Chitosan coating enriched with *Ruta graveolens* L. essential oil reduces postharvest anthracnose of papaya (*Carica papaya* L.) and modulates defense-related gene expression

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Papaya (*Carica papaya* L.) is an economically important fruit crop in many tropical and subtropical countries, with fast maturation and high susceptibility to fungal diseases. Chitosan coating has shown ability to control postharvest decay of fruits and can be a carrier of essential oil, like *Ruta graveolens* L. essential oil.

In this study were analyzed the effects of:

- ❑ **0.5 % chitosan** (**CS**)
- ❑ **0.5 % *Ruta graveolens* essential oil** (**REO**)
- ❑ **their combination** (**CS-REO**)

1 **- In postharvest decay on papaya fruits during storage (9 days at 25°C);**

2 **-On defence mechanisms induced at 0.5, 6, 24, 48 and 72 hours post treatments (htp).**

1 **- CS-REO treatments provides additive effects against anthracnose reducing incidence and severity in papaya fruit**

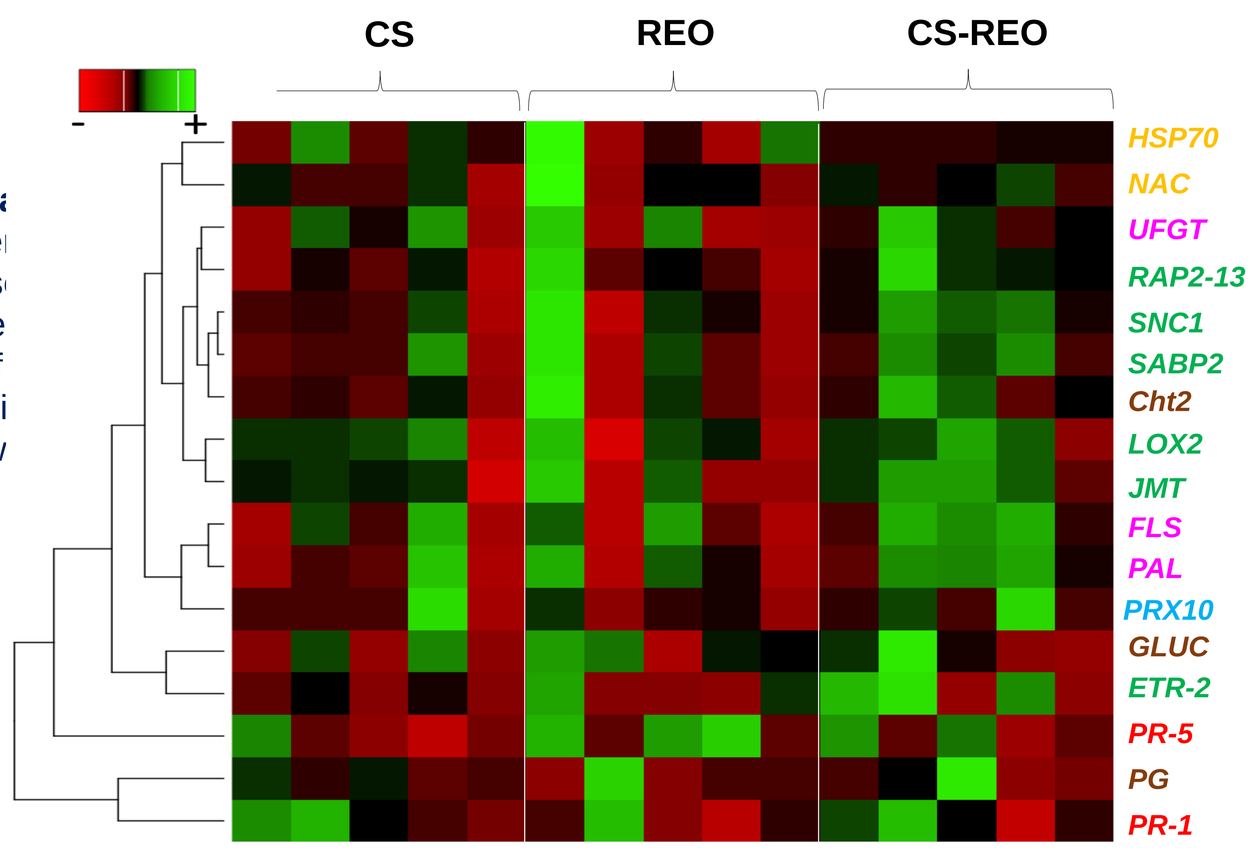
The REO and CS-REO emulsion reduced the papaya incidence decay by 21%, and 37%, respectively, and the disease severity by 22%, 29%, and 44% with CS, REO and, CS-REO treatments, respectively.

2 **RT-qPCR was performed according to 17 key genes of papaya linked to:**

- ❑ **Genes Involved in Abiotic Stress,**

Heat shock cognate 70 (HSP70);
NAC protein, NAC

✓ **Gene expression hea**
Hierarchical cluste
according to Pears
correlation similaritie
average linkage of
defense genes exami
papaya fruit follow
treatments with CS,
and CS-REO.



- ❑ **Genes Involved in Signaling Pathways That Regulate Plant Defense**

Salicylic acid binding protein 2; SABP2
Suppressor of npr1-1, constitutive1; SNC1
Jasmonate O-methyltransferase; JMT
Ethylene receptor, transcript variant X2; ETR-2
Ethylene responsive transcription factor RAP213; RAP2-13
Linoleate 13S- lipoxygenase 2.1, chloroplastic; LOX2

- ❑ **Genes for PR Proteins**

Pathogenesis related protein 1; PR-1
Pathogenesis related protein 5; PR5

- ❑ **Genes for Cell Wall-Degrading Enzymes**

Chitinase 2; Cht2
Endo1,3;1,4b-D-glucanase; GLUC
Polygalacturonase; PG

- ❑ **Genes Involved in Oxidative Stress**

Peroxidase 10; PRX10

- ❑ **Genes Involved in the Phenylpropanoid Pathway**

Phenylalanine ammonia-lyase; PAL
Anthocyanidin 3-O-glucosyltransferase; UFGT
Flavonol synthase; FLS

✓ **The fold-changes values used for hierarchical clustering.**
✓ In bold the data significantly different (P ≤ 0.05; Duncan's multiple range tests), compared to relevant controls were indicate

1.0	**5.2**	1.4	3.3	2.4	**24.2**	-2.6	2.4	-3.7	**7.9**	2.4	**2.5**	2.2	**3.1**	**3.3**	*HSP70*
2.3	**-1.6**	**-1.7**	2.6	-7.7	**26.8**	**-6.3**	1.1	1.2	**-4.0**	1.9	-1.0	1.0	**3.4**	-1.2	*NAC*
-1.1	**4.4**	**1.9**	6.3	-1.8	**9.8**	-1.8	**5.6**	-2.4	-1.8	1.6	**9.0**	**3.4**	1.3	**2.5**	*UFGT*
1.1	**2.7**	1.0	3.7	-2.7	**12.6**	1.1	**2.7**	1.5	-2.3	**2.5**	**12.6**	**3.9**	3.4	3.1	*RAP2-13*
1.1	1.6	1.1	4.5	-2.0	**14.9**	-2.7	**3.8**	2.1	-2.3	2.1	**7.6**	**4.8**	**5.2**	2.4	*SNC1*
1.4	**1.9**	**2.0**	10.0	-2.3	**19.9**	-2.0	**6.3**	1.5	-2.3	2.2	**9.3**	**6.0**	**8.8**	1.9	*SABP2*
1.8	**2.8**	1.5	5.1	-1.6	**20.7**	-2.4	**5.8**	1.2	-1.1	3.1	**12.8**	**7.2**	1.3	**4.2**	*Cht2*
1.2	1.4	1.5	2.8	-2.3	**5.5**	**-2.8**	1.6	1.0	-2.9	1.3	**1.7**	**4.0**	1.7	-1.9	*LOX2*
1.5	1.5	1.3	1.9	-2.6	**9.4**	-2.2	**2.9**	-2.7	**-3.9**	1.6	**5.6**	**5.7**	2.6	-1.4	*JMT*
-1.2	**3.3**	1.2	6.4	-1.1	**3.7**	-2.0	**5.8**	1.1	-1.4	1.5	**6.3**	**5.1**	**6.3**	1.8	*FLS*
-1.2	**2.2**	2.	13.7	-2.7	**11.4**	-1.7	**7.0**	2.2	-1.8	1.7	**8.8**	**8.3**	**10.7**	**3.5**	*PAL*
1.1	1.5	1.5	19.4	-3.1	**5.7**	-1.8	**2.4**	**2.7**	-2.1	1.8	**6.2**	1.7	**18.6**	1.6	*PRX10*
-1.0	**2.5**	-1.7	3.6	-1.5	**4.6**	**3.3**	-2.9	**1.8**	1.2	2.0	**10.1**	1.1	-1.2	-1.9	*GLUC*
3.1	**5.3**	1.9	**4.5**	1.9	**10.7**	**2.2**	**2.1**	1.2	**6.2**	**12.3**	**16.6**	1.1	**8.9**	1.3	*ETR-2*
1.4	-1.1	-1.7	-3.5	-1.2	**3.0**	-1.1	**2.2**	**4.2**	-1.0	2.0	-1.1	1.2	-2.3	-1.0	*PR-5*
7.8	**5.7**	**7.3**	**4.8**	**5.1**	**3.0**	**17.0**	**3.4**	**5.4**	**4.9**	**5.5**	**6.9**	**19.7**	**3.0**	**3.9**	*PG*
6.1	**8.2**	**3.4**	2.2	1.4	**2.1**	**9.0**	1.0	-1.7	**2.5**	**4.6**	**9.2**	**3.3**	-2.5	**2.4**	*PR-1*
0.5	**6**	**24**	**48**	**72**	**0.5**	**6**	**24**	**48**	**72**	**0.5**	**6**	**24**	**48**	**72**	

h post treatment

CS induced gene upregulation mainly at 6 hpt and 48 hpt, while REO induced the highest upregulation at 0.5 hpt. Furthermore, CS-REO treatment delayed gene upregulation by REO alone, from 0.5 to 6 hpt, and kept that longer over time.

This study suggests that CS stabilizes the volatile and/or hydrophobic substances of highly reactive essential oils. The additive effects of CS and REO were able to reduce postharvest decay and affect gene expression in papaya fruit.

REFERENCE: Landi L, Peralta-Ruiz Y, Chaves-López C and Romanazzi G (2021) Chitosan coating enriched with *Ruta graveolens* L. essential oil reduces postharvest anthracnose of papaya (*Carica papaya* L.) and modulates defense-related gene expression. Front. Plant Sci. 12:765806. doi: 10.3389/fpls.2021.765806

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