International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.9, No.9, pp 01-08, 2016

Evaluation of Safe Postharvest Treatments for Controlling Grey Mould and Soft Rot diseases of Strawberry Fruits

Farid Abd-El-Kareem

Plant Pathology Department, National Research Centre, Giza, Egypt.

Abstract : The strawberry fruit rot (grey mould and soft rot) caused by *Botrytis cinerea* and *Rhizopus stolonifer* respectively are the most important diseases attach strawberry fruits. Evaluate the efficiency of potassium sorbate and sodium benzoate against postharvest diseases of strawberry fruits were tested In vitro trails, results revealed that compete inhibition of linear growth was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L for *B. cinerea* and *R. stolonifer* respectively. The highest reduction was obtained potassium sorbate and sodium benzoate at concentrations of 15.0 g / L which reduced linear growth of both tested fungi more than 63.3 %. As for spore germination results revealed that compete inhibition of linear growth was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 g / L for both *B. cinerea* and *R. stolonifer*. The highest reduction was obtained potassium sorbate and sodium benzoate at concentrations of 15.0 g / L which reduced spore germination of both tested fungi more than85.1 %.
Moreover, in vivo trails results indicated that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the grey mould and soft rot (incidence and severity) of strawberry fruits . The highest reduction was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L which reduced the grey mould and soft rot incidence of strawberry fruits more than 88.0 and 86.0 % respectively. Treated strawberry fruits with potassium sorbate and sodium benzoate at concentrations of 15.0 g / L resulted in reducing grey mould and soft rot incidence more than 65.5 % . As for disease severity the highest reduction was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L which reduced the grey mould and soft rot severity of strawberry fruits more than 90.0 and 88.0 % respectively. It could be suggested that potassium sorbate and sodium benzoate are excellent treatments for controlling postharvest diseases of strawberry fruits.
Key words : Strawberry fruit- grey mould- Soft rot - Potassium sorbate - Sodium benzoate- Postharvest diseases.

Introduction

Botrytis cinerea, and *Rhizopus stolonifer* are the microorganisms that most commonly attack strawberries[1]. The strawberry fruit rot (grey mould) caused by *Botrytis cinerea* develops in any part of the fruit, but is mostly found on the calyx end or on the sides of fruit in contact with other rotten fruit. *Rhizopus stolonifer* fruit rot is associated with the presence of wounds in the fruit, but may also occur in intact fruit [2]. Alternative methods that have been pursued for the control of postharvest diseases include biological control, physical methods such as heat or radiations, and the use of safe low-toxicity chemicals such as food additives [3,4,5,6,7,8]. Food additives such as potassium sorbate (PS) and sodium benzoate (SB) have a broad spectrum antimicrobial activity and are commonly used as food preservatives [9, 10].

Sorbic acid and its water-soluble salts, especially potassium sorbate (PS), are common food preservatives. Sorbates are the best characterized of all food antimicrobials as to their spectrum of action. They inhibit certain bacteria and food-related yeasts and mould species[11,12,13]**.** Sodium benzoate (SB) is the sodium salt of benzoic acid. It is used as an antifungal agent**[(14)].** However, inhibition of microorganisms by (PS) and (SB) varies, depending on species and strain differences, extent of contamination, type and composition of the substrate, concentration and pH of sorbate, water activity, presence of other additives, temperature of storage, and type of packaging[(15)]**.** Using (PS) or (SB) against postharvest diseases of tomato, apple, carrots, potato and citrus fruits was reported by[8,16,17,18,19,20,21]**.** The objectives of the present work were to evaluate the efficiency of potassium sorbate (PS) and sodium benzoate (SB) against postharvest diseases of strawberry orange fruits.

Materials and Methods

Fungal isolates and strawberry fruits

Botrytis cinerea, and *Rhizopus stolonifer*, the causal organisms of grey and soft moulds respectively were obtained from Plant Pathol. Dept., (NRC) Egypt and were maintained on potato dextrose agar PDA for further study. While, strawberry fruits were obtained from the Department, of Vegetable Crop Research, Agricultural Research Centre, Giza, Egypt.

Salts preservatives

Salta preservatives, *i.e.* sodium benzoate (SB) and potassium sorbate (PS) were purchased from Sigma chemical Co. and used in the present study.

In vitro trails

Testing of potassium sorbate and sodium benzoate on linear growth of pathogenic fungi

Potassium sorbate and sodium benzoate at different concentrations *i.e* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L were tested to study their inhibitory effect on linear growth of *B. cinerea and R. stolonifer* . Salts solutions were added to conical flasks containing sterilized PDA medium to obtain the proposed concentrations, then mixed gently and dispensed in sterilized Petri plates (9 cm–diameter). Plates were individually inoculated at the center with equal disks (6-mm-diameter) of 10-days old culture of *B. cinerea and R. stolonifer*. Five plates were used as replicates for each particular treatments. Inoculated plates were incubated at 20 ± 2C° .The average linear growth of tested fungi was calculated after 10 days of incubation .

Testing of potassium sorbate and sodium benzoate on spore germination of pathogenic fungi

Potassium sorbate and sodium benzoate at different concentrations *i.e* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L were tested to study their inhibitory effect on spore germination of *B. cinerea and R. stolonifer*.. Spores of 10-days- old cultures of each fungus were harvested in sterilized water (containing 0.01% Tween 80) then adjusted to reach concentration of 10^6 spore/ ml. One ml of each prepared spore suspension was placed in Petri plates. PDA media containing different salt concentrations were poured before solidifying into the previous inoculated plates and rotated gently to ensure even distribution of fungal spores. Inoculated plates were incubated at 20°C for 24 h. Germinated spores were counted microscopically and percentage of spore germination was calculated.

Controlling grey mould and soft rot of strawberry fruits in vivo

Testing of potassium sorbate and sodium benzoate on spore germination of pathogenic fungi

Healthy and fresh strawberry fruits cv. Camarosa apparently free of physical damages and diseases were used in this experiment.

Fruits were immersing in water solutions containing potassium sorbate or sodium benzoate at different concentrations , *i.* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L for 30 seconds and then air dried for two hours in laminar flow. Inoculation of fruits was carried out by spraying fruits with spore suspension (10^6 spores/ml) of

B. cinerea and R. stolonifer individually then air dried. A set of inoculated fruits with *B. cinerea and R. stolonifer*, individually only were left as control. Each treatment as well as the control was performed in triplicate. All treated or un-treated (control) fruits were placed into carton boxes (46 × 23 × 30 cm) at the rate of 50 fruits/box and stored for 10 days at 20±2^{o}C and 90-95% relative humidity for assessment. The fruits were examined regularly to detect mould and regarded as infected if a visible lesion was observed. Results were expressed as percentage of fruit infected. Disease incidence (%) were expressed as percentage of fruit infected, while disease severity (%) were expressed as percentage of rotted part of fruit which was calculated from the following formula:

$$\text{Disease severity \%} = \frac{\text{Rotted part weight of fruit}}{\text{Fruit weight}} \text{ X } 100$$

Statistical analysis

Tukey test for multiple comparison among means was utilized [22].

Results

Effect of potassium sorbate and sodium benzoate on linear growth of pathogenic fungi

Potassium sorbate and sodium benzoate at different concentrations *i.e* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L were tested to study their inhibitory effect on linear growth of *B. cinerea* and *R. stolonifer*. Results in Table (1) reveal that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the linear growth of *B. cinerea* and *R. stolonifer*. Compete inhibition of linear growth was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L for *B. cinerea* and *R. stolonifer* respectively.The highest reduction was obtained potassium sorbate and sodium benzoate at concentrations of 15.0 g/L which reduced linear growth of both tested fungi more than 63.3 %. Other concentrations were less effective .

Table 1. Linear growth of *Botrytis cinerea,* and *Rhizopus stolonifer* as affected with potassium sorbate and sodium benzoate

Salt	**Conc. (g/L)**	**Linear growth (mm)**			
		Botrytis cinerea		***Rhizopus stolonifer***	
		Linear growth	**Reduction**	**Linear growth**	**Reduction**
Sodium benzoate	05.0	65.0 b	27.8	74.0 b	17.8
	10.0	32.0 d	64.4	62.4 c	30.7
	15.0	18.4 e	79.7	33.0 e	63.3
	20.0	00.0 f	100.0	12.0 g	86.7
	25.0	00.0 f	100.0	00.0 h	100.0
Potassium sorbate	05.0	59.0 b	34.4	63.0 c	30.0
	10.0	44.0 c	51.1	49.0 d	45.6
	15.0	18.2 e	79.8	32.1 e	64.3
	20.0	00.0 f	100.0	21.4 f	76.2
	25.0	00.0 f	100.0	00.0 h	100
Control	00.0	90.0 a	00.0	90.0 a	00.0

Figures with the same letter are not significantly different (p=0.05)

Effect of potassium sorbate and sodium benzoate on spore germination of pathogenic fungi

Potassium sorbate and sodium benzoate at different concentrations *i.e* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L were tested to study their inhibitory effect on spore germination of *B. cinerea* and *R. stolonifer*. Results in Table (2) reveal that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the spore germination of *B. cinerea* and *R. stolonifer*. Compete inhibition of linear growth was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 g / L for both *B. cinerea* and *R. stolonifer*. The highest reduction was obtained potassium sorbate and sodium benzoate at concentrations of 15.0

g / L which reduced spore germination of both tested fungi more than85.1 %. Other concentrations showed moderate effect .

Table 2. Spore germination of *Botrytis cinerea,* and *Rhizopus stolonifer* as affected with potassium sorbate and sodium benzoate

Salt	Conc. (g/L)	Spore germination			
		Botrytis cinerea		***Rhizopus stolonifer***	
		Spore germination	**Reduction**	**Spore germination**	**Reduction**
Sodium benzoate	05.0	61.0 b	35.1	70.0 b	24.7
	10.0	28.0 d	70.2	57.0 c	38.7
	15.0	14.0 e	85.1	29.0 e	86.8
	20.0	00.0 f	100	00.0 g	100.0
	25.0	00.0 f	00.0	00.0 g	100.0
Potassium sorbate	05.0	55.0 b	41.5	59.0 c	36.6
	10.0	39.0 c	58.5	42.0 d	54.8
	15.0	12.0 e	87.2	14.0 f	84.9
	20.0	00.0 f	100.0	00.0 g	100.0
	25.0	00.0 f	100.0	00.0 g	100
Control	00.0	94.0 a	00.0	93.0 a	00.0

Figures with the same letter are not significantly different (p=0.05)

Controlling grey mould and soft rot of strawberry fruits in vivo

Effect of potassium sorbate and sodium benzoate on grey mould and soft rot of strawberry fruits in vivo

Potassium sorbate or sodium benzoate at different concentrations , *i.* 0.0 , 5.0, 10.0, 15.0 ,20.0 and 25.0 g /L were tested to study their effect against grey mould and soft rot of strawberry fruits in vivo.

Effect on disease incidence

Results in Table (3) indicate that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the grey mould and soft rot of strawberry fruits . The highest reduction was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L which reduced the grey mould and soft rot incidence of strawberry fruits more than 88.0 and 86.0 % respectively. Treated strawberry fruits with potassium sorbate and sodium benzoate at concentrations of 15.0 g / L resulted in reducing grey mould and soft rot incidence more than 65.5 % .Meanwhile, other concentrations were less effective .

Effect on disease severity

Results in Table (4) indicate that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the grey mould and soft rot severity of strawberry fruits. The highest reduction was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L which reduced the grey mould and soft rot severity of strawberry fruits more than 90.0 and 88.0 % respectively. Treated strawberry fruits with potassium sorbate and sodium benzoate at concentrations of 15.0 g / L resulted in reducing grey mould and soft rot severity more than 76.5 % .Meanwhile, other concentrations were less effective .

Table 3. Grey mould and soft rot incidence of strawberry fruits as affected with potassium sorbate and sodium benzoate

Salt	Conc. (g/L)	Strawberry fruit rots			
		Grey mould		Soft rot	
		Disease incidence	Reduction	Disease incidence	Reduction
Sodium benzoate	05.0	52.0 b	48.0	62.0 b	38.0
	10.0	41.4 c	58.6	52.0 c	48.0
	15.0	24.0 d	76.0	31.4 e	68.6
	20.0	10.0 e	90.0	14.0 g	86.0
	25.0	10.0 e	90.0	14.0 g	86.0
Potassium sorbate	05.0	50.0 b	50.0	56.0 bc	44.0
	10.0	39.4 c	60.6	41.0 d	59.0
	15.0	21.0 d	79.0	34.5 e	65.5
	20.0	12.0 e	88.0	14.0 g	86.0
	25.0	12.0 e	88.0	13.0 g	87.0
Control	00.0	100.0 a	0.0	100.0 a	0.0

Figures with the same letter are not significantly different (p=0.05)

Table 4. Grey mould and soft rot severity of strawberry fruits as affected with potassium sorbate and sodium benzoate

Salt	Conc. (g/L)	Strawberry fruit rots			
		Grey mould		Soft rot	
		Disease severity	Reduction	Disease severity	Reduction
Sodium benzoate	05.0	49.0 b	51.0	58.0 b	42.0
	10.0	34.0 c	66.0	41.2 d	58.8
	15.0	18.0 d	82.0	23.4 e	76.6
	20.0	8.0 e	92.0	12.0 g	88.0
	25.0	7.0 e	93.0	11.0 g	89.0
Potassium sorbate	05.0	43.2 b	56.8	48.2 c	51.8
	10.0	33.2 c	66.8	35.4 d	64.6
	15.0	19.0 d	81.0	22.1 e	78.9
	20.0	10.0 e	90.0	12.0 g	88.0
	25.0	9.0 e	91.0	12.0 g	88.0
Control	00.0	100.0 a	0.0	100.0 a	0.0

Figures with the same letter are not significantly different (p=0.05)

Discussion

The strawberry fruit rot (grey mould and soft rot) caused by *Botrytis cinerea* and *Rhizopus stolonifer* respectively are the most important diseases attach strawberry fruits [1,2].

Sorbic acid and its water-soluble salts inhibit ed certain bacteria and food-related yeasts and mould species [11,12,13]**.** Sodium benzoate is used as an antifungal agent [9,10,14].

In the present study results indicate that in vitro trails, results revealed that compete inhibition of linear growth and spore germination was obtained with potassium sorbate and sodium benzoate at concentrations of 25.0 g / L for *B. cinerea* and *R. stolonifer*. Moreover, in vivo trails results indicated that all tested concentrations of potassium sorbate and sodium benzoate significantly reduced the grey mould and soft rot (incidence and severity) of strawberry fruits . The highest reduction was obtained with potassium sorbate and sodium benzoate at concentrations of 20.0 and 25.0 g / L which reduced the grey mould and soft rot incidence or severity of strawberry fruits more than 88.0 and 86.0 % respectively. In this respect, the efficiency of sodium benzoate (SB) and potassium sorbate (PS) treatments has been investigated on a wide range of postharvest diseases and horticultural crops[14,23,24]. The antifungal properties of (PS) and (SB) against several pathogenic fungi was reported several investigators [8,25,26]**.** Smilanick *et al***.** [8] showed an increase of (PS) toxicity with decreasing pH, and pointed out that the concentration of (PS) able to inhibit the germination of conidia of *P. digitatum* was similar from pH 4 to 6, and it was about 3- and 10-fold less toxic at pH 7 or pH 8, respectively. The antimicrobial activity of (PS) and (SB) is dependent on the presence of sorbic and acid benzoic acid in the solution, where the dissociated ionic form and the undissociated one (sorbic acid and benzoic acid) are in equilibrium. At pH below 4.76 the undissociated form prevails. According to[27] the effectiveness of organic acids is pH-dependent and the undissociated form of the acid is primarily responsible for antimicrobial activity. The mode of action of sorbate could be through the alteration of the morphological structure of the cell, genetic changes, cell membrane alterations, inhibition of cell transport processes, and inhibition of enzymes involved in metabolism of transport functions[15]**.** One of the primary targets of sorbic acid in vegetative cells appears to be the cytoplasmic membrane. It reduces the cytoplasmic membrane electrochemical gradient and consequently active transport, which in turn inhibits amino acid transport and could eventually result in the inhibition of many cellular enzyme systems [29]**.** It was reported that a decrease in adenosine triphosphate (ATP) level in conidia of *Aspergillus parasiticus* was related to decreased viability after exposure to sorbic acid. Sorbate treatment may also induce defensive responses in citrus fruit to pathogens [29]. Potassium sorbate (PS) treatment induced scoparone, caused structural changes, and increased the pH of rind tissue, all of which, in addition to the fungitoxicity of this compound, contributed to control of green and blue moulds by this treatment. Sodium benzoate (SB) has activity against yeast, mold, and bacteria. The effectiveness of sodium benzoate (SB) as a preservative and antifungal increases with decreasing pH (increasing acidity). This is because the ratio of undissociated (*i.e.*, free) benzoic acid to ionized benzoic acid increases as the pH decreases [30]. It is generally accepted that the undissociated benzoic acid is the active antimicrobial agent. Although no definite theory has been yet proposed to explain this antimicrobial effect, it is believed to be related to the high lipoid solubility of the undissociated benzoic acid which allows it to accumulate on the cell membranes or on various structures and surfaces of the microbial cell, effectively inhibiting its cellular activity [31]**.** It could be suggested that sodium benzoate (SB) or potassium sorbate (PS) considered as one of the applicable safely treatments for controlling postharvest diseases of strawberry fruits

References

1. Hilarino, M.P.A. (2009) Avaliação in vitro e in vivo do uso potencial de fungos endofíticos como agentes de controle biológico de doenças do morangueiro causadas por fungos fitopatogênicos. Dissertação de Mestrado. Universidade Federal de Minas Gerais, Belo Horizonte. 73p.
2. Ullio, L. and Macarthur, E. (2004) Strawberry disease control guide. Disponívelem: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/ 0011/119558/strawberry-disease-control.pdf.
3. Palou, L.; Usall, J.; Smilanick, J. L.; Aguilar, M. J. and Vinas, I. (2002). Evaluation of food additives and low-toxicity compounds as alternative chemicals for the control of *Penicillium digitatum* and *Penicillium italicum* on citrus fruit. Pest Manag. Sci., 58:459-466.
4. Palou, L.; Smilanick, J.L. and Droby, S. (2008). Alternatives to conventional fungicides for the control of citrus postharvest green and blue moulds. Stewart Postharv. Rev., 2:1-16.
5. Smilanick, J. L.; Mansour, M. F.; Gabler, F. M. and Sorenson, D. (2008). Control of citrus postharvest green mold and sour rot by potassium sorbate combined with heat and fungicides. Postharvest Biol. Technol., 47:226-238.
6. Montesinos-Herrero, C.; del Río, M. A.; Pastor, C.; Brunetti, O. and Palou, L. (2009). Evaluation of brief potassium sorbate dips to control postharvest penicillium decay on major citrus specie and cultivars. Postharvest Biol. Technol., 52:117-125.
7. Venditti, T.; Molinu, M. G.; Dore, A.; Agabbio, M. and D'Hallewin, G. (2005). Sodium carbonate treatment induces scoparone accumulation, structural changes, and alkalinization in the albedo of wounded citrus fruits. J. Agric. Food Chem., 53:3510-3518.
8. Aquino, S. D.; Fadda, A.; Barberis, A.; Palma, A.; Angioni, A. and Schirra, M.(2013). Combined effects of potassium sorbate, hot water and thiabendazole against green mould of citrus fruit and residue levels. Food Chemistry 141:858-864.

9. Arslan, U.; Ilhan, K.; Vardar, C. and Karabulut, O. A. (2009). Evaluation of antifungal activity of food additives against soilborne phytopathogenic fungi. World J. Microbiol. Biotechnol., 25:537-543.
10. Abd-El-Latif, F. M. and Abd-El-Kareem, F. (2009). Postharvest application of potassium sorbate and sodium carbonate for controlling blue and green moulds of navel orange. Egypt J. Phytopathol., 36:170-180.
11. Sofos, J. N. and Busta, F.F. (1993). Sorbic acid and sorbates. In: Davidson, P.M., Branen, A.L. (Eds.), Antimicrobials in Foods, Second ed. Marcel Dekker, Inc., New York, USA, pp. 49-94.
12. Elshahawy, I.E. Lashin, S.L. ; Saied, N.M. and Abd-El-Kareem, F. 2015. Evaluation of safe postharvest treatments for controlling Valencia orange green and blue moulds. International Journal of ChemTech Research, 8, No.9 : 237-244 .
13. Abd-El-Kareem, F. and Saied, N.M. 2015.Evaluation of hot water and potassium sorbate for controlling sour rot disease of lemon fruits. Journal of Chemical and Pharmaceutical Research, 7(12):505-510.
14. Stanojevi, C. D.; Comi, C. L.; Stefanovi, C. O. and Soluji-Sukdolak, C. (2009). Antimicrobial effects of sodium benzoate, sodium nitrite and potassium sorbate and their synergistic action *in vitro*. Bulgarian Journal of Agricultural Science, 15(4):307-311.
15. Sofos, J.N. (1989). Sorbate Food Preservatives. CRC Press, Inc., Boca Raton, FL, USA.
16. Gutter, Y. (1981). Investigations on new postharvest fungicides. Isr. Proc. Int. Soc. Citriculture 2:810-811.
17. Hall, D.J. (1988).Comparative activIty of selected food preservatives as citrus postharvest fungicides. Horticultural Society ,101:184-187.
18. Ryu, D. and Hold, D. L. (1993). Growth inhibition of *Penicilium expansum* by several commonly used food ingredients. J. of Food Protection, 56:862-867.
19. Olivier, C. ; Halseth, D. E.; Mizubuti, E. S. G. and Loria, J.(1998). Postharvest application of organic and inorganic salts for suppression of silver scurf on potato tubers. Plant Dis., 82:213-217 .
20. Smilanick, J. L. (2011). Integrated approaches to postharvest disease management in California citrus packinghouses. Acta Hort., 905:145-149.
21. Palou, L.; Usall, J.; Smilanick, J. L.; Aguilar, M. J. and Vinas, I. (2002). Evaluation of food additives and low-toxicity compounds as alternative chemicals for the control of *Penicillium digitatum* and *Penicillium italicum* on citrus fruit. Pest Manag. Sci., 58:459-466.
22. Neler, J.; Wassermann, W. and Kutner, M.H. (1985). Applied Linear Statistical Models. Regression, analysis of variance and experimental design : 2nd Ed. Richard, D. Irwin Inc. Homewood Illionois.
23. Gregori, R.; Borsetti, F.; Neri, F.; Mari, M. and Bertolini, P. (2008). Effects of potassium sorbate on postharvest brown rot of stone fruit. Journal of Food Protection, 71:1626-1631.
24. Karabulut, O. A., Romanazzi, G., Smilanick, J. L., & Lichter, A. (2005). Postharvest ethanol and potassium sorbate treatments of table grapes to control gray mold. Postharvest Biology and Technology, 37:129-134.
25. Smoot, J. J. and McCornack, A. A. (1978). The use of potassium sorbate for citrus decay control. Proceedings of the Florida State Horticulture Society, 91:119-122.
26. Guynot, M.E.; Ramos, A.J. ; Sanchis, V. and Marın, S. (2005). Study of benzoate, propionate, and sorbate salts as mould spoilage inhibitors on intermediate moisture bakery products of low pH (4.5–5.5). International Journal of Food Microbiology 101:161- 168.
27. Davidson, P. M. (1997). Chemical preservatives and natural antimicrobial compounds. In M. P. Doyle, L. R. Bechaut, & T. J. Montville (Eds.), Food microbiology, fundamentals and frontiers (pp. 520-556). Washington DC, USA: ASM Press.
28. Ronning, I. E. and Frank, H. A.(1987). Growth inhibition of putrefactive anaerobe 3679 caused by stringent-type response induced by protonophoric activity of sorbic acid. Appl. Environ. Microbiol., 53:1020-1027.
29. Przybylski, K.S. and Bullerman, L.B. (1980). Influence of sorbic acid on viability and ATP content of conidia of *Aspergillus parasiticus*. J. Food Sci., 45:375-376.
30. Valencia-Chamorro, S. A.; Pérez-Gago, M. B.; del Río, M. A. and Palou, L. (2009). Curative and preventive activity of hydroxypropyl methylcellulose-lipid edible composite coatings containing antifungal food additives to control citrus postharvest green and blue molds. J. Agric. Food Chem., 57:2770-2777.
31. Hammam,M.M.A.; El-Mohamedy, R.S.R.; Abd-El-Kareem, F. and Abd-Elgawad, M.M.M. 2016 . Evaluation of soil amended with bio-Agents and compost alone or in combination for controlling citrus

nematode *Tylenchulus semipenetrans* and Fusarium dry root rot on Volkamer lime under greenhouse conditions. International Journal of ChemTech Research, 9, No.7 : 86- 96 .

32. El-Mohamedy, R.S.R.; Hammam,M.M.A.; Abd-El-Kareem, F. and Abd-Elgawad, M.M.M.2016. Biological soil treatment to control *Fusarium solani* and *Tylenchulus semipenetrans* on sour orange seedlings under greenhouse conditions. International Journal of ChemTech Research, 9, No.7 : 73-85 .
33. Elshahawy, I.E. Lashin, S.L.; Saied, N.M. and Abd-El-Kareem, F. 2015. Evaluation of safe postharvest treatments for controlling Valencia orange green and blue moulds. International Journal of ChemTech Research, 8, No.9 : 237-244 .
34. Mawardika, H. and Suharjono, S. 2015. Antagonist Assay and Molecular Identification of Soil Molds Antagonist to Pathogenic Fusarium on Tomato Plants (Lycopersicum esculentum Mill.) in Bocek East Java Tomato Field. International Journal of ChemTech Researchm, 8, No.8,: 01-07.
35. Hathout, A.N. ; Abo-Sereih, N. A. ; Sabry, B.A. ; Sahab, A.F. and Aly, S.A. 2015. Molecular identification and control of some pathogenic Fusarium species isolated from maize in Egypt. International Journal of ChemTech Research, 7, No.1,: 44- 54.
36. Ghoname, A.A. ; Riad, G.S. ; El-basiouny, A.M. ; Hegazi, A.M. and El-Mohamady, R.S. 2015. Finding natural alternatives to methyl bromide in greenhouse cantaloupe for yield, quality and disease control. International Journal of ChemTech Research, 8, No.9: 84-92.
37. Abdalla M.Y.; Haggag, W.M. and Rayan, M.M.2015. Using Bioproducts Made with Native Microorganisms to Limit the Damage for Some Sugar Beet Cultivars Seeds. International Journal of ChemTech Research, 8, No.9: 245-260
38. Vimala Kumari, T.G.; Basu, K.; Nithya, T.G. ; and Kharkwa, K.S. 2015. Study of Bio-efficacy of Alkali tolerant Trichoderma against damping off and rotting diseases of Tomato and Cauliflower caused by Pythium spp. and Sclerotina spp. . International Journal of ChemTech Research, 8, No.6: 628-634.
39. El-Sayed, S. M. and Mahdy, M. E.2015. Effect of chitosan on root-knot nematode, *Meloidogyne javanica* on tomato plants. International Journal of ChemTech Research, 7,

*****