Formula Optimization of Active Packaging Treatments for Research

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Abstract—*Active packaging (AP) is one of the innovative food packaging concepts that have been introduced as a response to the continuous changes in current consumer and market demands. Very little work has been done on AP technology of fruits and vegetables in our country therefore; five AP treatments were chosen and formulated for laboratory study to reduce the post harvest losses. The main aim of the present study was to extend the shelf life of fruits and vegetables while maintaining its nutritional quality with minimum changes in terms of physico-chemical, microbial and organoleptic parameters with storage. Oxygen scavenger (iron powder), carbon dioxide scavenger (activated charcoal) ethylene scavenger (potassium permanganate), moisture scavenger (silica gel), chitosan based coating were selected under Active packaging concept. Their formulations were standardised and best formulation was finalised for research as per the results obtained. Prepared scavengers were filled into the sachet (4x4 cm) made from gas permeable high density woven fabric.*

Keywords*: Active packaging, formulation, fruits, sachet, scavengers.*

1. INTRODUCTION

India has emerged as the second largest producer of fruits and vegetables in the world only next to China, and in terms of total area and production our country is designated as "fruit and vegetable basket" of the world. In recent years, the major driving forces for innovation in food packaging technology is perhaps due to the increase in consumer demand for lightly processed food. In the present study, Active or smart packaging techniques are proposed for better quality retention and shelf life extension of fruits and vegetables. The term 'active' reflects to perform some role other than providing an inert barrier to external conditions. According to Suppakul [1] "Active packaging (AP) is an innovative concept that can be defined as a mode of packaging in which the package, the product and the environment interact to prolong the shelf-life or enhance safety or sensory properties, while maintaining nutritional quality of the product" (Active packaging systems can be classified into active scavenging systems (absorbers) and active-releasing systems (emitters). Vermeiren [2] suggested that scavenging systems remove undesired compounds such as oxygen, excessive water, ethylene, carbon dioxide, taints and other specific food compounds whereas releasing systems actively add compounds to the packaged food such as carbon dioxide, water, antioxidants or preservatives. Both absorbing and releasing systems aim at extending shelf-life and/or improving food quality.

Limited research has been done on Active Packaging (AP) of fruits and vegetables in our country. Therefore, the present work has been undertaken to optimize the AP treatments for fresh fruits and vegetables in prolonging the shelf life while maintaining its nutritional quality with minimum changes in terms of physico-chemical, microbial and organoleptic parameters with storage. In order to achieve this broad objective, Five treatments, oxygen scavenger, carbon dioxide scavenger, moisture scavenger, ethylene scavenger and chitosan based antimicrobial coating were selected under active packaging concept. Their formulations were standardized as per the results given, and best formulation was finalised for studying the effect of AP on fresh fruits and vegetables. These scavengers were prepared and filled into the sachet. The formulations/preparation of AP treatments is described under material and methods heading.

2. MATERIALS AND METHODS

2.1 Formula optimization of active packaging treatments

Formulation of four types of scavengers and an antimicrobial film forming solution are described below: For the preparation of O_2 and CO_2 scavengers, four different types of formulations were tried as given in Table 1-2. and the best one was selected on the basis of absorption of O_2 and CO_2 gases, respectively. O_2 and CO_2 concentrations were checked by placing 5g of sachet of these scavengers in two 100 ml air tight glass jars fitted with a rubber septum. O_2 and CO_2 concentrations were periodically analyzed by using headspace analyzer.

2.1.1 Oxygen scavenger

Table 1. describes the formulation of O_2 scavenger based on iron powder which was used in the present study. For this four different type of formulation ratios (2:1:1:1, 4:3:1:2, 4:3:2:1 and 4:2:3:1) were tried and finally 100g of oxygen scavenger was prepared by dry mixing of 40g Iron powder with 30g

magnesium sulphate, 20g sodium chloride and 10g silica gel by maintaining the ratio of 4:3:2:1, this concentration for O_2 scavenger was chosen on the basis of oxygen reduction by this formulation. As shown in the given Table 1. the selected concentration of O_2 scavenger, reduces the O_2 concentration from 21 to 19.96 per cent when analyzed after 2 days. On storage the grey coloured iron based oxygen scavenger changed into rusty colour due to oxidation.

Table 1: Formulation of oxygen scavenger

Material taken	O2 (%) present	Formulation selected
Iron Powder +MgSO4+NaCl +Silica gel (40+ 20+20+20)	20.03	Iron powder+MgSO4+NaCl+Silica gel (40+30+20+10)
Iron Powder +MgSO4+NaCl +Silica gel (40+30+10+20)	20.06	
Iron Powder +MgSO4 +NaCl +Silica gel (40+30+20+10)	19.96	
Iron Powder +MgSO4 +NaCl +Silica gel (40+20+30+10)	20.06	

2.1.2 Carbon dioxide scavenger

Table 2. describes the formulation of CO_2 scavenger based on activated charcoal, for this four types of formulations were tried by using activated charcoal as main ingredient and silica gel in different concentration ratios (1:0, 9:1, 8:2 and 7:3) and finally for 100g of CO_2 scavenger was prepared by mixing 80g activated charcoal with 20g silica gel by maintaining the ratio of 8:2. This concentration was selected on the basis of CO_2 absorption as shown in the given Table 2. The selected concentration of CO_2 scavenger reduces the CO_2 concentration from 0.03 to 0.016 per cent when measured after 4 days.

Table 2: Formulation of carbon dioxide scavenger

Material taken	CO2 (%) present	Formulation selected
Activated charcoal (100g)	0.02	Activated charcoal+silica gel (80+20)
Activated charcoal+silica gel (90+10g)	0.02	
Activated charcoal+silica gel (80+20g)	0.016	
Activated charcoal+silica gel (70+30g)	0.023	

2.3 Moisture scavenger

Silica gel acts as an effective desiccant therefore; it was used as such for the application of moisture scavenger as a treatment under active packaging (AP) for fruits and vegetables and is given in Table 3. Each sachet of 5g moisture scavenger was prepared for this purpose.

Table 3: Formulation of moisture scavenger

Material taken	Formulation selected
Silica gel (100g)	Silica gel

2.4. Ethylene Scavenger

Ethylene scavenger was prepared in the laboratory. Five different formulations of ethylene scavenger based on potassium permanganate were prepared, by impregnating 96g sand with 100 ml of 4% $KMnO_4$ solution, 96g jamuna ret with 100 ml of 4% $KMnO_4$ solution, 96g limestone with 100 ml of 4% $KMnO_4$ solution, 96g plaster of paris with 100 ml of 4% $KMnO_4$ and 96g silica gel with 4% $KMnO_4$, mixed and allowed to dry at 28-30°C temperature in hot air oven, packed in LDPE pouches and allowed to store at room temperature for two weeks. Ethylene scavenger selection was done on the basis of colour changes from bright purple (initial colour) to brown (oxidised colour) when stored for 15 days as described in Table 4. For the preparation of 100g ethylene scavenger, the formulation based on mixing of silica gel with 4% $KMnO_4$ was selected for further study.

Table 4: Formulation of ethylene scavenger

Material taken	Colour (visual basis)	Formulation selected
Sand + 4% KMnO4	Light Brown	Silica gel + 4% KMnO4
Jamuna Ret + 4% KMnO4	Light Brown	
Limestone + 4% KMnO4	Light Purple	
Plaster of Paris + 4% KMnO4	Light Purple	
Silica gel + 4% KMnO4	Bright Purple	

2.2.1. Selection of sachet material

Fresh produce packages have addressed their perceived primary problem by employing package structures that have high gas permeability by value of their polymeric structure, gauge, surface to volume ratio or mineral or other fill. Table 5. describes that the selection criteria of the sachet material for the preparation of sachets of various treatments like C_2H_4 scavenger, O_2 scavenger, CO_2 scavenger and moisture scavenger. As 100 gauge (thick) sachet material (woven fabric) was selected on the basis of permeability to gases but impermeable to the sachet ingredients.

Table 5: Selection of sachet material

Material taken	Material selected
40 gauge	100 gauge
60 gauge	
70 gauge	
80 gauge	
90 gauge	
100 gauge	

2.1.2. Sachet preparation: Sachet was prepared by selecting high density woven fabric (100 gauge) which was permeable to gases but impermeable to active packaging ingredients, it was cut into 8 x 4 cm with scissors and 2 sides were sealed by using an electronic form, fill and seal machine. 4 x 4 cm size of each sachet was prepared with one side remained open for incorporating the prepared scavengers and packed in LDPE pouches for further use.

2.1.3. Filling of prepared scavengers inside sachet: 5g dried scavenger granules of O_2, CO_2, moisture and ethylene scavengers were weighed and filled in sachet (4 x 4 cm) prepared from gas permeable high density woven fabric but impermeable to sachet ingredients and heat-sealed by using an electronic form, fill and seal machine and packed in LDPE pouches for further use.

Weighed 5g scavengers (O_2, CO_2, moisture and ethylene)
↓
Filled in (4 x 4cm) sachet
↓
Heat sealing
↓
Packed in LDPE bags (100 gauge)

Fig. 1: Preparation of sachet

2.5. Antimicrobial film/coating

To control undesirable microorganisms in foods, antimicrobial substances can be incorporated or coated. The application of chitosan based edible films to the fresh fruits and vegetables has been one method of extending its shelf-life by slowing down its metabolic processes. For the preparation of film forming solution (FFS) based on chitosan, four different concentrations were taken as described in Table 5. and FFSs were prepared by dissolving 2g chitosan in 100 ml of 1% acetic acid solution, secondly, 2g chitosan was dissolved in 1% acetic acid with the addition of 0.2 ml glycerol as a plasticizer, third concentration was prepared by dissolving 2g of chitosan in 100 ml of 1% acetic acid solution with the addition of 0.4 ml of glycerol and fourth concentration was prepared by dissolving 2g chitosan powder in 100 ml of 1% acetic acid with the addition of 0.6 ml glycerol. Glycerol as plasticizer was added to film forming solution to reduce brittleness, increase toughness, strength, tear and impact resistance and impart flexibility. Usually, the addition of a plasticizer increases the permeability of gas, water vapour and solute and decreases the tensile strength of the films.

All the film forming solutions that were prepared by above mentioned concentrations were allowed to stand for atleast 30 min. for complete dissolution of chitosan, the prepared solutions were degassed under vacuum for the removal of bubbles. 20 ml solution was pipetted out from each of the concentration, put it in the petri plates and placed in refrigerated conditions (6±1°C) at least for 48 hrs. After this the prepared films were automatically peeled off from the surface of petri plates. Finally, third concentration was selected because on the basis of the formation of film it showed best results. The films prepared from this formulation were transparent and good in quality in terms of colour, smoothness and extensibility whereas, the films produced form the first, second and fourth concentration were pale yellow in colour and had rough or gritty surface, pale yellow with gritty surface but less than first one and transparent, smooth but less elastic in nature, respectively.

Table 5: Formulation of antimicrobial film forming solution

Material taken	Observation of films	Formulation selected
2g chitosan+1% acetic acid	Pale yellow with Rough suface	2g chitosan+1% acetic acid + 20% glycerol (20% chitosan powder)
2g chitosan+1% acetic acid+0.2ml glycerol	Brittle and less Rough	
2g chitosan +1% acetic acid+0.4ml glycerol	Transparent and smooth surface	
2g chitosan+1% acetic acid+0.6ml glycerol	Transparent, smooth but not flexible	

2g Chitosan Powder
↓
Dissolved in 1% acetic acid
↓
Adding 0.4 ml glycerol (as a plasticizer)
↓
Mixing it properly for 30 min.
↓
Degassed using vacuum pump
↓
Keeping at 5±1°C for 24 hrs.

Fig. 2: Preparation of Film Forming Solution

3. CONCLUSION

Best formulations for different treatments under active packaging namely oxygen, carbon dioxide, moisture, ethylene scavengers and film forming solution for coating were optimized for further study.

REFERENCES

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