**Lippia graveolens** and **Carya illinoensis** Organic Extracts and there in vitro Effect Against **Rhizoctonia Solani** Kuhn

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**Abstract:** Problem statement: Plant extracts with polyphenolic compounds obtained with different solvents have been evaluated against plant pathogens. However, most of these extracts have been obtained using solvents no allowed under an organic production context. Approach: In the present research was to evaluate the inhibitory effect of polyphenolic extracts from **L. graveolens** and **C. illinoensis**, obtained with alternative organic solvents (lanolin and cocoa butter), water and ethanol against **R. solani** in order to determine the Inhibitory Concentration (IC₅₀) of each extract. Results: The results showed that extracts of both **L. graveolens** and **C. illinoensis** obtained with lanolin and ethanol (200 and 3000 ppm of total tannins, respectively) inhibited at 100% growth of **R. solani**. The IC₅₀ for each extract was highly variable, low IC₅₀ values were obtained with **L. graveolens** (4.50×10⁻¹) and **C. illinoensis** (4.33×10⁻²) extract using lanolin and ethanol respectively. Tannins extraction was strongly dependent on plant species and in the solvent used. Conclusion: The alternative organic solvents lanolin and cocoa butter allowed the recovery of polyphenols compounds with antifungal activity against **R. solani**.

**Key words:** **Lippia graveolens**, **Carya illinoensis**, Lanolin, Cocoa butter, IC₅₀, **R. solani**, mycelia inhibition

**INTRODUCTION**

Pesticide applications for control of fungal pathogens, among other effects causes: environmental pollution, affectation to beneficial organisms (Anderson *et al*., 2003) and generation of populations of resistant pathogens to chemicals in response to selection pressure due to high dose and continuous applications (Leroux, 2003). Currently seeking alternative for disease control, consider using plant derived compounds in extract form, the potential use of these to control plant pathogens has been shown in laboratory studies (Qasem and Abu-Blam, 1996), in greenhouse (Bergeron *et al*., 1995; Lomeli and Ochoa, 1999) and at field level (Cruz *et al*., 1999). Plants possess a variety of secondary compounds in their tissues such as polyphenols, terpenes and alkaloids. Among the polyphenolic polymers are tannins, these compounds have the ability to form complexes with proteins, polysaccharides, nucleic acids, steroids, alkaloids and saponins. Based on their chemical origin, tannins are classified into two main groups: hydrolysable and condensed tannins. The hydrolysable tannins are polymers of phenolic acids (gallic, hexahydroxidifenic acid), while condensed tannins are polymers of flavan-3-ols (Isaza *et al*., 2007). Among the plant families with presence of polyphenols are Leguminosae, Rosaceae, Polygonaceae, Fagaceae, Rhyzophoraceae, Myrtaceae and Melastomataceae (Isaza, 2007). In this sense, Mexico has native plants with high content of these compounds (Gamboa *et al*., 2003, Lira *et al*., 2007; Castillo *et al*., 2010), extracts obtained from these plants using methanol, acetone among others solvents, have proven effective antimicrobial activity, however there is a lack of knowledge about to obtaining these phytochemicals with unconventional solvents which can be used as a potential alternative disease management within a system of organic agriculture. In this context, this study aims determine antifungal in vitro effect of **L.**
graveolens and C. illinoensis extracts obtained with lanolin, cocoa butter, water and ethanol on R. solani mycelia inhibition growth.

MATERIALS AND METHODS

Vegetal material: Whole plants (leaves, stems and roots) of Mexican oregano (L. graveolens) and pecan husk (C. illinoensis) were collected on August and September 2008 in the Southern region of Coahuila State, Mexico. The samples were transported to the Microbiology Laboratory, Department of Food Research, Faculty of Chemical Sciences, Universidad Autonoma de Coahuila, in plastic bags. Dehydration process was performed under environment temperature and in an oven (LABNET International, Inc.) for two days at a temperature of 60°C. Then, dry samples were ground in a mill (Thomas Wiley) and passed through a 1mm screen. The fine and dried powder was stored in amber bottles or plastic bags and at room temperature under darkness.

Extraction of polyphenols: Polyphenolic compounds extraction from each collected sample was done in a proportion of 1:4 (w/v) for infusion method using water and ethanol (70%). Lanolin and cocoa butter extractions were done using emulsions with mineral oil (10%) at 60°C for 7 h. After this, extracts were filtered. The obtained extracts were stored in containers covered with aluminum or amber bottles at 5°C.

Determination of hydrolysable and condensed tannins: The tannin concentrations were determined by spectrophotometry as hydrolysable tannins (Makkar, 1999), as condensed tannins (Swain and Hillis, 1959) of a sample extract diluted at 1:20 (extract: distilled water). For hydrolysable tannins determination, a reference curve was done by using 400 µL of gallic acid (0.01M) and 2.5 mL of distilled water were added. Finally absorbance was read at 725 nm.

For condensed tannins determination, 0.5 mL of plant extract was used with 3mL of HCl/butanol (1:9) and 0.1 mL of ferric reagent. The standard was prepared using catechin dissolved in distilled water at different concentrations (0, 200, 400, 600, 800 and 1000 ppm). Samples were heated for 1 h in water bath at 90°C and absorbance was read at 460 nm.

Table 1: Plant extract concentrations (ppm) against Rhizoctonia solani used in this study

| Extract/solvent      | Concentration (ppm) |
|----------------------|---------------------|
| L. graveolens/water  | 500, 1000, 1500, 2000, 3000 |
| L. graveolens/lanolin| 200, 400, 600, 800, 1000 |
| L. graveolens/cocoa butter | 500, 1000, 1500, 2000, 3000 |
| L. graveolens/Ethanol| 500, 1000, 1500, 2000, 3000 |
| C. illinoensis/water | 500, 1000, 1500, 2000, 3000 |
| C. illinoensis/lanolin| 200, 400, 600, 800, 1000 |
| C. illinoensis/cocoa butter | 500, 1000, 1500, 2000, 3000 |
| C. illinoensis/Ethanol| 500, 1000, 1500, 2000, 3000 |

Effect of the plant extracts on R. solani mycelia growth: This work step was carried out in the Laboratory of Microbiology, Agricultural Parasitology Department at Universidad Autonoma Agraria Antonio Narro, Saltillo Coahuila, Mexico. Tannin concentrations of the tested extracts are shown in Table 1. The poisoned culture medium technique was used to determine the effect of different extracts on inhibition of R. solani mycelia growth. In this case, four Petri dishes with one of the different extract concentration were used per treatment. First, the volume required for each extract and concentration was determined. This amount was added to an Erlenmeyer flask with the required water content and PDA medium. Then, flasks were sterilized at 120°C for 15 min.

Discs with fungal mycelia (0.4 cm in diameter) were placed on Petri dishes, which had poisoned culture media. This was done for each different extract and concentration. Petri dishes were incubated at 25±2°C. The efficacy of treatments was evaluated measuring fungal radial growth (cm). The percent of mycelia growth inhibition (P) was estimated using as reference the control treatment (Petri dishes only with PDA medium) as follows:

\[
P = \frac{(C-T)}{C} \times 100\%
\]

where, C is the colony diameter under the control treatment and T is the colony diameter under the extract treatment. The experiment was established under a completely randomized design with four replications. The Probit analysis was made to determine the 50% Inhibitory Concentration (IC50) of each extract. Data were analyzed using the software SAS V8.1.

RESULTS

Effect of solvents on total polyphenols content extraction: The extraction of polyphenols compounds varied among species according to the solvent used. In addition, it was observed an interaction between plant species and solvent for total tannins extraction. The highest concentration was obtained from L. graveolens with 2.327×10⁵ ppm using ethanol, followed by C. illinoensis with 1.93×10⁵ ppm using cocoa butter.
Table 2: Concentrations IC$_{50}$ and IC$_{90}$ (ppm) of the extracts of *Lippia graveolens* and *Carya illinoensis* obtained with different solvents against *Rhizoctonia solani*.

| Extract | Solvent   | IC$_{50}$ | Fiducial limits | IC$_{90}$ | Fiducial limits |
|---------|-----------|-----------|-----------------|-----------|-----------------|
| L. graveolens | Ethanol   | 1.93×10$^3$ | Superior 1.72×10$^3$ | 2.21×10$^3$ | 2.25×10$^4$ | Superior 1.45×10$^4$ | 4.19×10$^4$ |
| L. graveolens | Lanolin   | *i*      | Superior 8.61×10$^7$ | 1.36×10$^1$ | 4.03×10$^3$ | Superior 2.87×10$^3$ | 7.69×10$^3$ |
| L. graveolens | Water     | 0.00     | Superior 0.00 | 0.00 | 0.00 | Superior 0.00 | 0.00 |
| C. illinoensis | Ethanol   | 4.34×10$^2$ | Superior 2.39×10$^2$ | 5.88×10$^2$ | 1.45×10$^3$ | Superior 1.15×10$^3$ | 2.11×10$^3$ |
| C. illinoensis | Lanolin   | 2.14×10$^1$ | Superior 1.69×10$^1$ | 3.10×10$^1$ | 1.25×10$^2$ | Superior 6.61×10$^3$ | 5.11×10$^3$ |
| C. illinoensis | Cocoa | 0.00 | Superior 0.00 | 0.00 | 0.00 | Superior 0.00 | 0.00 |
| C. illinoensis | Water     | 0.00     | Superior 0.00 | 0.00 | 0.00 | Superior 0.00 | 0.00 |

*i*: Inhibition at 100% to 200 ppm

The solvent that yielded the highest tannin concentration was ethanol (1.17×10$^5$ ppm) and with lanolin was obtained the lowest (2.79×10$^3$ ppm) total polyphenols content (Fig. 1).

**Effect of plant extracts on inhibition of *R. solani* mycelia growth:** The effect of different extracts of Mexican oregano and pecan husk obtained using four different solvents on *R. solani* was highly significant at 72 h. Figure 2 shown that as extract increases, the mycelia growth of *R. solani* is significantly reduced, with exception of the water extract for both Mexican oregano and pecan husk and cocoa butter extract from pecan husk. According to the values of inhibition mean, lanolin and ethanol extracts were statistically (p≤0.01) more efficient, with an inhibition mean of 69.1 and 63.5% respectively, while water extract was the least efficient with an inhibition mean of 16.0%.

The greater mycelia inhibition (100%) was observed with *L. graveolens* extract using lanolin as solvent at a concentration of 200 ppm of total tannins, followed by cocoa butter extract with 83% of mycelia inhibition to 3000 ppm, while that with ethanol extracts was obtained a 60% of mycelia inhibition at 3000 ppm, the water extract had little effect on *R. solani* mycelia inhibition (Fig. 2A).

In the case of *C. illinoensis* extracts, the greatest effect was found with ethanolic extracts with doses from 500-3000 ppm of totals tannins with a range of  

![Fig. 1](image1.png)  
![Fig. 2A](image2A.png)  
![Fig. 2B](image2B.png)
mycelia inhibition of 60-100% (Fig. 2B), followed for the lanolin extracts with 62% of R. solani mycelia inhibition using 3000 ppm of total tannins and only 23% of mycelia inhibition was observed with water and cocoa butter extracts respectively.

Inhibitory concentrations of plant extracts to 50% (IC$_{50}$): The IC$_{50}$ of each extract on fungus growth was highly variable among extracts with the different solvents within each particular species. The lowest IC$_{50}$ was obtained with L. graveolens with 4.50×10$^3$ ppm with lanolin as solvent and the highest with pecan husk to 2.13×10$^3$ ppm using lanolin (Table 2).

DISCUSSION

These differences in total tannins production for ethanol, is correlated with the high polarity of ethanol and partition point to extract more polyphenolic compounds. These results are consistent with those reported by Lira et al. (2003) whom mentioned that absolute ethanol extracts less resin from Larrea tridentata (SEES and Moc. Ex DC) that its use at lower concentration. In this study, ethanol (70%) yielded higher concentration of polyphenol compounds from L. graveolens than the other solvents. There is only a reference about the use of lanolin and cocoa butter in extraction of polyphenolic molecules with antifungal effect, where it was found that the use of cocoa butter and lanolin as solvents allowed higher extraction of polyphenolic compound than water (Castillo et al., 2010).

This results corroborated the antifungal effect of L. graveolens against R. solani (Hernandez et al., 2008) and in contrast with those obtained by Garcia et al. (2006), whom found a fungicidal effect at 1000 ppm of oregano essential oil, although these differences are given by the different genus and specie (Origanum vulgare) used, as pointed out by Hernandez et al. (2008). Likewise, there is little information regarding the use of polyphenolic extracts from C. illinoensis, Osorio et al. (2009) found high sensitivity of R. solani to acetonic extracts obtained from C. illinoensis nuts shell to 0.20 mg L$^{-1}$, these results contrast with those obtained in this work to 3000 ppm of tannin required to inhibit in 100% this fungus, these differences could probably be explained by the different plant tissue used and the evaluation conditions, in our case, growth was assessed in a radial way as opposed to only qualitative presence or absence of growth on plaques of polystyrene employed by Osorio et al. (2009).

The use of lanolin and cocoa butter for the extraction of highly efficient phytochemicals to inhibit fungus growth in vitro was reported previously (Castillo et al., 2010), where they mentioned that efficiency differences for inhibit mycelia growth of extracts with these solvents are given because emulsions are best to extract more and different phytochemicals from plants, the type and concentration of phytochemicals recovered during the extraction process determines the efficiency of inhibitory capacity, due to differences in polarity and partition points of these solvents. Results with extracts using ethanol as solvent agree with those obtained with extracts from Flourensia cernua using ethanol and other solvents, where similar concentrations than those evaluated here, which inhibited the mycelia growth of Alternaria alternata, Penicillium digitatum and Collectotrichum gloeosporioides from 80-100% respectively (Guerrero et al., 2007).

The obtained IC$_{50}$ values are different to those obtained by Hernandez et al. (2008) whom found an IC$_{50}$ of 10 µg mL$^{-1}$ although these differences are probably given by the use of essential oil that may have other compounds with antifungal activity, so it is less than the required dose of methyl tolclofos for total inhibition of R. solani in vitro (Gamboa et al., 2003).

CONCLUSION

The use of different alternative organic solvents allowed the obtaining of extracts with antifungal activity against R. solani, in specific, the amount of phenolic compounds is a function of solvent and vegetal specie used. The highest activity against R. solani was obtained with extracts from L. graveolens with lanolin and C. illinoensis with ethanol. To the best of our knowledge, this is one of the first reports with nonconventional organic solvents (lanolin and cocoa butter) for extract phytochemicals with antifungal activity from L. graveolens and C. illinoensis husks. These solvents represent an attractive alternative for development of natural products to control plant pathogen fungi, which may avoid the use of synthetic fungicides.

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REFERENCES

Anderson, B.S., J.W. Hunt, B.M. Phillips, P.A. Nicely and V. de Vlaming et al., 2003. Integrated assessment of the impacts of agricultural drainwater in the Salinas River (California, USA). Environ. Pollut., 124: 523-532. DOI: 10.1016/S0269-7491(03)00012-5
Bergeron, C., A. Marston, E. Hakizamungu and K. Hostettmann, 1995. Antifungal constituents of Chenopodium procerum. Pharm. Biol., 33: 115-119. DOI: 10.3109/13880209509055209

Castillo, F., D. Hernandez, G. Gallegos, M. Mendez and R.A. Rodriguez et al., 2010. In vitro antifungal activity of plant extracts obtained with alternative organic solvents against Rhizoctonia solani Kuhn. Ind. Crops Prod., DOI: 10.1016/j.indcrop.2010.05.013

Cruz, O.J., A.S. Montoya, R.F. Estrada and C.J.M. Castro, 1999. Vegetal extracts for viral diseases vector control in squash in Culiacan, Sinaloa. Proceeding 26th National Congress of The Mexican Phytopathology Society and X Phytopathology Latin-American Congress, (PMSPLAC’99), Guadalajara, Jalisco, Mexico, pp: 1-10.

Gamboa, A.R., F.D. Hernandez-Castillo, E. Guerrero-Rodriguez and A. Sanchez-Arizpe, 2003. Mycelial inhibition of Rhizoctonia solani Kuhn and Phytophthora infestans Mont (De Bary) with methanolic extracts from Florencia cernua D.C., Origanum majorana L. and Bouvardia ternifolia (Ca.) Schlecht. Rev. Mex. Fitopatol., 21:13-18.

Garcia, C.E.A., V.M.Y. Quezada, L.J. Moreno, H.G. Sanchez and M.E. Moreno et al., 2006. Antifungal activity of essential oils of cinnamon (Cinnamomum zeylanicum blame) and oregano (Origanum vulgare L.) and their effect on aflatoxin production in pecan nut [C. illinoensis (F.A. Wangenh) K. Koch]. Rev. Mex. Fitopatol., 24: 8-12.

Guerrero, E.R., S. Solis-Gaona, F.D. Hernandez-Castillo, A. Flores-Olivas and V. Sandoval-Lopez, 2007. Antifungal activity in vitro of Florensia cernua D.C. extract on postharvest pathogen: Alternaria alternata (Fr:Fr.) Keissl., Colletotrichum gloeosporioides (Penz.) Penz. and Sacc. and Penicillium digitatum (Pers.:Fr) Sacc. Rev. Mex. Fitopatol., 25: 48-52.

Hernandez, T., M. Canales, A.M. Garcia, A. Duran and S. Meraz et al., 2008. Antifungal activity of the essential oils of two verbenaceae: Lantana achyranthifolia and Lippia graveolens of zapotitlan de las salinas, puebla (México). Soc. Latinoamer. de Fitoquimica, 7: 203-207.

Isaza, M.J.H., 2007. Vegetal tanins or polyphenols. Scientia Technica, 8: 13-18.

Isaza, M.J.H., C.L.A. Veloza, A.L.S. Ramirez and C.A. Guevara, 2007. Spectrophotometric estimation of hydrolysable and condensed tannins in melastomataceas plants. Sci. Tecnica, 8: 261-266.

Leroux, P., 2003. Mode of action of agrochemicals towards plant pathogens. Compt. Rendus Biol., 326: 9-21. DOI: 10.1016/S1631-0691(03)00005-2

Lira, S.R.H., G.F. Balvatin-Garcia, F.D. Hernandez-Castillo, R. Gamboa-Alvarado and D. Jasso de Rodriguez et al., 2003. Evaluation of resin content and the antifungal effect of Larrea tridentata (Sesse and Moc. ex D.C.) Coville extracts from two Mexican desert against Phythium sp. Pringsh. Rev. Mex. Fitopatol., 21: 97-101.

Lira, S.R.H., M. Hernandez-Suarez, C. Chavez-Betancurt, F.D. Hernandez-Castillo and E. Cuellar-Villareal, 2007. Biopesticides and biological control. CIQA.

Lomeli, R.M.G. and R.H.G. Ochoa, 1999. Fungicide evaluation of Coco nucifera Linn mesocarp extract. Proceeding 26th National Congress of The Mexican Phytopathology Society and X Phytopathology Latin-American Congress, (PMSPLAC’99), Guadalajara, Jalisco, Mexico, pp: 1-7.

Makkar, H.P.S., 1999. Quantification of tannins in tree foliage. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. http://naweb.iaea.org/nafa/aph/public/pubd31022manual-tannin.pdf

Osorio, E., M. Flores, D. Hernandez, J. Ventura and R. Rodriguez et al., 2009. Biological efficiency of polyphenolic extracts from pecan nuts shell (Carya Illinoensis), pomegranate husk (Punica granatum) and creosote bush leaves (Larrea tridentata Cov.) against plant pathogenic fungi. Ind. Crops Prod., 31:153-157. DOI: 10.1016/j.indcrop.2009.09.017

Qasem, J.R. and H.A. Abu-Blan, 1996. Fungicidal activity of some common weed extracts against different plant pathogenic fungi. J. Phytopathol., 144: 157-161. DOI: 10.1111/j.1439-0434.1996.tb01507.x

Swain, T. and W.E. Hillis, 1959. The phenolic constituents of Prunus domestica L.-the quantitative analysis of phenolic constituents. J. Sci. Food Agric., 10: 63-68. DOI: 10.1002/jsfa.2740100110

Swain, T. and W.E. Hillis, 1959. The phenolic constituents of Prunus domestica L.-the quantitative analysis of phenolic constituents. J. Sci. Food Agric., 10: 63-68. DOI: 10.1002/jsfa.2740100110