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Effect of Pre Harvest Sprays of Calcium Compounds and Bagging on Post Harvest Quality of Summer Season Guava (*Psidium guajava* L.) cv. Allahabad Safeda

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ABSTRACT: An experiment entitled entitled "Effect of pre harvest sprays of calcium compounds and bagging on post harvest quality of summer season guava (*Psidium guajava* L.) Cv. Allahabad Safeda" was carried at Jookal village in Jayashankar Bhupalpally district during the year 2022-2023. The experiment was carried out with Factorial Randomized Block Design (FRBD) with 15 treatments and three replications with 2 factors. Factor one consists of sprays *viz.*, S_1- $CaCl_2$ @ 1 %, S_2- $Ca(NO_3)_2$ @ 1 %, S_3- $CaSO_4$ @ 1 % and factor two consists of bagging materials *viz.*, B_1- Muslin cloth bag, B_2- Non woven bag, B_3- Brown paper bag, B_4- Blue polyethylene bag, B_5- No bagging (Control).The experiment results revealed that pre harvest sprays of calcium compound $Ca(NO_3)_2$ @ 1 % and bagging with muslin cloth bag resulted in maximum fruit quality parameters such as TSS (13.33 °Brix), total sugars (15.55 %), reducing sugars (5.72 %), non reducing sugars (9.83 %), ascorbic acid content (196.99 mg /100g of pulp), pectin content (1.28 %) and minimum titratable acidity (0.28 %).These findings highlight the importance of different spraying of calcium compounds and bagging materials on fruits that controls fruit flies,pests ,diseases and improves the post harvest quality of fruits.

Keywords: Allahabad safeda, Spraying, bagging, Quality improvement and fruit flies.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the popular fruits in India. It is a member of the Myrtaceae family and is called as 'Apple of the tropics' or 'Poor man's apple'. It is native to tropical and sub-tropical regions of Mexico, Central and South America. The guava tree is fairly hardy and can withstand adverse climate conditions. It has ability to grow in a diverse ecological situation, such as wastelands and sandy loam to clay loam soils with substantially higher pH levels of 8.6 to 9.6. Guava is one of the most delicious and healthy fruits, liked for its refreshing taste and pleasant flavor. It is consumed commonly as a fresh fruit and may also be used to make many processed products including jelly, jam, toffee, juice, RTS, canned dices, nectar, squash, ice cream, wine and syrup. Guava has significant economic and productive potential. It has nutritional value and therapeutic characteristics. It is low calorie fruit, rich in dietary fiber. The guava fruit is an excellent source of vitamin C (235 mg/100g fruit) and pectin (1.15%). The fruit has an appreciable amount of minerals such as phosphorus (23 to 37mg/100g), calcium (14 to 30 mg/ 100g), iron (0.6 to 1.4 mg/100 g) as well as vitamins like niacin, thiamine, riboflavin and vitamin A (Singh *et al*., 2013).

Spraying calcium during the pre harvest period is becoming a feature of modern integrated agricultural systems strategies because it enhances fruit qualities and reduces the need for fungicides in the last stages of harvest thereby enhancing ability of fruit to resist postharvest rot (Gao *et al.*, 2019). Calcium is an essential nutrient, which is directly involved in fruit growth, cell division, and cell elongation. It preserves the structural integrity of the cell membrane, delay fruit senescence and protects fruit from softening which further extend the shelf life of fruits. Physiological disorders and susceptibility to mechanical damages are also reduced with calcium treatments (Serrano *et al.*, 2004). Pre harvest calcium compounds application on guava fruits is a viable strategy to improve the quality parameters of the fruits. It reduces the activity of hydrolytic enzymes, stimulating less weight loss, rot incidence, and therefore extends shelf life.

In spite of demand of guava fruit, fruit fly infestation, fruit rot and abiotic barriers causes excessive fruit drop and renders it unfit for human consumption. It severely decreases the market of fruit, which causes growers to suffer significant losses during summer. They also cause browning of fruit, rapid deterioration, poor taste and short shelf life (El-Baz *et al*., 2011). The use of intensive pesticide sprays before the harvest of summer crops typically results in higher amounts of chemical residues in fruits by limiting the attack of fruit flies (Abbasi *et al*., 2014). The quality of guava fruit produced by conventional farming may contain pesticide residue. Sustainable agriculture practices are advised to generate profitable commercial marketing and reduce the adverse effects on the environment. Physical treatments like pre harvest fruit bagging decreases the deterioration of fruit quality. Fruit bagging can enhance fruit colour and reduce pesticide residue, insect, disease, sunburn, and mechanical damage (Campbell *et al*., 2021). The pre harvest fruit bagging enhances overall fruit appearance and also modifies the micro environment for fruit development, having many implications on the interior quality of fruits. It is also easy to use, safe for growers, and advantageous for the production of high quality crops. Thus, this study is aimed at investigating the "Effect of pre harvest sprays of calcium compounds and bagging on post harvest quality of summer season guava (*Psidium guajava* L.) Cv. Allahabad Safeda".

MATERIAL AND METHODS

An experiment was conducted on four years old trees of guava, which have been grown at Jookal village, Jayashankar Bhupalpally district during 2022-2023. It is situated in deccan plateau of Telangana State at 18.42° latitude, 79.66° longitude and at altitude of 227 m above the mean sea level. The field experiment was laid out in factorial randomized block design with two factors (sprayings and bagging materials). Factor one consists of sprays *viz*., S_1- $CaCl_2$ @ 1 %, S_2- $Ca(NO_3)_2$ @ 1 %, S_3- $CaSO_4$ @ 1 % and factor two consists of bagging materials *viz*., B_1- Muslin cloth bag, B_2- Non woven bag, B_3- Brown paper bag, B_4- Blue polyethylene bag, B_5- No bagging (Control).Data on TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid content, pectin content and titratable acidity were recorded and subjected to statistical analysis, the test of significance (F-test) and critical difference (C. D.) at 0.05 probability Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Quality parameters

Total soluble solids (°Brix): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded highest TSS (11.98 °Brix) followed by S_1- $CaCl_2$ @ 1 % (11.01°Brix), whereas lowest TSS (10.48 °Brix) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag recorded highest TSS (12.43 °Brix) followed by B_2- Non woven bag (11.68 °Brix) whereas lowest TSS (9.82 °Brix) was recorded in B_5- No bagging (Control).

However, significant difference was found in TSS in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The highest TSS (13.33 °Brix) was recorded in S_2B_1 - $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag followed by S_2B_2- $Ca(NO_3)_2$ @ 1 % + Non woven bag (12.75 °Brix) whereas lowest TSS (9.78 °Brix) was recorded in S_3B_5 - $CaSO_4$ @ 1 % + No bagging (Control).

The increase in TSS with $Ca(NO_3)_2$ application might be caused due to hydrolytic enzymes breaking down complex polymers into simple molecules, which were later used during respiration during storage (Mukherjee and Dutta 1967). The findings of present investigation are in accordance with the results reported by Bagul and Masu (2017) in custard apple and Sankar *et al.* (2013) in mango Cv. Alphonso.

Pre harvest fruit bagging with muslin cloth might have acted as a physical protection which altered the micro environment inside the bags, which in turn impacted the fruits quality. The temperature inside the bag might have favoured conversion of starch into sugars during fruit development and that might have resulted in higher TSS in fruits (Wu *et al.*, 2009). The findings of present investigation are similar to the results reported by Mishra *et al*. (2017) in guava and Bakshi *et al*. (2013) in strawberry Cv. Chandler.

Total sugars (%): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded maximum total sugars (10.92 %) followed by S_1- $CaCl_2$ @ 1 % (10.22 %) whereas minimum total sugars (9.54 %) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag recorded maximum total sugars (13.57 %) followed by B_2- Non woven bag (10.69 %) whereas minimum total (8.41 %) was observed in B_5 - No bagging (Control).

However, significant difference was found in total sugars in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The maximum total sugars (15.55 %) was recorded in S_2B_1- $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag followed by S_1B_1- $CaCl_2$ @ 1 % + Muslin cloth bag (13.97 %) whereas minimum total sugars (8.24 %) was noticed in S_3B_5- $CaSO_4$ @ 1 % + No bagging (Control).

According to (Sankar *et al.*, 2013), calcium nitrate might have the activated hydrolytic enzymes that caused the conversion of carbohydrates into simple sugars which might be because of involvement of calcium or nitrogen components. These results are in agreement with findings of Tsomu *et al.* (2015) in sapota Cv. Kalipatti and Kaur *et al.* (2005) in pear Cv. Baggugosha.

Pre harvest fruit bagging of muslin cloth bag might have ensured good fruit quality, by creating a microclimate where temperature rises which in turn enhanced total sugars. This might be a result of polysaccharides breaking down into water-soluble sugars like glucose, fructose, and sucrose. This rise in the total sugar content of bagged fruits may be due to improved carbohydrate metabolism (Banday, 1996). The findings of present investigation are similar to the results reported by Nagaharshitha *et al*. (2014) in mango Cv. Alphonso and Wu *et al*. (2013) in mango.

Reducing sugars (%): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded maximum reducing sugars (4.51 %) followed by S_1- $CaCl_2$ @ 1 % (4.20 %) whereas minimum reducing sugars (3.96 %) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag recorded maximum reducing sugars (5.06%) followed by B_2- Non woven bag (4.50 %) whereas minimum reducing sugars (3.50%) was recorded in B_5- No bagging (Control).

However, significant difference was found in reducing sugars in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The maximum reducing sugars (5.72 %) was recorded in S_2B_1- $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag followed by S_1B_1- $CaCl_2$ @ 1 % + Muslin cloth bag (5.00 %) whereas minimum reducing sugars (3.48 %) was recorded in S_3B_5- $CaSO_4$ @ 1 % + No bagging (Control).

According to (Behera and Pathak 2015), calcium might have activated hydrolytic enzymes that resulted in the breakdown of carbohydrates into simple sugars. Involvement of calcium or nitrogen components might be the result of less sugar being used for respiration and starch conversion to sugar. The present investigation is in accordance with the results reported by Arvind *et al.* (2012) in mango Cv. Dashehari, Bhusan *et al.* (2015) in mango Cv. Amrapali.

Pre harvest fruit bagging of muslin cloth bag might have converted sucrose into glucose inside the bag that might be the cause of the higher reducing sugar. It might also be due to the increased activity of sucrose and sucrose phosphate synthesis inside the bags (Jakhar and Pathak 2016). The present investigation is in accordance with the results reported by Meena *et al*. (2016) in guava and Zhao *et al.* (2013) in mango.

Non Reducing sugars (%): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded maximum non reducing sugars (6.41 %) followed by S_1- $CaCl_2$ @ 1 % (6.02 %) whereas minimum non reducing sugars (5.57 %) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag recorded maximum non reducing sugars (8.51 %) followed by B_2- Non woven bag (6.18 %) whereas minimum non reducing sugars (4.90 %) was recorded in B_5- No bagging (Control).

However, significant difference was found in non reducing sugars in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The maximum non reducing sugars (9.83 %) was recorded in S_2B_1- $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag followed by S_1B_1- $CaCl_2$ @ 1 % + Muslin cloth bag (8.97 %) whereas minimum non reducing sugars (4.72 %) was recorded in S_3B_5- $CaSO_4$ @ 1 % + No bagging (Control).

Calcium nitrate might have converted starch into sugar during storage, which might be the cause of the rise in non-reducing sugars (Patel *et al*. 2017). The findings of present investigation are similar to the results reported by Karemera and Habimana (2014) in mango, Bisen *et al.* (2014) in guava.

This increase in non reducing sugars might be because of enhanced enzymatic activity in guava which might be because of an optimum micro environment surrounding the fruit created by muslin cloth bag (Watanawan *et al*., 2007). The present investigation is in agreement with the results reported by Singh *et al.* (2017) in mango.

Ascorbic acid content (mg/100g of pulp): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded maximum ascorbic acid content (187.08 mg/100g of pulp) followed by S_1- $CaCl_2$ @ 1% (181.69 mg/100g of pulp) whereas minimum ascorbic acid content (177.49 mg/100g of pulp) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1 - Muslin cloth bag recorded maximum ascorbic acid content (192.97 mg/100g of pulp) followed by B_2- Non woven bag (189.79 mg/100g of pulp) whereas minimum ascorbic acid content (168.64 mg/100g of pulp) was recorded in B_5- No bagging (Control).

However, significant difference was found in ascorbic acid content in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The maximum ascorbic acid content (196 .99 mg/100g of pulp) was recorded in S_2B_1- $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag which was statistically on par with S_2B_2- $Ca(NO_3)_2$ @ 1 % + Non woven bag (195.58 mg/100g of pulp) followed by S_1B_1- $CaCl_2$ @ 1 % + Muslin cloth bag (192.32 mg/100g of pulp) whereas minimum ascorbic acid content (164.88 mg/100g of pulp) was recorded in S_3B_5- $CaSO_4$ @ 1 % + No bagging (Control).

Calcium nitrate might have bound to the membrane and made it more stable, preventing free radicals and reactive oxygen species from attaching to the membrane and maintaining the health of biological membranes. Additionally, calcium slows down the quick oxidation of ascorbic acid by boosting the activity of the enzyme ascorbate peroxidase. This might result in increase in ascorbic acid content in fruits (Rahman *et al*. (2018). The findings of this investigation are in agreement with the results reported by Rajput *et al.* (2008); Bisen *et al.* (2014) in guava.

Increase in ascorbic acid content of the bagged fruits of muslin cloth bag might be because of the reduced temperature and increased humidity around the fruit inside the bags, which stimulated additional phytochemical processes to occur and had a synergistic impact Akter *et al.* (2020). The above findings are similar to the results reported by Behera and Pathak (2015); Meena *et al.* (2016) in guava.

Titratable Acidity (%): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1 % recorded minimum titratable acidity (0.32 %) followed by S_1- $CaCl_2$ @ 1 % (0.39 %) whereas maximum titratable acidity (0.47 %) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag recorded minimum titratable acidity (0.34 %) followed by B_2- Non woven bag (0.36 %) whereas maximum titratable acidity (0.45 %) was recorded in B_5- No bagging (Control).

However, no significant difference was found in the case of interaction effect of pre harvest sprays of calcium compounds and bagging.

Calcium nitrate resulting in low titratable acidity might be due to respiration process that might have lead to conversion of acids into sugars. The use of organic acids in the pyruvate decarboxylation reaction that takes place throughout the ripening process might be the cause of the decline in titratable acidity (Vidya *et al.*, 2014). The present investigation is in similarity with the results reported by Karemera *et al.* (2014) in mango.

Bagging of fruits with muslin cloth bag might have created micro environment inside the bag that lead to conversion of acids into sugars (Ulrich 1970). The results of this study are in conformity with those of Meena *et al.* (2016); Rahman *et al*. (2018).

Pectin content (%): Regarding the effect of pre harvest sprays of calcium compounds (S), application of S_2- $Ca(NO_3)_2$ @ 1% recorded maximum pectin content (1.09 %) followed by S_1- $CaCl_2$ @ 1 % (1.00 %) whereas minimum pectin content (0.93 %) was recorded in S_3-$CaSO_4$ @ 1 %. Regarding the effect of bagging treatments (B), bagging with B_1- Muslin cloth bag showed maximum pectin content (1.20 %) followed by B_2- Non woven bag (1.08 %) whereas minimum pectin content (0.76 %) was recorded in B_5 - No bagging (Control).

However, significant difference was found in pectin content in the case of interaction effect of pre harvest sprays of calcium compounds and bagging. The maximum pectin content (1.28 %) was recorded in S_2B_1- $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag followed by S_2B_2- $Ca(NO_3)_2$ @ 1 % + Non woven bag (1.20 %) whereas minimum pectin content (0.66 %) was recorded in S_3B_5- $CaSO_4$ @ 1 % + No bagging (Control).

Calcium has ability to delay the ripening and consequent softening of guava fruits. This might be the reason for decrease in the hardness of fruit along with its protopectin and methoxyl levels in $Ca(NO_3)_2$ @ 1 % spray. The present investigation is in accordance with the results reported by Chandra *et al.* (1994) in guava.

Bagging of muslin cloth bag might influence pectin content by environmental factors like temperature and relative humidity that insoluble pectin levels decrease in an equivalent way during ripening process and softening of fruits (Abreu *et al.*, 2012). The present findings are similar to the results reported by Saxena *et al.* (2021) in guava.

TOTAL SOLUBLE SOLIDS (°Brix)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	12.44	11.62	10.89	10.29	9.80	**11.01**
S_2	13.33	12.75	12.31	11.65	9.88	**11.98**
S_3	11.53	10.68	10.50	9.91	9.78	**10.48**
Mean of B	**12.43**	**11.68**	**11.23**	**10.62**	**9.82**	
	S. Em ±	**C. D. at 5%**				
S	0.067	0.195				
B	0.087	0.252				
S × B	0.150	0.437				

TOTAL SUGARS (%)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	13.97	10.52	9.62	8.59	8.42	**10.22**
S_2	15.55	11.10	10.36	9.00	8.57	**10.92**
S_3	11.20	10.45	9.31	8.53	8.24	**9.54**
Mean of B	**13.57**	**10.69**	**9.76**	**8.71**	**8.41**	
	S. Em±	**C.D. at 5%**				
S	0.129	0.376				
B	0.167	0.485				
S × B	0.289	0.841				

REDUCING SUGARS (%)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	5.00	4.43	4.32	3.75	3.50	**4.20**
S_2	5.72	4.84	4.59	3.89	3.52	**4.51**
S_3	4.46	4.25	3.91	3.70	3.48	**3.96**
Mean of B	**5.06**	**4.50**	**4.50**	**3.78**	**3.50**	
	S. Em±	**C.D. at 5%**				
S	0.041	0.120				
B	0.053	0.155				
S × B	0.092	0.269				

NON-REDUCING SUGARS (%)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	8.97	6.09	5.30	4.84	4.92	**6.02**
S_2	9.83	6.26	5.77	5.11	5.05	**6.41**
S_3	6.73	6.20	5.39	4.82	4.72	**5.57**
Mean of B	**8.51**	**6.18**	**5.49**	**4.92**	**4.90**	
	S. Em±	**C.D. at 5%**				
S	0.121	0.352				
B	0.156	0.455				
S × B	0.271	0.788				

ASCORBIC ACID CONTENT (mg/100g of pulp)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	192.3	187.99	184.40	176.70	167.06	**181.69**
S_2	196.9	195.58	188.46	180.41	173.97	**187.08**
S_3	189.60	185.80	175.88	171.30	164.88	**177.49**
Mean of B	**192.97**	**189.79**	**182.91**	**176.14**	**168.64**	
	S. Em ±	**C. D. at 5%**				
S	0.227	0.660				
B	0.293	0.852				
S × B	0.507	1.476				

TITRATABLE ACIDITY (%)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	0.34	0.36	0.39	0.43	0.45	**0.39**
S_2	0.28	0.30	0.32	0.34	0.37	0.32
S_3	0.41	0.43	0.47	0.50	0.55	0.47
Mean of B	**0.34**	**0.36**	**0.39**	**0.42**	**0.45**	
	S. Em ±	**C.D. at 5%**				
S	0.004	0.011				
B	0.005	0.014				
S × B	0.008	NS				

PECTIN CONTENT (%)						
Treatments	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**Mean of S**
S_1	1.17	1.09	1.03	0.96	0.76	**1.00**
S_2	1.28	1.20	1.19	0.94	0.85	**1.09**
S_3	1.17	0.96	0.94	0.93	0.66	**0.93**
Mean of B	**1.20**	**1.08**	**1.05**	**0.94**	**0.76**	
	S. Em ±	**C.D. at 5%**				
S	0.007	0.021				
B	0.009	0.028				
S × B	0.016	0.048				

CONCLUSIONS

Among the pre harvest sprays of calcium compounds, significantly maximum TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid content, pectin content and minimum titratable acidity was recorded in S_2- $Ca(NO_3)_2$ @ 1 %. Among bagging materials, significantly maximum TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid content, pectin content and minimum titratable acidity was recorded in B_1- Muslin cloth bag. In interaction effect of pre harvest sprays of calcium compounds and bagging, significantly maximum TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid content, pectin content and minimum titratable acidity was recorded in S_2B_1 - $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag .

It is concluded that pre harvest sprays of calcium compounds and bagging on quality parameters *viz.*, total soluble solids, total sugars, reducing sugars, non reducing sugars, ascorbic acid content, titratable acidity and pectin content was observed best with the treatment $Ca(NO_3)_2$ @ 1 % + Muslin cloth bag. The experiment concluded that different sprayings of calcium compounds and bagging materials improve the post harvest quality of fruits.

FUTURE SCOPE

One of the key factors that significantly effects the improvement of post harvest quality of guava. Therefore, the experiment can be done with storage conditions in room temperature and refrigerator conditions for finding the best combination of sprayings of calcium compounds and bagging materials. The effect of different bagging materials and other locally available materials has to be studied for their suitability, cost effectiveness and economic feasibility.

Studies can be carried out by using different concentration of calcium compounds and other biodegradable bagging materials for improving post harvest quality of guava.

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Conflict of Interest. None.

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