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RESEARCH ARTICLE

Effect of pre-harvest spray on the yield and shelf-life of white button mushroom [*Agaricus bisporus* (Lange) Sing.] during storage

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ABSTRACT

Pre-harvest sprays on white button mushroom (from pinning to harvesting) using different compounds has been found very effective in increasing quality and shelf-life. Pre-harvest spray of ascorbic acid (3%) was found to be the best as there was maximum sporophore yield (373.75 g/2 kg of compost) followed by ascorbic acid (4%) and calcium chloride (0.4%) by giving mushroom yield of 352.50 and 309.25 g/2kg of compost, respectively. Maximum number of fruit bodies (32.00) were recorded in 4 per cent ascorbic acid followed by 3 per cent ascorbic acid (31.75). Pre-harvest spray with 0.4 per cent $CaCl_2$ was found to increase the shelf-life of button mushroom as there was minimum colour change and reduced veil opening even after 144, 120, 96 hours of storage at 5, 12 and 18°C temperature, respectively.

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INTRODUCTION

When the supplies of water, organic substances and minerals are cut off at harvest, the fresh mushroom enters a deterioration or perishable phase. Veil opening and stem elongation are the usual symptoms of senescence constituting visible appearance of deterioration. At room temperature, the shelf-life of button mushroom can not be more than 48 hrs. During this period, there are considerable changes in colour, texture and taste. In addition, water is continuously being lost as a result of transpiration and respiration. The effective extension of storage life of fresh mushroom is a very delicate problem and shares higher costs in the post-harvest phase before selling by a growers, minimizing the number of handling, reducing the shocks during transportation and controlling the fast metabolic activity of the fresh mushroom would target to extent the storage life.

Chopra *et al.* (1985) studied the effect of pre-harvest aqueous sprays of honey, citric acid and *Euphorbia royleana* latex in different combinations on the storage life of *A. bisporus*. Veil opening was delayed and shrivelling was negligible even after 21 days of storage. The shelf-life was increased by more than a week over control at 3-5°C and 2-3 days at ambient temperature. Combination treatments of honey + citric acid + latex (0.5%+0.5%+0.5%) was also fairly effective.

Bartley *et al.* (1991) conducted the experiments and found that a combination of calcium chloride (0.25%) and 50 ppm stabilized chlorine dioxide (oxine) added to irrigation had significantly improved shelf-life of off-white button mushroom but had no effect on colour prior to harvest and resulted in a yield reduction. Soloman *et al.* (1991) grew both off-white and white hybrid strain of *A. bisporus* using four irrigation water treatments as : Tap water (control) : 50 ppm of stabilized chlorine dioxide (oxine) : 0.25 per cent of calcium chloride, and a combination of the two agents added together to tap water. With white hybrid mushrooms, none of the treatment had significant effect on yield but post-harvest quality and shelf-life were significantly improved, especially by the combination treatment.

Barwal (1992) observed that pre-harvest spray of

ascorbic acid (2%) improved the whiteness of sporophore of *A. bisporus* by inhibiting the polyphenol oxidases (PPO) activity and enzyme responsible for browning. Beelman *et al.* (1993) reported that shelf-life of mushroom can be improved by treatment of all irrigation water with 0.3 per cent $CaCl_2$ from the pinset through the end of the crop.

Suzanne and Beelman (1995) reported that influence of $CaCl_2$ in the water used to irrigate cultivated mushrooms (*A. bisporus*) was examined for its effect on protein and nitrogen content of the fresh mushroom, canned product yield and quality. Results of this study indicated the addition of $CaCl_2$ to irrigation water can provide an inexpensive and easy to employ method for processors to improve yield and quality of the canned product.

MATERIALS AND METHODS

To study the effect of different pre-harvest treatments on yield and shelf-life of *A. bisporus,* an experiment was laid out in which different concentrations of different chemicals alone and in combinations *viz.*, citric acid (1 and 2%), ascorbic acid (2, 3 and 4%), calcium chloride (0.2, 0.3 and 0.4%), citric acid (1%)+calcium chloride (0.3%), citric acid 2 per cent + honey 1per cent and turmeric (2 and 4 %) were sprayed at different stages of white button mushroom growth from pinning to harvesting to reduce the enzymatic browning and veil opening of white button mushroom. First spraying was done at sixth day of casing and second after fourth day of pinning, bags without pre-harvest treatment served as the control. Each treatment had four replications. The yield of white button mushroom, number of fruit bodies per bag, stipe pileus ratio, veil opening and whiteness were recorded.

To know the effect of pre-harvest spray on shelf-life of button mushroom, fruit bodies of same size, shape and uniform age were selected and were packed in non-perforated polythene bags (18x15 cm size, 100 gauge thickness) separately and kept at different temperatures (5, 12 and 18°C). Observations were recorded after 24, 48, 72, 96, 120 and 144 hrs of storage.

RESULTS AND DISCUSSION

The maximum sporophore yield (373.75 g/2 kg of compost) was recorded with 3 per cent concentration of ascorbic acid followed by sporophore yield 352.50 g and 309.25 g/2 kg of compost, respectively with 4 per cent concentration of ascorbic acid and 0.4 per cent concentration of $CaCl_2$ (Table 1a and Fig.1). In case of ascorbic acid when first spraying was done at pinning and 3-4 sprays were given after every flush and pinning started. Whereas, in case of $CaCl_2$ spraying was done from pinning to harvesting every day. The results are highly significant at 5 and 1 per cent level of significance (Table 1b).

Table 1a : Effect of pre-harvest spray of different chemicals on fruit bodies production of *Agaricus bisporus*

Sr. No.	Pre-harvest spray with different chemicals and concentration (%)	Avg. mushroom yield* (g/2kg of compost)	Avg. no. of fruit bodies/2kg of compost	Avg. individual fruit body weight (g)	Avg. biological efficiency (%)
1.	Citric acid 1%	281.25	25.25	11.13	14.06
2.	Citric acid 2%	266.25	22.00	12.10	13.31
3.	Ascorbic acid 2%	221.25	19.25	11.49	11.06
4.	Ascorbic acid 3%	373.75	31.75	11.77	18.68
5.	Ascrobic acid 4%	352.50	32.00	11.01	17.62
6.	$CaCl_2$ 0.3%+ Citric acid 1%	268.75	25.00	10.63	13.43
7.	Citric acid 1%+ Haney 1%	145.00	14.75	9.83	7.25
8.	Citric acid 2%+Honey 1%	105.00	12.00	8.75	5.25
9.	Turmeric extract 2%	171.25	19.50	8.78	8.56
10.	Turmeric extract 4%	193.75	20.50	9.45	9.68
11.	$CaCl_2$ 0.2%	232.25	18.00	12.90	11.61
12.	$CaCl_2$ 0.3%	266.75	21.50	12.40	13.33
13	$CaCl_2$ 0.4%	309.25	22.50	13.74	15.46
14	Tap water (control)	196.25	19.75	9.93	9.81
S.E.±		15.61		1.69	
C.D. at 5%		44.47		4.80	
C.D. at 1%		59.40		6.43	
C.V (%)		12.92		15.55	

* Average of four replications

Table 1b : Effect of pre-harvest spray of calcium chloride on quality of *Agaricus bisporus*

Sr. No.	Characters	$CaCl_2$ concentration			
		0.2%	0.3%	0.4%	Control
1.	Whiteness	+ + +	+ + +	+ + +	+ +
2.	Toughness	+ + +	+ + +	+ + +	+ +
3.	Veil opening	NVO	NVO	NVO	PVO
4.	Retention of whiteness during storage at 5^0C in refrigerator in unperforated polythene bags	7 days	7 days	8 days	5 days

+ + + = Excellent white; + + = Good white; + = Cream/ Off white, + + + = More tough; + + = Tough; + = Loose, NVO = No veil opening, PVO = Partial veil opening, VO = Veil opening

Table 1c : Effect of pre-harvest spray of ascorbic acid on quality of *Agaricus bisporus*

Sr. No.	Characters	Ascorbic acid concentrations			
		2.0 %	3.0 %	4.0 %	Control
1.	Whiteness	+ + +	+ + +	+ + +	+ +
2.	Toughness	+ + +	+ + +	+ + +	+ +
3.	Veil opening	NVO	NVO	NVO	PVO
4.	Retention of whiteness during storage at 5^0C in refrigerator in unperforated polythene bags	7 days	8 days	9 days	5 days

+ + + = Excellent white; + + = Good white; + = Cream/ Off white, + + + = More tough; + + = Tough; + = Loose, NVO = No veil opening, PVO = Partial veil opening, VO = Veil opening

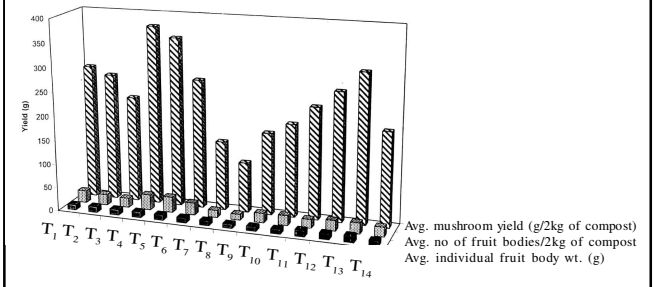

Fig.1 : Effect of per-harvest spray of different chemicals on yield, number of fruit bodies and average individual fruit body weight of *Agaricus bisporus*

The maximum number of fruit bodies were recorded in pre-harvest spray of ascorbic acid 4 per cent with 32.00 numbers per 2 kg of compost, followed by ascorbic acid 3 per cent with 31.75 and citric acid 1 per cent with 25.25. The maximum individual fruit body weight was found in $CaCl_2$ 0.4 per cent (13.74g) followed by $CaCl_2$ 0.2 per cent (12.90g) and $CaCl_2$ 0.3 per cent (12.40g). The maximum biological efficiency was recorded with ascorbic acid 3 per cent (18.68%) followed by ascorbic acid 4 per cent (17.62%) and $CaCl_2$ 0.4 per cent (15.66%), respectively (Table 1c).

It is apparent from data presented in Table 2 that pre-harvest spray of different chemicals with irrigation water significantly improved the shelf life of sporophore of white button mushroom. In case of citric acid (2%) veil was not opened up to 144 hours of storage at 5°C, 120 hours of storage at 12°C and 96 hours of storage at 18°C whereas, in the citric

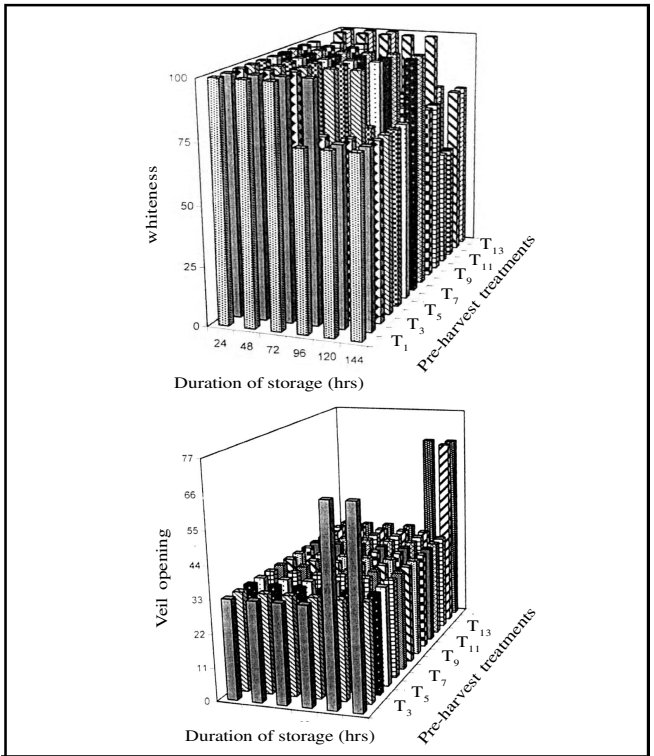

Fig. 2 a: Effect of different pre-harvest sprays of different chemicals on whiteness and veil opening of *Agaricus bisporus* at different durations at 5^0C temperature

acid (1%) veil was not opened after 120 hours at 5°C, 72 hours at 12°C and 48 hours at 18°C temperature (Fig. 2 a, b and c). Thus, it can be concluded that higher concentration (2%) of citric acid proved better as compared to 1 per cent concentration.

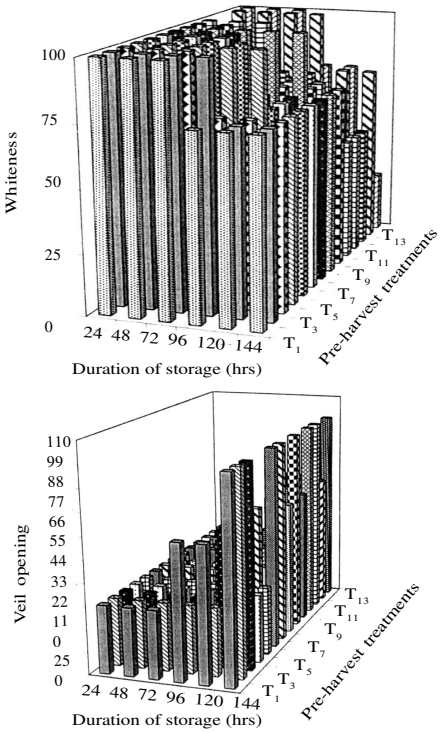

Fig. 2 b: Effect of different pre-harvest sprays of different chemicals on whiteness and veil opening of *Agaricus bisporus* at different durations at 12^{0}C temperature

Regarding the colour of mushroom (whiteness) excellent whiteness was observed up to 96 hours of storage at 5, 12 and 18°C temperature whereas, good whiteness was observed up to 144 hours of storage at 5, 12 and 18°C, when mushroom were given pre-harvest treatment of citric acid (2%). In case of ascorbic acid higher concentration (3% and 4%) improved the shelf life as compared to lower concentration (2%). Veil was not opened up to 144 hours of storage period at 5 and 12°C temperature whereas, at 18°C excellent whiteness with no veil opening was recorded up to 96 hours of storage period. Ascorbic acid (3 and 4%) had similar results.

When pre-harvest spray of calcium chloride (0.2 and 0.3%) were given to casing excellent whiteness with no veil opening was retained up to 144 hours of storage at 5°C whereas, good whiteness with no veil opening was observed only up to 96 hours of storage period at 12°C. Moreover, good whiteness with no veil opening was found only up to 96 hours of storage at 18°C. Higher concentration of calcium

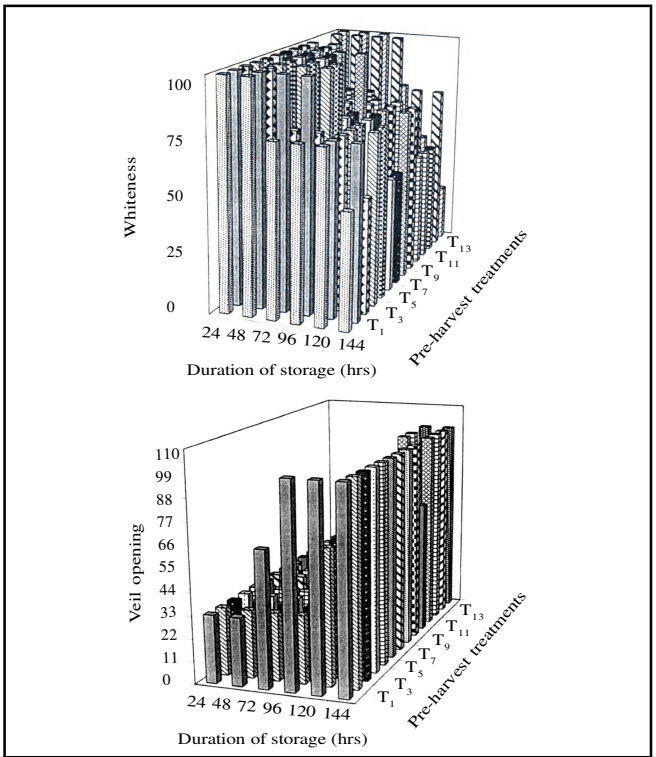

Fig. 2 c: Effect of different pre-harvest sprays of different chemicals on whiteness and veil opening of *Agaricus bisporus* at different durations at 18^{0}C temperature

chloride (0.4%) gave very good results *i.e.*, excellent whiteness with no veil opening was retained up to 144, 120 and 96 hours of storage at 5, 12 and 18°C temperature, respectively. Combination of citric acid 1 per cent + honey 1 per cent and citric acid 2 per cent + honey 1per cent gave good whiteness with no veil opening up to 144 hours of storage at 5°C whereas, good whiteness and no veil opening was found up to 96 hours of storage at 12 and 18°C storage temperature.

To check the bacterial population in the casing soil extract of fresh turmeric was sprayed on casing soil, from pinning to harvesting. It was observed that 2 and 4 per cent of fresh turmeric extract resulted in good whiteness and no veil opening up to 96 hours of the storage at 5 and 12°C whereas, good whiteness and no veil opening was found up to 72 hours of storage at 18°C. However, there was no significant variation in both the concentrations.

In control (tap water) [pH 8.3, EC 1.61 dS/m, SAR 23.67, RSC 14.3 Meq/litre, CO_3^- 1.6, HCO_3^- 18.9, Cl- 6.2, Ca+Mg 6.6, Na^+ 43, K^+ 1.3 Meq/litre] excellent whiteness with no veil opening was observed up to 72 hours of storage at 5, 12 and 18°C and good whiteness and partial veil opening were observed after 96 hours of storage. Moreover, at 12 and 18°C browning and rotting were observed after 144 hours of storage.

Thus, it can be concluded that $CaCl_2$ 0.3 and 0.4 per cent

retained excellent whiteness with no veil opening up to 144 hours of storage and ascorbic acid (3%), citric acid (1%)+$CaCl_2$ (0.3%) and $CaCl_2$ (0.2, 0.3 and 0.4%) retained excellent whiteness and no veil opening up to 120 hours of storage at 5°C temperature.

Moreover, citric acid (2%), ascorbic acid (3 and 4%) and $CaCl_2$ (0.4%) showed the excellent whiteness and no veil opening up to 96 hours even kept at higher temperature (18°C). Even after 168 hours of storage at 18°C pre-harvest treatment of mushroom with turmeric extract (4%) the bacterial blotch and rotting was found in traces as compared to other treatments followed by citric acid (1%)+honey (1%), turmeric extract (2%). Whereas, remaining treatments showed severe rotting and blotch development.

It was found that pre-harvest spray of ascorbic acid (3%) gave significantly higher yield and improved the whiteness by inhibiting the polyphenol oxidases activity. The results also indicate that pre-harvest spray of 4 per cent ascorbic acid and 4 per cent $CaCl_2$ also increased the yield than the other treatment in the experiment when first spraying is done at pinning and 3-4 sprays up to harvesting while in case of $CaCl_2$ spray every day after pinning up to harvesting.

In the present study the fruit bodies produced after pre-harvest spray were kept at 5, 12 and 18°C for different durations. Pre-harvest spray of $CaCl_2$ (4%) was found best for increasing the shelf-life of sporophore as it did not allow veil opening up to 96 hrs at 18°C though at lower temperature the period taken was 120 hrs and 144 at 12°C and 5°C, respectively. The whiteness remained excellent at all the temperatures and duration of storage studied before veil opening.

Ahlawat and Rai (1996) reported that commercially popular strain (S-11) of *A. bisporus* was grown using various irrigation treatments *i.e.,* tap water as control, 0.1, 0.2, 0.3 and 0.4 per cent $CaCl_2$ in irrigation water commencing from basidiocarp initiation. Yield was not affected much by any of the treatments, however, 0.2 and 0.4 per cent $CaCl_2$ treatment gave slightly more yield than control, whiteness and toughness were found better in 0.2 and 0.4 per cent $CaCl_2$ treatment and the whiteness of mushroom in 0.4 per cent treatment after 7 days of storage at 10°C remained almost equal to fresh mushrooms from control treatment. Singh *et al.* (1997) studied the pre-harvest influence of different chemicals in relation to enzymatic browning in *A. bisporus*.

These results are in confirmation with Barwal (1992) who observed that pre-harvest spray of ascorbic acid (2%) improved the colour by inhibiting the polyphenol oxidases activity and enzyme responsible for browning. In present investigation it was found that treatment of all irrigation water with 0.4 per cent calcium chloride from the pinset through the end of the crop resulted in higher mushroom yield and improved whiteness.

Beelman *et al.* (1993) reported that the shelf-life of mushroom can be improved by treatment of all irrigation water with 0.3 per cent $CaCl_2$ from pinset through the end of the crop. Rai and Ahlawat (1997) worked on white button mushroom (*A. bisporus*) by addition of $CaCl_2$ in irrigation water. The finding in the present studies are in agreement with the work of Beelman *et al.* (1993) and Rai and Ahalawat (1997).

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