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Effect of Sulphur Dioxide Pads on Enhancement of Shelf Life of Strawberry (*Fragaria ananassa*) under Ambient Condition

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A B S T R A C T

The research was carried out to study the effect of sulphur dioxide pads on shelf life of strawberry (*Fragaria ananassa*) under ambient condition (24 ± 26°C) with six treatments. SO_2 pads containing different mixtures of KMS and citric acid had no significant effect on the shelf life of strawberry. All the treatments, control as well as sulphur dioxide pads containing varied levels of SO_2 between 400 ppm and 2000 ppm were found on par with one other for shelf life of strawberry fruits under ambient condition. Thus the use of SO_2 pads had not prolonged shelf life of strawberry fruits and spoilage occurred in all the treated and controlled fruits within 4 days of storage.

Introduction

Strawberry (*Fragaria* x *ananassa* Duch) belongs to the family of Rosaceae which is one of the most important temperate fruit crops. The cultivated strawberry (*Fragaria* x *ananassa* Duch.) is a result of hybridization of two Native American species *F. chiloensis* (L) Duch. and *F. virginiana* Duch (Prakash, 1997).

Strawberry fruits are economically and commercially important and widely consumed as fresh or in processed forms, such as jams, juices, and jellies (Prakash, 1997). Because strawberry has high nutritive value which is rich in vitamins such as vitamin C (58.8 mg $100g^{-1}$), thiamine (0.024 mg $100g^{-1}$), niacin (0.386 mg $100g^{-1}$) and minerals like calcium (16 mg $100g^{-1}$), iron (0.41 mg $100g^{-1}$), magnesium (13 mg $100g^{-1}$), phosphorus (24 mg $100g^{-1}$) and potassium (153 mg $100g^{-1}$). In addition to that, it has energy (32 kcal $100g^{-1}$), protein (0.67g $100g^{-1}$), carbohydrates (7.68g $100g^{-1}$) and sugars (4.89g $100g^{-1}$) as well as 90.96 per cent water content. The red colour of the strawberry is because of one of the important phytochemical in the form of anthocyanin, present in fresh fruits and its values ranges

from 150 to 600 mg kg^{-1} total anthocyanin contents (Giampieri *et al.*, 2012).

Because of high moisture and high acidity contents strawberry are highly susceptible to fungal diseases and spoil within short period of time, hence less storage life. Strawberry fruits need to be harvested carefully and all the postharvest practices as packaging, transportation and handling have to be performed based on standard procedure accordingly (Zhang *et al.,* 2007). Some of the chemicals such as SO_2 and citric acid were used at varying levels to regulate the spoilage of strawberry fruits under refrigerated condition (Samiullah *et al.,* 2015). Sulphur dioxide reacts with water content of product and forms sulphurous acid at low pH (Rajesh, 1993). Sulphurous acid (H_2SO_3) react with cell membrane and block enzymes of the microorganism by reducing essential disulphide (-S-S-) linkage. Therefore inhibits the multiplication of microorganisms (Verma and Joshi, 2006). Hence, the investigation was conducted under ambient condition with use of sulphur dioxide pads on strawberries to minimize the postharvest decay and extend their shelf life.

Materials and Methods

The study on "Effect of sulphur dioxide pad on enhancement of shelf life of strawberry (*Fragaria ananassa*)" under ambient condition was carried out in the Department of Postharvest technology, College of Horticulture, University of Horticultural Sciences Campus, Gandhi Krishi Vigyana Kendra (PO), Bengaluru- 560065, Karnataka, India during the year 2013-2014.

The (Dimonte) cultivar of strawberry fruits procured from the Namdhari farm, Arkadu, Ooty, Tamil Nadu had been subjected for the study. Fruits were harvested at white tip stage of maturity in the early hours of morning and then transported through good transportation system. The fruits were subjected to treatment at lapsed time of 24 hours from the harvesting and on arrival at laboratory once again sorted (to remove misshaped, bruised, diseased and insect infected fruits) and graded for homogeneity of the experiment.

Sulphur dioxide pads were prepared from brown laminated paper which was essentially of quick release formulation. These guards were designed to release SO_2 gas within 24 - 48 hours of packing with strawberry.

The brown laminated paper was first cut into 14 cm × 11 cm sheets divided into 4 quarters per packet and they were sealed using an impulse heat sealing machine (SEPACK, India). The calculated amount of potassium metabisulphite (KMS) + citric acid (CA) was weighed and sealed in small packets.

Corrugated fiber board (CFB) boxes with dimensions of 15.50 cm × 12.50 cm × 9 cm bearing capacity to accommodating 500 g strawberries were used as a packaging material. These boxes had single 0.5" diameter holes punched at each side of the boxes.

The folded boxes were first opened up and the bottom closed and sealed with tape. The boxes were then lined with 1 layer of crepe paper (as cushion) with enough crepe paper left on the top to be used as flap for folding over the strawberries.

The boxes were lined with crepe paper both lengthwise and breadth wise. In each boxes 500 g of strawberry fruits were placed and the strawberry guard was placed onto the fruits. The crepe papers were folded over and the boxes sealed with sealing tape (Samiullah *et al.,* 2015).

The sulphur dioxide pad formulation consisted of two chemicals namely potassium metabisulphite (KMS) and citric acid (CA)

were mixed in the ratio of 10: 6 to prepare quick release formulation. The quick release formulation was prepared by mixing 100 g KMS and 60 g citric acid.

The efficacy of sulphur pads was tested using a complete randomized design with six treatments. Five treatments had SO_2 pads made up of mixture of KMS and citric acid @ 0.2g (400 ppm SO_2), 0.4g (800 ppm SO_2), 0.6g (1200 ppm SO_2), 0.8g (1600 ppm SO_2), and 1.0g (2000 ppm SO_2), and one control ((zero ppm SO_2). The treatments were replicated four times and conducted under ambient condition (24 ± 2^0C).

The parameters like TSS, titratable acidity, reducing sugar, total sugar, ascorbic acid, anthocyanin content, Cumulative Physiological Loss of Weight, firmness and decay loss were estimated by using standard procedures (Srivastava and Kumar, 2012 ; Khezrzadeh *et al.*, 2013). The sensory evaluation has done by using composite scoring test (Verma and Joshi, 2006).

Results and Discussion

Sulphur dioxide pads used to study their efficacy on decay control and also their effect on various physicochemical and quality attributes on fresh strawberries under ambient condition.

Study reveal that SO_2 pads had not showed significant effect on the shelf life of fruits as compared to the control and recorded continuous changes in physico-chemical parameters compared to initial data such as TSS(4.20^0B), titratable acidity (0.200%), reducing sugar (2.13%), total sugar (2.78%), ascorbic acid (59.0 $mg100g^{-1}$), anthocyanin (15.82 $mg100g^{-1}$) and firmness (0.832 $kgcm^{2-1}$) (Giampirie *et al.*, 2012). Results indicated that there was a continuous loss in weight and decay loss of the strawberries (Table 1) during storage. Significant differences in CPLW, decay losses and fruit firmness were not noticed among the treatments. The fruits treated with sulphur dioxide pads did not showed minimum loss in weight and decay losses and also high firmness as compared to control (without SO_2 pad), recorded on (1^{st}, 2^{nd} and 3^{rd} days respectively) (Krishnan, 2001; Shin *et al.*, 2008).

The data revealed that, the total soluble solids (TSS) had increased up to the last day of storage and not decreased as storage progressed (Table 2).

SO_2 pads did not have a significant effect on titratable acidity of strawberries and its content decreased continuously till end of storage (Jouki and Khazaei, 2012; Samiullah *et al.*, 2015).

Significant differences in reducing sugar and also total sugar of strawberries was not observed among the treated and control units of strawberry recorded on 1^{st}, $2^{nd}$and 3^{rd}days of storage respectively (Table 3).

Similar decreasing of reducing sugar and total sugars observed in all treatments and control units of strawberries until the end of shelf life of fruits (Cordenunsi, 2003; Nielsen and Leufven, 2008).

Ascorbic acid content of the strawberry fruits had decreased during storage period. The SO_2 pads had not have a significant effect on ascorbic acid content of strawberries as compared with control during three days of storage (Table 4).

Also the anthocyanin content of strawberries had increased during storage period. And there was not significant effect of SO_2 pads to maintain lowest content of anthocyanin in strawberries during storage period (Table 4) (Holcroft and Kader, 1999; Cordenunsi, 2003; Wang and Gao, 2013).

Table.1 Effect of different concentrations of sulphur dioxide pads on physiological properties of Strawberry fruits stored under ambient condition

Treatments	PLW (%) on storage days			Decay loss (%) on storage days			Firmness ($Kgcm^{-2}$)
	1st day	2nd day	3rd day	1st day	2nd day	3rd day	3rd day
T_1: Control	3.00	5.05	9.38	15.48	26.25	41.18	0.64
T_2: 0.2g (KMS + Citric acid)	2.90	4.62	9.17	12.53	26.18	41.30	0.64
T_3: 0.4g (KMS + Citric acid)	2.93	5.19	9.42	13.85	26.75	41.13	0.64
T_4: 0.6g (KMS + Citric acid)	2.87	4.83	9.25	11.63	26.53	40.70	0.63
T_5: 0.8g (KMS + Citric acid)	2.82	4.95	9.23	7.85	25.05	41.15	0.66
T_6: 1.0g (KMS + Citric acid)	2.65	5.15	9.08	5.48	25.38	41.70	0.66
S. Em±	0.165	0.279	0.272	0.437	0.456	0.794	0.022
CD @ 1%	0.671	1.137	1.109	1.781	1.859	2.525	0.091

Initial PLW = 0.00%; Initial decay loss = 0.0%;
Initial firmness = 0.832 $kgcm^{-2}$; KMS: Citric Acid @ 10: 6

Table.2 Effect of different concentrations of sulphur dioxide pads on biochemical properties of Strawberry fruits stored under refrigerated condition

Treatments	TSS (^{0}Brix) on storage days			Titratable acidity (%) on storage days		
	1st day	2nd day	3rd day	1st day	2nd day	3rd day
T_1: Control	4.98	6.03	4.53	0.153	0.138	0.119
T_2: 0.2g (KMS + Citric acid)	4.93	6.05	4.68	0.176	0.135	0.118
T_3: 0.4g (KMS + Citric acid)	4.78	5.98	4.68	0.137	0.157	0.118
T_4: 0.6g (KMS + Citric acid)	4.40	5.85	4.70	0.176	0.148	0.118
T_5: 0.8g (KMS + Citric acid)	4.63	5.95	4.70	0.188	0.149	0.121
T_6: 1.0g (KMS + Citric acid)	4.68	5.90	4.95	0.194	0.145	0.120
S. Em ±	0.121	0.198	0.116	0.006	0.006	0.002
CD @ 1%	0.493	0.809	0.473	0.026	0.025	0.008

Initial TSS = 4.20 ^{0}Brix;
Initial titratable acidity = 0.20 %;
KMS: Citric Acid @ 10: 6

Table.3 Effect of different concentrations of sulphur dioxide pads on reducing and Total sugars of strawberry fruits stored under ambient condition

Treatments	Reducing sugars (%) on storage days			Total sugars (%) on storage days		
	1st day	2nd day	3rd day	1st day	2nd day	3rd day
T_1: Control	3.23	3.50	3.08	3.78	3.87	3.57
T_2: 0.2g (KMS + Citric acid)	3.28	3.50	3.10	3.83	4.03	3.71
T_3: 0.4g (KMS + Citric acid)	3.30	3.48	3.20	3.60	3.89	3.69
T_4: 0.6g (KMS + Citric acid)	3.28	3.53	3.17	3.60	3.93	3.67
T_5: 0.8g (KMS + Citric acid)	3.43	3.60	3.12	3.66	3.91	3.71
T_6: 1.0g (KMS + Citric acid)	3.45	3.55	3.20	3.70	3.90	3.68
S. Em ±	0.125	0.086	0.131	0.091	0.085	0.119
CD @ 1%	0.512	0.350	0.536	0.370	0.346	0.487

Initial reducing sugars = 2.13%; Initial total sugars = 2.78%; KMS: Citric Acid @ 10: 6

Table.4 Effect of different concentrations of sulphur dioxide pad on ascorbic acid and Anthocyanin content of strawberry fruits stored under ambient condition

Treatments	Ascorbic acid (mg100g^{-1})			Anthocyanin (mg100g^{-1})
	1st day	2nd day	3rd day	3rd day
T_1: Control	58.04	57.31	55.75	33.89
T_2: 0.2g (KMS + Citric acid)	58.18	57.68	56.00	34.50
T_3: 0.4g (KMS + Citric acid)	58.12	57.68	55.88	33.85
T_4: 0.6g (KMS + Citric acid)	58.13	58.05	55.96	34.30
T_5: 0.8g (KMS + Citric acid)	57.98	57.97	55.85	34.20
T_6: 1.0g (KMS + Citric acid)	58.35	57.78	55.70	34.23
S. Em ±	0.251	0.137	0.261	0.461
CD @ 1%	1.025	0.557	1.064	1.877

Initial ascorbic acid = 59.0 mg 100g $^{-1}$; Initial anthocyanin = 15.82 mg 100 $^{-1}$, KMS: Citric Acid @ 10: 6

Table.5 Effect of different concentrations of sulphur dioxide pad on sensory traits of strawberry Fruits stored under ambient condition at 3rd day of storage

Treatments	Colour	Taste	Texture	Flavour	Absence of defects	Total scores
T_1: Control	13	12	12	13	13	63
T_2: 0.2g (KMS + Citric acid)	13	13	13	14	12	65
T_3: 0.4g (KMS + Citric acid)	14	13	12	13	13	65
T_4: 0.6g (KMS + Citric acid)	12	12	13	13	14	64
T_5: 0.8g (KMS + Citric acid)	13	13	12	14	13	65
T_6: 1.0g (KMS + Citric acid)	15	14	14	15	15	73
Initial scores	17	20	19	18	20	94

KMS: Citric Acid @ 10: 6

The study inferred that, SO_2 pads did not show positive effect on sensory characters such as colour, taste, texture, flavour and absence of defects in strawberry fruits under ambient condition of storage. The fruits treated with sulphur dioxide pad with various grams of KMS + citric acid had not recorded significant scores compared against initial score of 94 points (Table 5) (Pelayo *et al.*, 2003). This might be due to high respiration and transpiration rates, high temperature, increased microbial infection, induce catabolic activity of strawberry fruits and had not control of loss of weight (Shin *et al.*, 2008; Jouki and Khazaei, 2012; Srivastava and kumar, 2012).

The result revealed that, SO_2 pad is not effective treatment for enhancement of shelf life of strawberry under ambient condition. This might be due to high temperature that sulphur gas would be released quickly from the pads and then remove from containers. Meanwhile high temperature caused chemical injured fruits' surface through sulphur dioxide gases at first stage of its releasing as strawberry has fleshy tissues without any protective skin.

Therefore high respiration and transpiration rates, and also high catabolic process occur and thus fruits may be affected through severe microbial infection within storage period (Shin *et al.*, 2008).

The investigation, conclude that SO_2 pad did not show significant effect on shelf life of strawberry fruits under ambient condition. Sulphur dioxide pads containing different concentrations of KMS + citric acid did not prevent postharvest decay and had not extended the shelf life of Dimonte strawberries under ambient condition, compared to shelf life of fruits in control. All the treatments including the control have decayed in four days at ambient storage.

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