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Md. Shamsher Ahmad
Department of Food Science and Postharvest Technology, BAC, Sabour, India

MW Siddiqui
Department of Food Science and Postharvest Technology, BAC, Sabour, India

Md. Abu Nayyer
Department of Horticulture (Fruit and Fruit Technology), BAC, Sabour, India

MA Anwer
Department of Plant Pathology, BAC, Sabour, India

Correspondence
Md. Shamsher Ahmad
Department of Food Science and Postharvest Technology, BAC, Sabour, India

Alleviating pericarp browning in litchi using active packaging

Md. Shamsher Ahmad, MW Siddiqui, Md. Abu Nayyer and MA Anwer

Abstract
The litchi cultivation is confined to a few states of India where Bihar tops the list with > 70% of total production. Being highly perishable in nature, it becomes unmarketable within 2-3 days due to pericarp browning. Postharvest sulphuring process is the only commercially exploited treatment to prevent pericarp browning, however, it is cumbersome to perform and it requires sulphuring room or chamber and pre cooling facility. An alternative method has been developed using grape gourd. In this method, grape gourd is kept inside the polyethylene liner in packaged litchi. It was observed that litchi fruit with or without stalk packed with grape gourd and liner maintained a shelf life of 5-7 days at ambient conditions without pericarp browning. Initially red peel color of litchi was bleached, but regained slowly with the passage of time. Minimum weight loss was observed in sulphited litchi (commercial process) followed by fruits having grape gourd and liner. Minimum disease incidence was also observed in Sulphited Litchi followed by grape gourd and liner. TSS was increased in all treatments. However, minimum increase was observed in sulphited litchi followed by litchi packed with grape gourd and liner. Based on the results, it can be suggested that in-package sulphuring of litchi fruits using grape gourd and liner may be an alternative to commercial sulphuring process.

Keywords: Litchi chinensis, pericarp browing, grape gourd, sulphuring, active packaging

Introduction
Litchi is one of the most important subtropical fruits, grown in many countries of the world and known for its attractive pericarp colour and delicious aril. In India, it occupies an area of 82.7 thousand hectare with an annual production of 5.80 lakh MT (NHB-2013-14). Bihar is the largest producer of litchi among Indian states with a production of 234200.0 MT (NHB-2013-14). Litchi fruit is a well-established fruit of commercial importance and it has immense potential and demand in domestic and international markets as fresh fruit. Being non climacteric in nature, litchi fruit do not continue to ripen after harvest (Joubert 1986). The fruits are harvested at ripe stage as development of full color and flavour is possible only when fruits are attached with the tree. The harvest maturity of the litchi fruit is therefore, very important and judged by flattening of tubercles and the development of red colour on the pericarp (Kumar *et al*., 2011). However, once the fruit is harvested, pericarp of the fruit loses its bright red peel color and turns brown within 24 to 28 h after harvest (Zheng & Tian, 2006), a physiological disorder (Holcroft and Mitcham, 1996), which drastically reduces the commercial value of the fruit (Underhill, 1992, Kumar *et al*., 2011). The incidence of postharvest pericarp browning in litchi fruit is regulated by various factors such as activity of polyphenol oxidase (PPO), desiccation or loss of water, storage conditions and temperature, postharvest treatments etc. However, the major factors include rapid loss of moisture, enzymatic acitivity (polyphenol oxidase (PPO) enzyme) and decrease in antioxidants (Sun *et al*., 2010).

Sulphur compounds have been reported to prolong quality and shelf life of fruits. Sulphuring or sulpher fumigation posses fungicidal effect and bleach the red colouration of the pericarp and prevent brittleness during storage and transportation (Normand, 1995). Sulphuring litchis is currently the only commercially viable means to control decay and retain colour, and the sole legal postharvest method according to current European legislation (Wermund, *et al*. (2014). However, fumigation process is cumbersome and needs initial investment for construction of a sulphuring room, a pre cooling facility and a cold storage. Grape gourds or SO2 releasing pads are extensively used on commercial scale in grape against the incidence of gray mould (Pretel *et al*., 2006) and to maintain quality during storage (Morris *et al*., 1992, Mahajan *et al*. 2009). The same grape gourd may be used for getting sulphuring effect on litchi when packed in polyethylene pouches or plastic punnets. The liner creates MAP and retains SO2 produced by grape guard inside the box.

Modified Atmosphere Packaging (MAP) has been tried with sealed polyethylene bags, either with or without SO2 pads or treatment (Paull and Chen 1987). Wermund, *et al*. (2014), reported that dual release Uvasys sulphur (SO2) sheets and smartPac liners performed very well in terms of retaining fruit quality whilst maintaining SO2 residues less than 10 mg/kg in the litchi fruit flesh (European maximum residue limit). The SO2 is anti-oxidant, which inhibits oxidising enzymes responsible for pericarp browning, controls saprophytic surface fungal growth and retains the paliability of the skin (Lemmer and Kruger, 2002).

The use of grape guard may be an alternative to sulpher fumigation at very low cost with zero infrastructures requirement. As per our knowledge, no research has been reported so far on the use of grape guard (SO2 releasing pads) for reducing intensity of pericarp browning and maintaining quality of litchi fruit. Therefore, looking into the importance of the litchi fruit for small and marginal farmers in the domestic market, there is an urgent need to explore a low cost, low investment method to reduce pericarp browning and maintaining postharvest quality of litchi fruit.With this main objective, the present study was conducted to assess the fruit quality and to increase the shelf life of litchi at ambient temperature by the use of grape gourd and liner.

Material and Methods

Litchi fruits Cv. Purbi were harvested at commercial maturity stage from the University Orchards, Bihar Agricultural University, Sabour and transported to the Research Laboratory of the department of Food Science and Postharvest Technology. After sorting and grading, only matured fruits having uniform size and colour were selected for the study and treated as per the treatment details. T1- fruits were packed in a liner along with grape gourd, T-2 commercial sulpher fumigation process followed, T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment. Both treated and control fruits were kept at ambient and observations were recorded on daily basis. For determining weight loss (WL), ten fruits were weighed initially and after one day intervals. Then the weight loss was calculated as the difference between the initial weight and the weight of the fruit at the time of measurement and expressed as percentage (% of initial fruit weight). Total Soluble Solids (TSS) and acidity were determined as per standard methods of AOAC (1990). Rotting percentage were calculated on the basis of disease appearance, irrespective of the severity and decay percentage was calculated by the formula:(number of fruits decayed at each day/total number of fruits kept for observations at the beginning of storage) × 100. Shelf life of litchi fruit was assessed on the basis of rotting percentage (Chandramonti *et al*., 1991) and pericarp browning (Sharma and Ray, 1992). For this, score value of 5 for pericarp browning and 10% rotting of the fruits were considered as the critical limit of shelf life acceptance. All analyses were performed with three replications. The data obtained from each treatment in respect to different parameters during storage were subjected to analysis of variance (ANOVA) with treatment and storage time as sources of variation. Tukey's HSD (Honestly significant difference) test was carried out at a significance level of $P \leq 0.05$ to ascertain significant differences between the means.

Results and Discussion

The data pertaining to moisture loss is presented in Table 1 and also shown in graph-1. There is a progressive decrease in moisture loss due to evaporative loss during storage (Van den Berg 1987). As observed, minimum weight loss after sulphitation was recorded in Sulphited Litchi (T2) during storage followed by TI (Grape gourd + Liner) and maximum in control fruits. Packaging can reduce moisture loss by maintaining a high level of relative humidity (RH) inside the box or surrounding the fruits. Control of RH is mostly achieved by the use of packaging particularly in polyethylene pouches or any packaging material having quality to retain moisture. By using grape gourd and liner, high RH has been maintained and this might have prevented loss of moisture and hence less water loss is observed in T1. Paull and Chen (1987) also observed that litchi fruits packed in polyethylene film bags have shown reduced rate of dehydration. Also grape gourd and liner prevented direct exposure of fruits to air current as reported by Bagshaw 1995 in fruits. The increase in physiological loss in weight in control fruits might be due to evaporation and transpiration processes without any barrier.

The data pertaining about anthocynin content is presented in Table 2. It was observed from the table that the initial anthocynin content was high and found 34.6 mg/100g. Maximum anthocynin degradation was observed in sulphur fumigation (T2) followed by T4 (KMS sachet). It was observed that slowly red color bleached in treatment T1 (liner + grape gourd) and T4. This might be due to slow release of SO2 by grape gaurd and KMS sachets which might have reacts with moisture released by the fruits followed by production of sulphuric (H2SO4.) and sulphurous acid (H2SO3). The acid might have bleached the color of pericarp. It was also reported earlier by the researchers that the application of sodium metabisulphite (Na2S2O5) in the form of granular or powdered salts or Pad impregnated with sodium metabisulphite (Na2S2O5) or Potassium metabisulphite) releases SO2 when comes in contact with moist air and after reaction forms H2SO3 and H2SO4. The formation of H2SO3 and H2SO4 acids by the SO2 releasing pads induces fruit and stem bleaching (Zoffoli *et al*., 2001, Crisosto and Mitchell, 2002), Sulphur based treatments, particularly sulphur dioxide fumigation is widely applied in many lychee growing areas world-wide. Sulphur dioxide controls browning through the inhibition of PPO (Zauberman *et al.* 1991). Paper sheets impregnated with sodium metabisulphite (Na_2S2O_5) were also found to give good browning control (Schutte *et al*. 1990).

The result of total soluble solids (TSS) is tabulated in table 3 and graph 1. From the table, statistically non-significant increase was observed in total soluble solids (TSS). This might be due insignificant loss of moisture loss and dehydration of litchi juice. Morris *et al*., (1992) also noticed non-significant increase in total soluble contents. Similar results were also observed by Mhlophe, S.D. and Kruger, F.J., (2014) in sulphited Mauritius' Litchi Fruit before and after hydro cooling.

The data pertaining to spoilage is shown in Table 4. It was observed that maximum spoilage was observed in control treatment followed by the fruits packed with Liner only (T5). Minimum spoilage was observed in commercial practice of sulpher fumigations followed by grape gourd and liner (T2). This is in agreement with Morris *et al*. (1992) who observed that grapes stored with SO2 pads showed less decay than the controls irrespective of the pad used. Studies in South Africa by Schoeman *et al*. (2007) have shown that Uvasys SO2

sheets in combination with commercially fumigated fruit have a positive effect in terms of reducing decay during storage. Grape gourd along with Polyethylene liners provided a good decay control via stable SO2 emission rates by grape gaurd and homogeneous distribution of the SO2 gas inside the liner. The SO2 sheets (Uvasys and Vinguard) placed on the top of the litchi box showed overall good results in terms of decay control and SO2 residues analysis, as was also found for the cultivar 'Mauritius' in the trials by Schoeman *et al*. (2007).
Using grape gourd and liner for getting sulphuring inside the box may be an alternative method for small and marginal farmers who can't afford to create a commercial sulphuring facility. This method of in package sulphuring is not the replacement of commercial sulphuring process but an alternative. Fresh litchi fruits are packed in polyethylene liner along with grape gourd, KMS and sulpher powder sachets and kept in CFB box. It was observed that litchi fruit with or without stalk packed with grape gourd and liner maintained a shelf life of 5-7 days at ambient conditions without pericarp browning. Initially red peel color of litchi was bleached similar to sulphuring, but regained slowly with the passage of time. Based on the results, it can be suggested that grape gourd and liner used in package sulphuring of litchi fruits may be an alternative to commercial sulphuring process.

Table 1: Percent (%) water loss in litchi fruits

Treatment	% Water Loss			
	Storage Period (At Room Temperature)			
	Day- 2	Day- 3	Day-4	Day- 5
T1	1.75	1.95	2.43	3.53
T2	1.51	1.81	2.53	2.60
T3	1.85	2.46	3.50	4.07
T4	3.20	4.25	5.63	5.83
T5	5.31	4.50	5.50	5.31
T6	13.76	14.27	15.77	16.80
Sem	0.07	0.14	0.15	0.19
CD 5%	0.34	0.60	0.67	0.85

Treatment Combinations Used- T1- fruits were packed in a liner along with grape gourd, T-2 commercial practice of fumigation process T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment (Control).

Table 2: Anthocynin content (mg/100g)

Treatment	Anthocynin (mg/100g)			
	Storage Period (At ambient condition)			
	Day 2	Day 3	Day4	Day 5
T1	32.333	30.067	28.533	25.600
T2	10.200	9.533	10.733	12.533
T3	30.467	28.433	25.700	24.000
T4	19.667	18.067	12.533	13.000
T5	34.600	34.000	32.867	30.500
T6	30.300	28.167	0.000	0.000
SEm	0.983	0.497	0.649	0.401
CD 5%	NS	NS	2.910	1.798

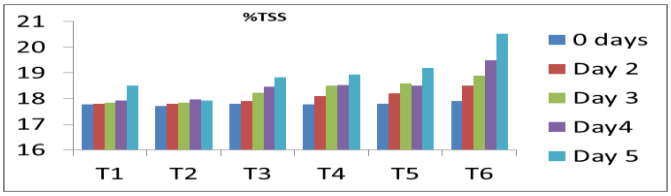
Initial anthocynin content 34.60 mg/100g

Treatment Combinations Used- T1- fruits were packed in a liner along with grape gourd, T-2 commercial practice of fumigation process T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment (Control)

Table 3: Total Soluble Solids (^{0}B)

Treatment	Total Soluble Solids (^{0}B)				
	Storage Period (At ambient condition)				
	Day 0	Day 2	Day 3	Day4	Day 5
T1	17.77	17.80	17.83	17.93	18.50
T2	17.70	17.80	17.83	17.97	17.93
T3	17.80	17.90	18.23	18.47	18.83
T4	17.77	18.10	18.50	18.53	18.93
T5	17.80	18.20	18.60	18.50	19.20
T6	17.90	18.50	18.90	19.50	20.53
SEm	0.25	0.22	0.38	0.45	0.40
CD 5%	NS	NS	NS	NS	NS

Treatment Combinations Used: T1- fruits were packed in a liner along with grape gourd, T-2 commercial practice of fumigation process T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment (Control).



Graph 1

Treatment Combinations Used- T1- fruits were packed in a liner along with grape gourd, T-2 commercial practice of fumigation process T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment (Control).

Table 4: Spoilage (%)

Treatment	% Spoilage			
	Storage Period (At ambient condition)			
	Day 2	Day 3	Day4	Day 5
T1	1.743	0.867	6.633	8.433
T2	0.000	0.000	0.000	0.847
T3	5.833	8.900	14.933	NA
T4	3.633	5.200	9.367	12.400
T5	9.000	20.100	NA	NA
T6	11.833	NA	NA	NA
SEm	0.110	0.127	0.171	0.141
CD 5%	NS	0.568	0.768	0.630

Treatment Combinations Used: T1- fruits were packed in a liner along with grape gourd, T-2 commercial practice of fumigation process T3- sachets of sulpher powder kept (2g) inside the liner before packing into the CFB boxes, T4- sachets of KMS (2g) kept inside the liner before packing into the CFB boxes. T5- Fruits kept in liner without any sachet and packed in CFB boxes. T6- fruits packed loose in the box without any treatment (Control).

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