Artículo de investigación

doi: http://dx.doi.org/10.16925/od.v12i24.1657

Chemical Composition of *Spilanthes americana* Extract

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Recibido: 7 de mayo del 2016 **Aprobado:** 13 de septiembre del 2016

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Cómo citar este artículo: Zuluaga- López, OH. Chemical composition of *Spilanthes americana* extract. Rev Nac Odontol. 2017;13(24):7-16. doi: http://dx.doi.org/10.16925/od.v12i24.1657

Abstract. *Introduction:* The *Spilanthes americana* flower has been commonly used in the treatment of recurrent herpes labialis through the flower extract fraction in yellow oil, which has often been diluted in Vaseline or alcohol. *Objective:* To identify and compare the chemical composition of the *Spilanthes americana* flower head and extract diluted in Vaseline and alcohol. *Methods*: A descriptive study was carried out to make the chemical identification of the *Spilanthes americana* flower head and extract diluted in Vaseline and alcohol, which was subjected to the Fourier Transform Infrared Spectroscopy. *Results:* Characteristic functional groups of spilanthol (N-isobutyl-2,6,8-decatrienamide) such as linear aliphatic hydrocarbon, gem-dimethyl group, carbonyl group, and disubstituted unsaturated alkenes were identified in the *Spilanthes americana* flower head and extract diluted in Vaseline and alcohol,. The analysis permitted identification of various functional groups in different samples. In the pure *Spilanthes americana* sample, the presence of a secondary amine, a nitro group, an ester, a nitrite, and nitrate and sulfur in the form of aromatic sulfonamide was determined. In the spectra of pure solid and Vaseline-diluted extract samples, disubstituted unsaturated alkenes with *trans* isomer were observed, while in the alcohol-diluted extract a *cis* configuration was found. *Conclusion:* The spectroscopic analysis evidenced the presence of characteristic functional groups of spilanthol, which changed the *trans* isomer of the pure and Vaseline-diluted samples to *cis* in the extract prepared in alcohol. Finally, common compounds to the three sulfur samples and an organic ester functional group were found.

Keywords: Herpes labialis; chemical composition; plant extracts, (DeCS Bireme), Oral Medicine.

p-ISSN 1900-3080 | e-ISSN 2357-4607

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Composición química del extracto de *Spilanthes americana*

Resumen. *Introducción*: la flor de *Spilanthes americana* se ha utilizado comúnmente en el tratamiento del herpes labial recurrente a través de la fracción del extracto de flor en aceite amarillo que a menudo se diluye en vaselina o alcohol. *Objetivo*: identificar y comparar la composición química del capítulo y el extracto de *Spilanthes americana* diluido en vaselina y alcohol. *Métodos***:** se realizó un estudio descriptivo para hacer la identificación química del capítulo y el extracto de *Spilanthes americana* diluido en vaselina y alcohol, los cuales se sometieron a la Espectroscopía Infrarroja por Transformada de Fourier. *Resultados*: se identificaron grupos funcionales característicos de espilantol (N-isobutil-2,6,8-decatrienamida) tales como hidrocarburo alifático lineal, grupo gem-dimetilo, grupo carbonilo y alquenos insaturados disustituidos en el capítulo y el extracto de *Spilanthes americana* diluido en vaselina y alcohol. El análisis permitió la identificación de varios grupos funcionales en diferentes muestras. En la muestra pura de *Spilanthes americana*, se determinó la presencia de una amina secundaria, un grupo nitro, un éster, un nitrito y nitrato y azufre en forma de sulfonamida aromática. En los espectros de la muestra sólida pura y del extracto diluido en vaselina, se observaron alquenos insaturados disustituidos con isómero *trans*, mientras que en el extracto diluido en alcohol se encontró una configuración *cis*. *Conclusión*: el análisis espectroscópico evidenció la presencia de grupos funcionales característicos de espilantol, que modificaron el isómero *trans* de la muestra pura y diluida en vaselina a *cis* en el extracto preparado en alcohol. Finalmente, se encontraron compuestos comunes a las tres muestras de azufre y un grupo funcional orgánico de éster.

Palabras clave: herpes labial, composición química, extractos vegetales, (DeCS Bireme), medicina oral.

Composição Química do Extrato de *Spilanthes americana*

Resumo. *Introdução:* A flor da *Spilanthes americana* vem sendo comumente utilizada no tratamento de herpes labial recorrente mediante o uso da fração do extrato da flor em óleo amarelo, o qual é frequentemente diluído em vaselina ou álcool. *Objetivo:* Identificar e comparar a composição química dos capítulos da flor de *Spilanthes americana* e do extrato diluído em vaselina ou álcool. *Métodos*: Um estudo descritivo foi conduzido para gerar a identificação química dos capítulos da flor de *Spilanthes americana* e do extrato diluído em vaselina ou álcool, o qual foi submetido à Espectroscopia no Infravermelho por Transformada de Fourier. *Resultados:* Grupos funcionais característicos de espilantol (N-isobutil--2,6,8-decatrienamida) tais como hidrocarboneto alifático linear, grupo gem-dimetil, grupo carbonila e alcenos insaturados dissubstituídos foram identificados nos capítulos da flor de *Spilanthes americana* e do extrato diluído em vaselina ou álcool. A análise possibilitou a identificação de vários grupos funcionais em diferentes amostras. Na amostra pura de *Spilanthes americana*, a presença de uma amina secundária, um grupo nitro, um éster, um nitrito, um nitrato e enxofre na forma de sulfonamida aromática foi determinada. Nos espectros das amostras do sólido puro e do extrato diluído em vaselina foram observados alcenos insaturados dissubstituídos com isomeria do tipo *trans*, enquanto no extrato diluído em álcool encontrou-se uma configuração do tipo *cis*. *Conclusão:* A análise espectroscópica evidenciou a presença de grupos funcionais característicos do espilantol, o qual alterou a isomeria trans das amostras pura e diluída em vaselina para cis no extrato preparado em álcool. Por fim, enxofre e um grupo funcional orgânico tipo éster foram encontrados como compostos comuns para as três amostras.

Palavras-chave: Herpes labial; composição química; extratos de plantas, (DeCS Bireme), Medicina Oral.

Introduction

According to Jacobson's taxonomic classification, different *Spilanthes* species, including *Spilanthes americana,* were found. This plant has been commonly used to treat symptoms of various diseases such as toothache or mucosal lesions through the flower extract fraction in yellow oil, which has often been diluted in Vaseline or alcohol [1].

Moreover, it has been historically used in an empirical way; reports indicate that one of the most important active ingredients is spilanthol, which has exhibited a very weak insecticidal activity. This compound is also recognized by its sialagogue activity, and almost every research reports its ability to numb the tongue and oral mucosa [2]. Asano and Kamatsu isolated pure spilanthol from *Spilanthes acmella* and described it as a burning yellow liquid with a 165°C boiling point. Subsequent studies led them to propose a new structure for spilanthol under the formula N-isobutyl-2,6,8-decatrienamide [3].

Since the 80's, different studies have been carried out; some of them deal with the verification of the local anesthetic activity of the *Spilanthes americana* extract and its ability to stimulate the central nervous system like other local anesthetics. In turn, the cholinergic action in experimental animals was also demonstrated and the LD50 in mice was determined, which was 22.5 mg per kilogram [4].

A study carried out by Nigrinis in 1989 reported biologically active substances of *Spilanthes americana* (N-isobutyl-2,6,8-decatrienamide and taraxasterol acetate), and demonstrated an anesthetic activity by efficient conduction similar to that of lidocaine and a rapid healing action due to decreased inflammatory phenomena induced in a surgical wound (microscopic evaluation). It may also have local surface anesthesia effects in moist mucous membrane alterations; when persistent, it results in an analgesic action that facilitates the healing process [5].

Some cholinergic actions that may bring side effects such as nausea, diarrhea, bradycardia, salivary hypersecretion, bronchospasm and mental confusion were also identified, but only when the extract had an intra-oral topical administration, which facilitated higher concentration of the extract chemical compounds in bloodstream. This led to recommend the use of the extract only topically and on dry mucous membranes [6].

Zuluaga et al. in 2008 carried out a study in Swiss albino mice in which they showed absence of sub-chronic toxicity and genetic abnormalities of *Spilanthes americana* through histopathological and genetic analyses [7]. Calle and Prada assessed the anti-aphtha and anti-herpes effect of the extract by processing the active ingredient in petroleum ether, which proved to be able of dissolving the lipid membranes of microorganisms [8].

Later, Duque et al. demonstrated greater efficiency of an alternative herpes simplex treatment using *Spilanthes americana* in the clinical evolution of lesions compared with Acyclovir. Its added value was the absence of adverse clinical reactions and its affordable cost to the public [9]. In 1998, the healing clinical effect of *Spilanthes americana* was analyzed at different concentrations on recurrent herpes simplex lesions in patients at an early stage of the disease. As a result, a powerful healing effect on labial herpes lesions was observed regardless of the concentration at which the extract had been used [10].

Several authors have reported the multiple features and applications of the extract on herpes lesions without any observed adverse clinical effects. The low cost and accessibility to the plant facilitate its use in patients affected by this disease [6-10]. However, it is important to mention that few studies report chemical compounds of the extract and none describes its chemical composition clearly, regardless of the vehicle used. This is especially important to evaluate aspects related to the extract pharmacokinetics and determine which constituent compound is the biologically active ingredient of the extract.

Knowledge of these components will allow to identify the active ingredients and conduct the trials required to establish which of them is anti-herpetic. Thus, the objective of this study was to identify and compare the chemical composition of the *Spilanthes americana* flower head and extract diluted in Vaseline and alcohol.

Methods

A descriptive study was carried out in order to record the chemical composition of the *Spilanthes americana* extract diluted in different vehicles. The flower head was identified according to the characteristics described by Gomez [21] and was obtained

in the rural area of Manizales. After obtaining the flower heads, three preparations of the plant were made. The first preparation consisted in macerating and compacting the flower head for a solid phase analysis. The second sample consisted of the *Spilanthes americana* extract diluted in alcohol. The third sample consisted of the *Spilanthes americana* extract diluted in Vaseline.

Preparation of the pure solid *Spilanthes* extract

15 g of dried flowers were weighted, macerated, sieved, and then packaged in three glass containers. Subsequently, 2 mg of the sample and 200 g of KCl (potassium chloride) were taken to obtain a pellet, which was subsequently used for the chemical description of the pure solid flower head.

Preparation of the alcohol diluted *Spilanthes* extract

15 g of the plant were weighed and mixed with 100 ml of alcohol (96%). The mixture was macerated and filtered, resulting in a homogeneous extract at a concentration of 14% [10].

Preparation of the Vaseline diluted *Spilanthes* extract

The flower head of the plant was dried and pulverized, and 60 g were mixed with 400 g of Vaseline previously melted in a double boiler to make an ointment at a concentration of 15% [7].

Laboratory procedure

All the samples were sent to the plasma physics laboratory at the Universidad Nacional de Colombia in Manizales, where the Fourier Transform Infrared Spectroscopy (FTIR) analysis was performed. The FTIR is an analytical tool that identifies the molecular composition of many organic and inorganic materials [20].

When materials are analyzed, they produce an infrared absorption spectrum, which is the fingerprint of a molecule that provides specific information of the chemical bonds in the molecular structure of matter. With this fingerprint method, many substances can be characterized, identified and quantified [20].

Spectroscopy is the detailed study of light. Light is energy moving through space and may be considered as a wave or a particle. In general, light consists of many types of wavelengths. Spectrometers are instruments that scatter light and the scattering angle depends on the wavelength creating the spectrum [20].

Once the various spectra were described, a univariate descriptive analysis, in which the only variable is chemical composition of extracts, was carried out. The description is focused on the chemical compounds identified in the different extracts and their comparison to detect common compounds. Absolute or relative proportions, represented through histograms, expressed data.

Results

Pure extract

Forty scans, with a resolution of 4.00 cm-1 ranging between 450 cm-1 and 4000 cm-1, were conducted for the analysis using a Perkin Elmer Spectrum BX Fourier Transform Infrared Spectrometer. The spectrum obtained for this sample is presented in Figure 1.

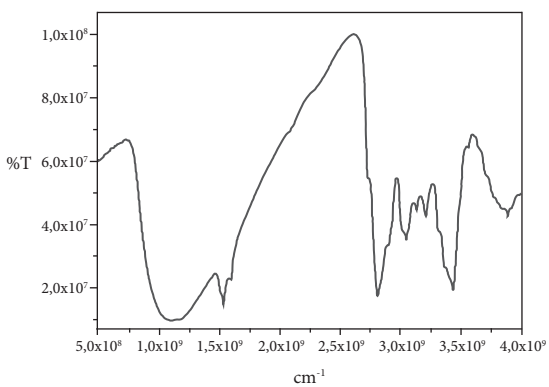

Figure 1. FT-IR spectrum of pure *Spilanthes* powder extract
Source**:** Compiled by the author

For the pure extract sample, multiple resonance frequencies corresponding to various functional groups, related to the compounds of spilanthol, were obtained. The chemical formula of this compound is N-isobutyl-2,6,8-decatrienamide.

A straight-chain aliphatic hydrocarbon related to the main chain of spilanthol, which makes part of the ten-carbon chain, was the first element identified. The dimethyl gene that belongs to the methyl group (CH_3), which is located in the positions 4 and 6 for spilanthol, was also found. This methyl gene is a functional group, hydrophobic alkene, derived from methane (CH_4). The presence of the methyl group is confirmed by the appearance of an alkyl group, which is a group formed by removing one hydrogen atom from a hydrocarbon (CH_3, in this case).

Similarly, an aliphatic compound with a carbonyl group, which is a functional group consisting of a carbon atom double-bonded to an oxygen atom, was identified. This group corroborates the presence of a carbon-oxygen double bond that can be bonded to the spilanthol amide or to some type of ester or ketone. According to the previous result, the group that coincides with this carbon-oxygen double bond was related and the amide group present in spilanthol was found. This group is an organic compound whose functional group is RCONR'R" in which CO is a carbonyl, N a nitrogen atom, and R, R' and R" organic radicals or hydrogen atoms.

However, there was a secondary amide with substituent ketone further related to the spilanthol compound since the amide of this compound is substituted (when the amide group is substituted, an N is added at the beginning of the formula) and a ketone group, which is a carbonyl group bonded to two other carbon atoms, is formed. A tertiary alkyl butyl group (four-carbon chain) or Isobutyl, which also belongs to spilanthol, was identified.

Finally, double bonds, *i.e.*, disubstituted unsaturated alkene groups, were found. Furthermore, for the alkene group, a geometric configuration belonging to a *trans* isomer was found. Apart from the characteristic functional groups of spilanthol, a secondary amine, a nitro group, an ester (probably aliphatic), sulfur in the form of aromatic sulfonic acid or salt, an aromatic sulfonamide and an inorganic nitrite and nitrate compound were identified through the spectrophotometric analysis.

Spilanthes americana in alcohol

A liquid sample diluted in yellow alcohol. Zero point five mL of the sample in ATR (Attenuated Total Reflectance) were analyzed by depositing the solution in a saline cell of ZnSe. In the analysis, 40 scans ranging between 4000 cm-1 and 650 cm-1 were conducted in a Perkin Elmer Spectrum BX Fourier Transform Infrared Spectrometer. Figure 2 shows the spectrum obtained from this sample.

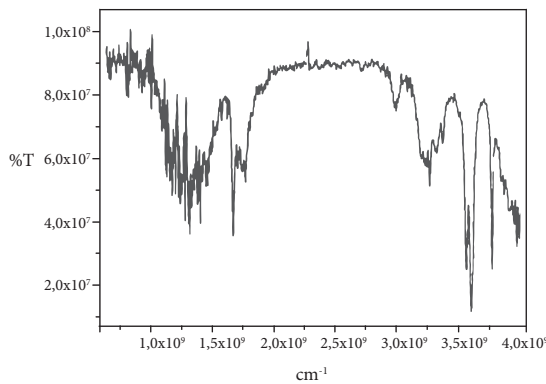

Figure 2. FR-IR spectrum of *Spilanthes* diluted in alcohol
Source**:** Compiled by the author

In this spectrum, most of the compounds identified in the pure extract sample were found, but new functional groups, produced by the reaction of alcohol OH groups primarily with hydroxyl groups (forming a double bond with oxygen), were also identified. This occurs because of the high reactivity of oxygen with carbon and other elements, attributable to its high electronegativity.

In the first instance, an aliphatic hydrocarbon, a straight-chain compound which was found highly branched where various functional groups could be located, was identified. A multiple substitution of methyl groups was found in this chain. In contrast, the dimethyl gene (two substituents of the methyl group, which are in positions 4 and 6 in the spilanthol) was identified in the pure sample.

The functional groups found in this sample and in the previous one are the main constituent groups of spilanthol; some of them are an alkyl substituent, alkenes (double bonds), a general amino or hydroxyl group, a secondary aliphatic amide, and a carbonyl group. The isobutyl group was not found. On the contrary, in this sample, a disubstituted alkyne group corresponding to a triple bond was evident.

Other hydroxyl groups (double bonded with oxygen), not previously present, were found. One of them is an unsaturated aliphatic aldehyde, which is an organic compound characterized by the -CHO functional group, *i.e.,* it is bound to a single organic

radical. An unsaturated tertiary aliphatic amide, which is more replaced than the secondary, was also found.

Another class of cyclic amide identified is the aliphatic amide in which the position of double or triple bonds is altered. A conjugated ketone group was found, possibly quinone. This is one of the two isomers of cyclohexanedione or a derivative thereof, with formula $C_6H_4O_2$. Quinone is a common constituent of biologically relevant molecules (*e.g.*, vitamin K) or serves as an acceptor of electrons in their transport chain.

Finally, an alkene with *cis* geometry configuration was found. Unlike the pure extract sample, which represents an isomer of alkenes, its physical and chemical properties are different to the *trans* isomer of the previous sample due to its distribution. Some of the compounds do not belong to spilanthol, but were identified in the pure extract sample diluted in alcohol. These compounds are the nitro group and the inorganic nitrate, an ester group and a sulfonamide. As in the previous sample, new functional groups such as trialkyl phosphate, carboxylic acid salt, silica or inorganic silicate, aromatic dimethyl, N-nitro group, unsaturated aliphatic alcohol, and sulfur were found, but in this case, in the form of coal disulfide.

Spilanthes americana in Vaseline

A heterogeneous oily sample. Two mg of the sample deposited between two windows of halogenated salt (NaCl) were analyzed. In the analysis, 40 scans ranging between 4000 cm-1 and 450 cm-1 were conducted in a Perkin Elmer Spectrum BX Fourier Transform Infrared Spectrometer. Figure 3 shows the spectrum obtained for this sample.

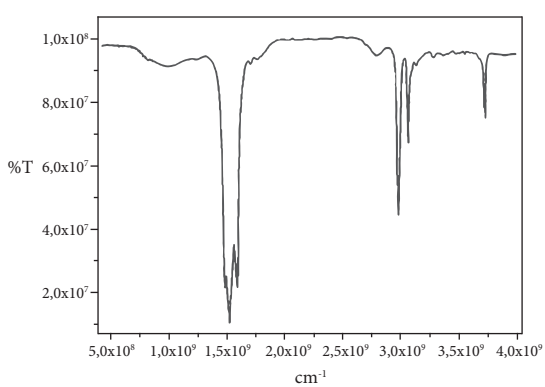

Figure 3. FT-IR spectrum of *Spilanthes* in Vaseline
Source: Compiled by the author

The spectrum of this sample represents the typical vibrations of a hydrocarbon as a result of the Vaseline added. This spectrum does not allow for easy identification of other functional groups included in the sample, since the hydrocarbon in the Vaseline is present in large proportions and acts, to some extent, as a shield of the *Spilanthes* organic compounds. The typical functional groups of Vaseline are a long-chain aliphatic hydrocarbon, a long-chain alkyl group, and an aliphatic hydrocarbon with multiple methyl substitution.

Despite the large amount of the aforementioned groups, some compounds of spilanthol were identified. Mainly, a carbonyl compound, possibly of the amide type corresponding to the ethyl in the spilanthol formula, was evidenced. Peaks were also found in the spectrum, possibly representing an unsaturated carboxylic acid. This characteristic group bonded to organic moiety R is represented as COOH.

The carboxyl groups react with the amino groups to form amides. For amino acids that react with other amino acids to produce proteins, the formed amide bond group is called peptide bond. Similarly, carboxylic groups can react with alcohols to form esters or halides to form acid halides, or together to form anhydrides. Esters, anhydrides, acid halides, and amides are called acid derivatives.

It was also possible to identify an unsaturated hydrocarbon, *trans* alkene, which was observed in the pure extract sample, but not in the alcohol-diluted extract sample. Other compounds identified in the previous samples are an ester group, an aldehyde group, and an aromatic group. Similarly, the presence of sulfur as carbon disulfide was evidenced. For this sample, a new compound was observed, the phenyl group or substituted aryl compound. The radical consisting of six-carbon atoms and five-hydrogen atoms is called phenyl; formally, it is a benzene system when a hydrogen is replaced by the rest of the molecule.

Discussion

Identification and features of spilanthol

The *Spilanthes* extracts from *Spilanthes americana* have shown antiseptic and analgesic effects and insecticidal activity against adult mosquitoes, several leaf-eating insects, and houseflies. The *Spilanthes*

americana flower extracts also have application in the treatment of Herpes simplex and Herpes zoster [22]. Research on *Spilanthes americana* has focused on the isolation and identification of spilanthol, a biologically active metabolite with an insecticidal activity that is isolated from the *Spilanthes americana* and other *Spilanthes sp.* flowers [22].

In this study, one of the compounds identified in the different preparations of the *Spilanthes americana* extract has been spilanthol, considered, without any certainty, as one of the active ingredients that has been attributed the medicinal properties such extract possesses. This compound was obtained for the first time in its natural state from the *Spilanthes oleracea* family, and it was named spilanthol, in which isobutylamides and polymerized acid materials [11] were obtained by hydrolysis processes.

Spilanthol has been considered the main constituent of the *Spilanthes* family, which has effective antiparasitic characteristics and has been used natively against malaria. It also has antiviral and antifungal properties, making this substance an option for multiple purposes [12]. Another study refers to several biological activities of spilanthol such as analgesic, antinociceptive, antioxidant, anti-inflammatory, anti-mutagenic, anti-wrinkle, antifungal, bacteriostatic, insecticidal, antimalarial, anti-larvicide (against *Aedes aegypti*) and anticonvulsant actions, pancreatic lipase inhibitor, antimicrobial agent, diuretic, among others. However, the human toxicity of spilanthol has not been tested [23].

In different chemical and pharmacological studies related to the *Spilanthes americana* flower head, the presence of spilanthol (N-isobutyl-2,6,8-decatrienamide), which is a biologically and physiologically active compound, has been consistently reported [6].

Analysis of the compounds found

Apart from spilanthol, several components worth keeping in mind as they may contribute to the spilanthol activity and give certain characteristics to the various preparations analyzed in the study were also identified.

Cis and *trans* isomers

In the present study, a chemical composition with *trans* isomerism in the pure extract and the Vaseline-diluted extract preparation was observed. In contrast, in the alcohol-diluted extract preparation, *cis* isomerism was identified.

Cis-trans isomerism or geometric isomerism is a type of stereoisomerism of alkenes and cycloalkanes. It is different from the *cis* isomer, where substituents are on the same side of the double bond or cycloalkane, and from the *trans* isomer, where substituents are on the opposite side of the double bond or cycloalkane. Figures 2 and 3 show both kinds of isomerism in more detail [13].

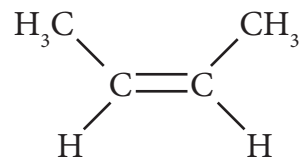

Figure 4. *Cis* configuration of the structure *cis* – 2 – butane

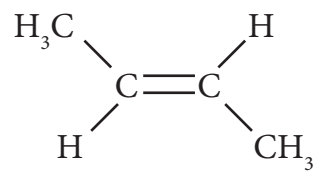

Figure 5. *Trans* configuration of the structure *trans* – 2 – butane

Jacobson refers to spilanthol as an isomer of Pellitorine, which is an isolated amide of pellitory roots, and presents a study on the synthesis and stereochemistry of three compounds obtained [14]. Since the advance of the structure for Pellitorine I, an amide insecticide occurs at the pellitory root. *Trans-cis*, *cis-cis* and *trans-trans* isomer configurations of this structure have been synthesized. Each of these isomers has proven to be inert in its insecticidal effect, although the *trans-cis* isomer has demonstrated a physiologically active effect, causing profuse salivation and partial insensitivity of the tongue [15].

Spilanthol is a Pellitorine isomer, whose natural compound has been reported to possess both physiological and insecticidal activity. In previous research with unsaturated isobutylamides, *cis-trans* isomers have shown to play an important role in the insecticidal and physiological action, such as N-isobutyl-*trans*-2-*trans*-4-decadienamide that

can cause paralysis of the mucous membranes, while the same compound with at least one double bond in a *cis* configuration is an inactive compound [16].

This study showed changes in isomerism for the *Spilanthes americana* extract preparations according to the vehicle used. The literature shows how different components may have biological effects or be inactive according to their isomerism [16], which was not the purpose of this study; however, further analysis may reveal that isomers change their biological action as described above.

Amide functional group

Amide functional groups were identified in the three preparations analyzed in the study. All amides, except amides from the first series, are solid at ambient temperature and their boiling points are higher than the corresponding acids. They have excellent solvent properties and are very weak bases. One of the main methods to obtain these compounds consists in reacting ammonia (or primary or secondary amines) with esters. The amides are common in nature and one of the best known is urea, a diamide that does not contain hydrocarbon. Proteins and peptides are composed of amides. Amides are also widely used in the pharmaceutical industry [17].

Amide group in spilanthol

The importance of acetate for spilanthol is evident, as the hydroxyl group is a reactive and allows for the formation of other reactive groups, such as amides and others. For forming amides, some groups such as carboxyl and ethers are involved. The last two groups were found in all samples, contributing, in part, to the formation of such compounds (amides), which determine the spilanthol formula.

Gem dimethyl

In chemistry, one methyl or one methyl group is a functional, hydrophobic alkene group derived from methane (CH_4), whose formula is -CH_3. In chemistry, it is a branch or moiety of a hydrogenated chain into an organic compound. The methyl group is part of a family of organic compounds called "homologous series," since they follow the same pattern [18]. For *Spilanthes americana*, Ospina and his group reported the presence of a compound (N-isobutyl-deca-5-ino-8-ene-trans-amide) [5], which has a gem-dimethyl and a *trans* configuration. In this study, gem dimethyl structures, the *trans* configuration, and the presence of an amide group were found in all preparations.

Other functional groups

For all samples, the presence of other groups was evident. Although they are not part of the traditional spilanthol structure, they cannot be discarded because of the influence they exercise on other groups, achieving the formation of other compounds. Groups such as esters, carboxylic acids, aldehydes, phenols, amongst others, derive in alcohols and may even intervene decisively in the structure of the *Spilanthes americana* extract, but these effects should be verified by establishing other characterization techniques to elucidate the action and importance of these substances within *Spilanthes americana*.

In this study, it is necessary to highlight the presence of sulfur in the different analyzed samples. This element took the form of aromatic sulfonamide in the pure *Spilanthes* extract (sample 1) and carbon disulfide in alcohol- and Vaseline-diluted extracts (samples 2 and 3).Sulfonamides, a series of compounds with an excellent antibacterial activity in humans, were also identified in the three preparations.

Based on this, new drugs that were encompassed within the "sulfa" group were further developed. Due to their increasing resistance and new classes of antibiotics, sulfa drugs are being replaced. However, today they are used in combination with other agents such as trimethoprim [18]. Sulfonamides are the generic form of sulfanilamide and contain a sulfide group bonded to a benzene ring and NH2 groups, which confers the bacteriostatic activity to the molecule [19].

These drugs are analogues of para-aminobenzoic acid (PABA) and thus act as its competitive antagonists, which is necessary for the synthesis of the bacterial folic acid. In addition, they inhibit dihydropteroate synthase, which is necessary for the incorporation of PABA into the dihydropteroic acid, which is the precursor of the folic acid. Unlike eukaryotic mammalian cells (that take the previously synthesized folic acid), bacteria have to

synthesize their own folic acid. Therefore, bacteria are more sensitive to the action of sulfonamides than the host [19].

The chemical composition of the *Spilanthes* extract described in the present study shows that it has elements with a biological effect on various pathological entities and not exclusively on herpes simplex or zoster virus. Future research will provide knowledge not only to standardize its use, but also to visualize other possible effects on different medical conditions.

Conclusions

Characteristic functional groups of spilanthol were identified in both the *Spilanthes americana* flower head and the Vaseline- and alcohol-diluted extracts, corresponding to the chemical formula N-isobutyl-2,6,8-decatrienamide.

In the pure *Spilanthes americana* sample, characteristic functional groups of spilanthol, such as a linear aliphatic hydrocarbon, gem dimethyl, a carbonyl group indicating the presence of an amide, an alkyl butyl group, and disubstituted unsaturated alkenes with *trans* isomerism were identified.

The alcohol-diluted *Spilanthes americana* sample exhibited the same functional groups of the pure sample, which are characteristic of spilanthol, but with *cis* isomerism. Moreover, the chain of hydrocarbons is branched with multiple substitution, added to the presence of a disubstituted alkyne, a conjugated acetone (quinone), a nitro group, a nitrate, an ester, and sulfur as sulfonamide.

In the Vaseline-diluted *Spilanthes americana* sample, compounds similar to spilanthol with *trans* isomerism were identified. In turn, the presence of an ester, an aldehyde, a phenyl, and sulfur was determined.

Some common compounds found in the three samples were sulfur in different forms, such as aromatic sulfonamide and carbon disulfide in the flower of the plant and the extracts respectively, as well as an ester group.

Recommendations

The chemical description of the *Spilanthes americana* extract is just the beginning of a line that can be oriented towards the isolated study of the components to which different biological effects already demonstrated in the literature are attributed. Likewise, it would be possible to identify any additional medicinal effects of these components in order to apply them to a number of local or systemic diseases.

Acknowledgements

This study acknowledges Dr. Dora Cardona (Bachelor in Bacteriology and Clinical Laboratory, Master in Research and Educational Development, and Ph.D. in Social Sciences) and Dr. Alfonso Devia (Professor, Researcher and Head of Plasma Physics Laboratories at the Universidad Nacional de Colombia, Manizales) who directly or indirectly assisted in the development of the research process.

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