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STUDY ON EFFECT OF AZOXYSTROBIN ON SHELF LIFE OF FRESH CUSTARD APPLE FRUITS

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ABSTRACT
An attempt was made to study the efficacy of postharvest treatment of azoxystrobin on the keeping quality of fresh custard apple fruits under cold storage. The custard apple fruits were treated with different concentrations of azoxystrobin and the results revealed that the fruits treated with 0.2 per cent azoxystrobin for 5 minutes had minimum per cent weight loss (5.42±0.30), least respiration rate (24.85 mlCO2/kg/hr), maximum firmness (3.36N), maintained good color values of peel *viz., L** 51.32; *b** 28.41; *C** 31.54; and *ho* 90.70 and minimum *a** value (-1.16). The treatments also maintained good pulp color values *viz., L** 46.13; *b** 11.86; *C** 9.95; and *ho* 92.10, and minimum *a** value (-0.96) and higher sensory scores with respect to appearance (4.75), texture (4.88) and taste and flavour (4.88) at the end of 12 days of cold storage as compared to other treatments. These results show that azoxystrobin is a potential candidate and has immense scope to be used as a post harvest treatment to increase the shelf life of the fruits.

INTRODUCTION

Custard apple fruits are one of the best tasting fruits with appropriate balance of sugars, acids and highly flavoured with soft creamy flesh. The fruit crop is regarded as an underutilized fruit crop which is bagging premium price in the super markets of metro cities. With so much of economic value, this crop suffers a very short postharvest shelf life *i.e.* the fruit become soft within 2-3 days of harvest and sometimes they will crack open, if not consumed within 4-5 days (Gohlani and Bisen, 2012). The pericarp will turn brown to black losing its commercial value and fruits will ultimately decay (Ke *et al.*, 1983). This may be due to combined physicochemical changes like ethylene evolution, respiration, high pectin methyl esterase activity leading to losing the firmness and shortening of shelf life. Even though many works were conducted to overcome these problems but still a successful method is yet to be evolved.

The introduction of new reduced-risk fungicides, as low mammalian toxicity, low toxicity to non-target organisms, low maximum residue limits, compatible with other post harvest management practices (Adaskaveg *et al.*, 2005), opens the possibility to use chemical control strategies to protect custard apple fruits thereby prolonging their shelf life. Azoxystrobin, a fungicide by nature, belongs to strobilurin group having a broad spectrum control against major groups of pathogenic fungi. It is non-toxic to humans and the environment and approved for use at EU level. Studies have shown that strobilurins have some influence on the physiological processes of plants even if it is not infected with the disease. Azoxystrobin is the first of a new class of pesticidal compounds called ß-methoxyacrylates, which are derived from the naturally-occurring strobilurins. Their biochemical mode of action is inhibition of electron transport and cessation of normal energy production which leads to cell death thus inhibiting the pathogen growth (Harrison and Tedford, 2002). Azoxystrobin is of low acute and chronic toxicity to humans, birds, mammals, and bees. It is a systemic, broad-spectrum fungicide that was first introduced in 1998. Among the diseases it controls are rusts, downy and powdery mildew, rice blast and apple scab (Richard, 2014). The present study was planned with the hypothesis that reduction of disease incidence in custard apple fruits may in turn help in retaining the fruit quality during its storage as in some of the studies this compound has show positive effect in enhancing the quality of the fruits. Keeping all these facts in view this study was planned with the objective to check the effect and efficacy of azoxystrobin at different concentrations on the shelf life of custard apple fruits stored under low temperature

MATERIALS AND METHODS

Fruits of uniform size, shape and maturity were harvested in the evening cool hours to avoid the field heat and brought to the laboratory in plastic crates. The damaged, bruised, punctured and infected fruits were discarded manually. Then, the healthy fruits were pre-cooled in cold storage at 13 ± 1ºC for twelve hours to reduce field heat. After removal from the cold room, fruits were thoroughly washed in 0.2 per cent sodium hypochlorite solution for five minutes to remove the surface microbial load and dirt adhered to the fruit surface. Immediately, fruits were air dried under fan to remove the surface moisture. These fruits were then used for further experimentation to impose postharvest treatment with azoxystrobin at different concentrations to study its influence on behaviour and shelf life during storage.

The fruits were divided into four lots of 80 fruits each, the first being control, the second, third and fourth lot were treated with azoxystrobin at a concentration of 0.05, 0.1 and 0.2 per cent respectively for 5 mins. The experiment contained 4 treatments with 5 replications involving 16 fruits per replication. After subjecting to dipping for specific duration in the respective treatment, custard apple fruits were surface dried under electric fan. Then the fruits were packed in ventilated corrugated fibre board (CFB) boxes. Paper lining was provided between the two layers of the fruits and paper shreds were used to provide cushioning and avoid fruits directly coming in contact with each other.

Physical parameters

Physiological loss in weight (PLW %)

In each replication, 4 fruits were ear marked to record the PLW. The marked fruits in each replication of the respective treatment were weighed individually at the beginning of storage to record the initial weight. On subsequent days of observation, the fruits were weighed again. The cumulative losses in weight of fruits were calculated and expressed as per cent physiological loss in weight.

$$\text{Physio log ical loss in weight} = \frac{\text{Initial weight - final weight}}{\text{Intial weight}} \times 100$$

Firmness (N)

Firmness of custard apple flesh was measured on both sides of the fruit at regular intervals taking a fruit from each replication by using force guage (Make: Lutron FG-5000A).

Respiration rate (ml CO2/kg/h)

Respiration rate was measured with a CO2 gas analyzer (Make: PBI Dansensor, CheckMate - II) following static method. The fruit was weighed and placed in a hermetically sealed container of 1250 ml capacity for 60 minutes. At the end of incubation period, gas sample was drawn from the container head space using gas tight syringe and injected into the CO2 analyzer. The change in CO2 gas concentration in the head space and time was read in the instrument was recorded. The respiration rate of the fruit was expressed as ml CO2/kg/h.

The rate of respiration was calculated using the formula-

$$\text{Rate of respiration(ml CO2/kg/hr} = \frac{\text{Change of CO}^2\text{con} \times \text{vol .of the.container(ml)}}{100 \times \text{Weight of the fruit(kg)} \times \text{Time(h)}}$$

Colour (*L *a** *b**, *C** and *ho*)**

The colour of the samples was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8 mm diameter aperture and the instrument was adjusted at 10° observer and D65 primary illuminant. The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovibond units *L** (Lightness/darkness), *a** (redness/greenness), *b** (yellowness/blueness), *C** (chroma) and *ho* angle (hue). Custard apple fruits were directly placed under the aperture of the colour meter to record the observations.

Biochemical parameters

TSS (oB)

The juice extracted by squeezing the fruit pulp through muslin cloth was used to measure the TSS. It was determined by using ERMA hand refractometer, replicated three times and the mean was expressed in oB.

Titratable acidity (%)

A known volume of juice sample (10 ml) was taken and titrated against standard NaOH using phenolphthalein indicator. The appearance of light pink colour was marked as the end point. The value was expressed in terms of citric acid as per cent titratable acidity of juice (AOAC, 1984).

Organoleptic evaluation of fruits

Organoleptic evaluation of fruits was carried out by a panel of 6 semi-trained judges at 4th, 8th and 12th day after treatment. The sensory characters like appearance, texture and, taste and flavour were evaluated on a 5 point Hedonic scale.

Statistical analysis

Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2.0 (Jangam and Thali, 2010). All data the collected were analysed by one-way analysis of variance (ANOVA). Significant differences among means at $P \leq 0.05$ were determined by post hoc tests using Duncan's multiple range test.

RESULTS AND DISCUSSION

The surface treatment with different concentrations of azoxystrobin significantly affected the post harvest life of custard apple fruits. The physiological loss in weight of the custard apple fruits increased with the increase in storage period (*Table 1*). The minimum per cent weight loss (5.42 ± 0.30) was observed in the fruits treated with azoxystrobin at 0.2 per cent for 5 minutes which was on par with the treatment 3 (0.1 per cent azoxystrobin) (7.43 ± 0.29) throughout the storage period of twelve days whereas maximum (14.01 ± 1.50) was observed in untreated fruits. The lower physiological loss in weight in the life of any fruit or vegetable is due to transpiration and due to other metabolic activities such as respiration. Higher weight loss in the untreated fruits is may be due the breakdown of stored food material, higher transpirational loss and increased respiration of the fruits.

Increase in the respiration rate of custard apple fruits was observed throughout the storage period of 12 days. The least respiration rate of 24.85 ± 1.64 ml CO2/kg/h was observed in the fruits treated with azoxystrobin at 0.2 per cent which was on par with the treatment 3 (azoxystrobin at 0.1 per cent) (29.74 ± 1.58). The maximum (37.52 ± 2.92) respiration rate was observed treatment 3 which was non-significantly related with the untreated fruits. This may be due to the treatment effect which might have delayed hydrolysis of starch in turn reducing the availability of sugars for the respiration process and also the prevailing low temperature in the storage which might have reduced the respiration rate.

As the storage period increased there was decrease in the firmness of the custard apple fruits in all the treatments. In the custard apple fruits firmness is the most important parameter which accounts for its shelf life. The firmness was higher in 0.2 per cent azoxystrobin treated fruits which might be due to the lower metabolic activity more precisely because of the lower respiratory activity during which there is utilization of carbohydrates which makes the cells to lose their turgidity. Increased respiration and conversion of pectin to simpler forms in the untreated fruits might have reduced the firmness.

There was increase in total soluble solids along the storage period in all the treatments. Significantly higher TSS was observed in the treatments T1 and T2 as compared to T3 and T4 (*Table 2*). The fruits treated with 0.1 and 0.2 per cent azoxystrobin shown significantly lower TSS which may be due to the lower respiration rate which might have reduced the conversion of starch to sugar.

There was increase in the titratable acidity along the storage period in all the treatments. The increased titratable acidity might be due to the synthesis of ascorbic acid in the fruits. The increase in ascorbic acid content might be the result of greater synthesis of glucose-6-phosphate, a precursor of L-ascorbic acid (Kumari *et al*., 2015). And in the untreated fruits the loss of higher amount of moisture might have concentrated the acid content the fruits so resulting in the higher titratable acidity.

Changes in the peel colour of custard apple fruits were monitored by measuring *L** (lightness value), *a** value, *b** value, chroma value (*C**) and hue angle (*ho*) during 12 days of storage at 13 + 1°C (*Table 3*). Parameter related to luminosity is an excellent index for evaluation of color in fruits (Saucedo-Pompa *et al.,* 2007). Treated and untreated fruit samples showed a significant decrease in the peel *L*, b*, C* value and *ho* and increase in *a** value during the storage period of twelve days. The least decrease in the peel *L*, b*, C* value and *ho* was observed in the treatment T4 as compared all other treatment indicating less darkening of the fruits. Similarly pulp *L*, a** value, *b** value, chroma value and hue angle was studied during 12 days of storage at 13 + 1°C. There was decrease in the pulp *L*, b*, C* value and *ho* and increase in *a** value was observed indicating change in the pulp colour

Table 1: Influence of azoxystrobin treatments on physiological loss in weight, firmness and respiration rate of custard apple fruits under cold storage (13 + 1°C and 85 % RH). Similar alphabets within the column represents non-significant differences at ($p < 0.05$) probability level according into Duncan's multiple range test.

Days after storage

	Initial	4	8	12
Physiological loss in weight (%)				
Control	0	3.97 ± 0.23a	8.28 ± 0.77a	14.01 ± 1.50a
0.05% Azoxystrobin		3.97 ± 0.17a	7.11 ± 0.26a	9.86 ± 0.26b
0.1% Azoxystrobin		2.70 ± 0.24b	5.06 ± 0.28b	7.43 ± 0.29bc
0.2% Azoxystrobin		1.74 ± 0.20c	3.77 ± 0.22b	5.42 ± 0.30c
Firmess (N)				
Control	7.37	3.86 ± 0.11b	2.75 ± 0.18b	1.73 ± 0.25c
0.05% Azoxystrobin		4.10 ± 0.19b	2.97 ± 0.21b	2.24 ± 0.27bc
0.1% Azoxystrobin		4.96 ± 0.35a	3.99 ± 0.22a	2.82 ± 0.33ab
0.2% Azoxystrobin		5.42 ± 0.24a	4.14 ± 0.46a	3.36 ± 0.30a
Respiration rate (ml CO2/Kg/h)				
Control	15.23	26.95 ± 1.86a	37.36 ± 4.14a	35.96 ± 4.58a
0.05% Azoxystrobin		24.12 ± 1.84ab	29.47 ± 2.45ab	37.52 ± 2.92a
0.1% Azoxystrobin		19.7 ± 2.55bc	24.58 ± 0.64bc	29.74 ± 1.58ab
0.2% Azoxystrobin		16.55 ± 2.13c	19.96 ± 1.66c	24.85 ± 1.64b

Table 2: Influence of azoxystrobin treatments on TSS and titratable acidity of custard apple fruits under cold storage (13 + 1°C and 85 % RH). Similar alphabets within the column represents non-significant differences at ($p < 0.05$) probability level according into Duncan's multiple range test.

Days after storage

	Initial	4	8	12
TSS (°B)				
Control		22.25 ± 0.95a	29.50 ± 0.87a	28.40 ± 0.36a
0.05% Azoxystrobin	10.6	18.60 ± 0.24b	24.15 ± 0.43b	27.50 ± 0.29a
0.1% Azoxystrobin		16.75 ± 0.25c	21.25 ± 0.48c	25.50 ± 0.29b
0.2% Azoxystrobin		14.80 ± 39d	19.50 ± 0.29d	25.00 ± 0.41b
Titratable acidity (%)				
Control	0.19	0.27 ± 0.01a	0.30 ± 0.01a	0.34 ± 0.01a
0.05% Azoxystrobin		0.25 ± 0.01a	0.29 ± 0.01a	0.32 ± 0.01b
0.1% Azoxystrobin		0.24 ± 0.01ab	0.27 ± 0.01b	0.29 ± 0.01c
0.2% Azoxystrobin		0.22 ± 0.01b	0.26 ± 0.01b	0.28 ± 0.01c

Table 3: Influence of azoxystrobin treatments on instrumental peel color values of custard apple fruits under cold storage (13 + 1ºC and 85 % RH). Similar alphabets within the column represents non-significant differences at (p < 0.05) probability level according into Duncan's multiple range test.

Days after storage

	Initial	4	8	12
L values*				
Control		47.33±0.36d	42.58±0.75d	37.66±0.33d
0.05% Azoxystrobin	63.04	52.08±0.49c	46.49±0.90c	42.42±0.40c
0.1% Azoxystrobin		55.60±0.33b	50.98±0.55b	46.26±0.76b
0.2% Azoxystrobin		60.88±1.46a	54.45±0.68a	51.32±0.67a
a value*				
Control	-5.65	2.61±0.11a	3.24±0.18a	4.19±0.19a
0.05% Azoxystrobin		0.52±0.24b	1.54±0.20b	3.13±0.31b
0.1% Azoxystrobin		-2.23±0.41c	-0.96±0.37c	0.06±0.37c
0.2% Azoxystrobin		-4.41±0.24d	-2.32±0.30d	-1.16±0.39d
b value*				
Control	40.9	23.73±0.38d	19.70±0.72d	16.28±0.48d
0.05% Azoxystrobin		25.87±0.28c	22.27±0.64c	18.27±0.65c
0.1% Azoxystrobin		32.81±0.27b	28.94±0.26b	25.35±0.41b
0.2% Azoxystrobin		35.07±0.46a	32.10±0.36a	28.41±0.34a
C values*				
Control	37.86	24.30±0.32d	20.93±0.45d	16.82±0.52d
0.05% Azoxystrobin		29.36±0.46c	26.37±0.52c	22.53±0.33c
0.1% Azoxystrobin		32.53±0.45b	28.76±0.15b	26.24±0.21b
0.2% Azoxystrobin		36.19±0.73a	34.02±0.34a	31.54±0.38a
h° values				
Control	103.78	88.33±0.83d	83.83±0.41d	79.99±0.56d
0.05% Azoxystrobin		92.01±0.32c	86.85±0.57c	83.13±0.71c
0.1% Azoxystrobin		94.98±0.61b	91.74±0.33b	88.60±0.45b
0.2% Azoxystrobin		98.83±0.60a	94.67±0.89a	90.70±0.55a

Table 4: Influence of azoxystrobin treatments on instrumental pulp color values of custard apple fruits under cold storage (13 + 1ºC and 85 % RH). Similar alphabets within the column represents non-significant differences at (p < 0.05) probability level according into Duncan's multiple range test.

Days after storage

	Initial	4	8	12
L values*				
Control		62.63±1.01d	49.59±2.42c	19.86±1.56d
0.05% Azoxystrobin	92.56	77.21±0.96c	59.48±1.08b	29.56±2.54c
0.1% Azoxystrobin		81.86±0.62b	68.98±1.38a	38.86±0.76b
0.2% Azoxystrobin		86.53±0.56a	74.28±2.01a	46.13±2.77a
a value*				
Control	-4.74	-0.82±0.04a	-0.20±0.08a	0.94±0.02a
0.05% Azoxystrobin		-0.93±0.04b	-0.45±0.05b	0.65±0.05a
0.1% Azoxystrobin		-1.25±0.03c	-1.05±0.01c	-0.31±0.31b
0.2% Azoxystrobin		-1.43±0.02d	-1.25±0.04d	-0.96±0.02c
b value*				
Control	19.54	10.08±0.17d	7.91±0.30d	5.26±0.48d
0.05% Azoxystrobin		12.07±0.22c	10.01±0.28c	7.41±0.18c
0.1% Azoxystrobin		14.52±0.37b	12.24±0.33b	10.27±0.66b
0.2% Azoxystrobin		18.02±0.33a	15.38±0.33a	11.86±0.44a
C values*				
Control	18.24	10.05±0.35d	7.74±0.10d	5.43±0.47c
0.05% Azoxystrobin		12.11±0.13c	10.64±0.28c	7.51±0.21b
0.1% Azoxystrobin		13.40±0.16b	11.66±0.35b	8.99±0.26a
0.2% Azoxystrobin		15.71±0.10a	12.91±0.44a	9.95±0.40a
h° values				
Control	101.45	92.81±0.40d	87.26±0.59d	81.88±0.64d
0.05% Azoxystrobin		94.81±0.21c	91.71±0.45c	86.75±1.01c
0.1% Azoxystrobin		96.58±0.34b	93.35±0.39b	88.96±0.07b
0.2% Azoxystrobin		99.03±0.38a	95.01±0.41a	92.10±0.24a

(*Table 4*). A significant difference was observed in between the treated and control treatment which can be because of the treatment effect. A favourable effect of azoxystrobin on mango fruit quality through effective decay control has been reported (Siliang *et al.,* 2012). Exact reason for this can[redacted]t be quoted because there is less exploitation of the comp[redacted]nd as a post harvest treatment so studies need to be conduct[redacted]d to know its role in retaining the quality of the fruits.

Table 5: Influence of azoxystrobin treatments on sensory qualities (5 point hedonic scale) of custard apple fruits under cold storage (13 + 1°C and 85 % RH). Similar alphabets within the column represents non-significant differences at ($p < 0.05$) probability level according into Duncan's multiple range test.

Days after storage	4	8	12
Appearance scores			
Control	4.32 ± 0.12b	4.13 ± 0.13c	1.88 ± 0.16d
0.05% Azoxystrobin	4.63 ± 0.07a	4.38 ± 0.07bc	3.32 ± 0.28c
0.1% Azoxystrobin	4.63 ± 0.13a	4.63 ± 0.07b	4.17 ± 0.06b
0.2% Azoxystrobin	4.88 ± 0.07a	4.94 ± 0.06a	4.75 ± 0.18a
Texture scores			
Control	4.44 ± 0.12a	4.25 ± 0.23b	1.32 ± 0.19c
0.05% Azoxystrobin	4.38 ± 0.07ab	4.25 ± 0.23b	2.69 ± 0.19b
0.1% Azoxystrobin	4.07 ± 0.16bc	4.75 ± 0.10ab	4.44 ± 0.12a
0.2% Azoxystrobin	4.00 ± 0.10c	4.94 ± 0.06a	4.88 ± 0.07a
Taste and flavour scores			
Control	4.69 ± 0.06a	3.94 ± 0.12c	1.19 ± 0.12d
0.05% Azoxystrobin	4.44 ± 0.06a	4.38 ± 0.24bc	1.82 ± 0.19c
0.1% Azoxystrobin	3.82 ± 0.24b	4.75 ± 0.10ab	4.44 ± 0.06b
0.2% Azoxystrobin	3.50 ± 0.20b	4.94 ± 0.06a	4.88 ± 0.07a

Azoxystrobin treated fruits obtained good sensory scores throughout storage period as compared to non-treated fruits. On the 8th day of storage highest scores were obtained by azoxystrobin treated fruits depicting the peak ripe stage of fruits and there was decrease in the scores thereafter (*Table 5*). Considering the low toxicity value and approvals from the EU, azoxystrobin is a potential candidate to use as a postharvest treatment to increase the useful life of the fruits.

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