life enhancement requirement of 12 days in storage at 4 ^{o}C.

5. References

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