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Original Research Article

In vivo anti-inflammatory and anti-nociceptive activities, and chemical constituents of essential oil from the leaf of *Gardenia jasminoides* J. Ellis (Rubiaceae)

NUDEWHENU OPEYEMI AVOSEH[1], OLADIPUPO ADEJUMOBI LAWAL[1], ISIAKA AJANI OGUNWANDE[2]✉*, ROBERTA ASCRIZZI[3], GUIDO FLAMINI[3] AND AMOO ELIZABETH[1]

[1]Department of Chemistry, Faculty of Science, Lagos State University, Lagos, Nigeria
[2]Foresight Institute of Research and Translation, Nigeria
[3]Dipartimento di Farmacia, Università di Pisa, Italy

ABSTRACT

The chemical constituents, anti-inflammatory and anti-nociceptive activities of the leaf essential oil hydrodisitlled from the *Gardenia jasminoides* J. Ellis (Rubiaceae) were reported. The chemical constituents of the essential were analyzed using gas chromatography-flame ionization detector (GC-FID) and gas chromatography coupled with mass spectrometry (GC/MS). The hot plate and carrageenan-induced models were used to determine the anti-nociceptive and anti-inflammatory activities. The main compounds of the oil were pentadecanal **17** (49.2%), geranial **4** (12.3%), *ar*-turmerone **14** (8.2%) and 10-*epi*-γ-eudesmol **10** (6.2%). The essential oil of *G. jasminoides* at 100 and 400 mg.kg^{-1} doses significantly ($p < 0.001$) increased the latency period for the reaction duration in the anti-nociceptive study. The carrageenan-induced edema model reveals the suppression of inflammatory mediators ($p < 0.001$) within 1st, 2nd and 4th h for 100 mg.kg^{-1} dose, 1st and 4th h (200 mg.kg^{-1}) and 1st-3rd h (400 mg.kg^{-1}). The results indicate the potential of *G. jasminoides* essential oil as a source of pain relieving agent.

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1. Introduction

Essential oils have been used for a long time as natural products (Ogunwande et al., 2019a,b). Not only are essential oils effective in the control and management of diseases, but their chemical components are also effective against most ailments and natural disaster (Avoseh et al., 2020a,b). *Gardenia jasminoides* Ellis, commonly called common gardenia or cape jasmine, is native to Southern China and Japan. It belongs to the family Rubiaceae. The plant is an evergreen shrub. The flowers are white and extremely fragrant.

The various extracts of the plant and their chemical compounds have been described with several pharmacological activities. The anti-hypertensive effect (Chen et al., 2017) and the anti-allergic activity (Sung et al., 2014) of *G. jasminoides* were associated with the active component, geniposide. The compounds, genipin and geniposide, found in *G. jasminoides* exhibited potent inhibitory effects and antifungal actions against *Pleurotus ostreatus*, *Fusarium oxysporum* and *Corynespora cassiicola* (Lelono et al., 20009). The anti-ulcer effects of *G. jasminoides* were derived from some important components, namely genipin gentiobioside and gardenoside isolated from the plant (Chen et al., 2014). A study has demonstrated that geniposide and crocins present in *G. jasminoides* could be responsible for its anti-inflammatory activity (Hu et al., 2019). Some compounds characterized from *G. jasminoides* including geniposide, 6α-hydroxygeniposide, ixoroside and shanzhiside exhibited significant immunosuppressive action (Chang et al., 2005). The fruits of *G. jasminoides* elicited cardiovascular effects (Liu et al., 2013). Other phytochemical compounds isolated and characterized from *G. jasminoides* include gardaloside and jasminoside G (Chang et al., 2005), imperatorin, isoimperatorin, crocetin, 5-hydroxy-7,3′,4′,5′-tetrainethoxyflavone, 2-methyl-3,5-di-

✉Corresponding author: Isiaka Ajani Ogunwande
Tel: +234 8059929304; Fax: +234 8059929304
E-mail address: isiakaogunwande@gmail.com

hydroxychromone, sudan III and crocin-3 (Chen et al., 2007). In addition, gardenoside, 6β-hydroxygeniposide, geniposidic acid, crocin-1, crocin-2, and crocin-4 were also obtained from the plant (Wang et al., 2015). A review of the chemical constituents and biological activities of both the non-volatile extracts of the plant was recently carried out (Phatak, 2017; Xiao et al., 2017).

The volatile constituents of *G. jasminoides* from various parts of the world have been studied and reported. The studies concentrated mainly on the flowers and fruits samples. The major volatile compound found in essential oils of *G. jasminoides* consists of diverse chemicals such as terpenes, aliphatic acids, ketones, aldehydes, esters, alcohols, fatty acids and aromatic derivatives. The contents and proportions of these phytochemicals varied from one region to another. The main compounds of the essential oils from different origin and plant parts as seen in the literature are summarized in Table 1. The essential oil of *G. jasminoides* was reported to have exhibited insecticidal activity towards *Bemisia tabaci* and *Tetranychus urticae* adult and nymph (Wagan et al., 2018). The oils also possessed good scavenging activities on 1,1-diphenyl-2-pic-rylhydrazyl [DPPH] and 2,2′-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) ($ABTS^{+)}$ with IC_{50} of 6.26 and 11.58 µg/mL, respectively (Gan et al., 2013). Although the chemical composition of essential oils from the fruits and flowers of *G. jasminoides* as well as biological activities such as antioxidant and insecticidal were reported, no reports exist on the composition and pain relieving action of the leaf oil. This noteworthy observation prompted our interest in the present research. The aim of this paper was to report the chemical constituents, anti-nociceptive and anti-inflammatory activities of essential oil hydrodisitlled from the leaf of *G. jasminoides* from Nigeria. This is in continuation of our ongoing research (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b) aimed at sourcing for biologically active products from essential oils form plants grown in Nigeria.

2. Experimental

2.1. Collection and authentication of the leaves of *G. jasminoides*

Mature leaves of *G. jasminoides* (Fig. 1., 156 g) were obtained from plants growing wild at Igando Area, Alimosho Local Government Area (GPS 6º36′38′N 3o17′45′E) of Lagos State (Fig. 2.), Nigeria. The leaves were collected on a single day in May 2017. The identification of *G. jasminoides* was done by Curators at Herbarium, University of Lagos Nigeria. A voucher specimen (LUH 3245) was deposited at the herbarium.

2.2. Preparing the samples ready for oil isolation

The leaves of *G. jasminoides* were dried at room temperature (30 ± 2 ºC) during two weeks in the Education Trust Fund Laboratory of Chemistry Department Lagos State University, Nigeria. After drying, *G. jasminoides* were ground into coarse powder, using locally made instrument to a total weight of 134.6 g which was used to obtain the essential oil.

2.3. Hydrodistillation of essential oil

The leaves of *G. jasminoides* were subjected to hydrodistillation using the method described earlier in previous studies (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). The coarse sample was introduced into a clean and dry 5 L flask and macerated completely with distilled water. Essential oil was then distilled in Clevenger-type distillation unit maintained at normal pressure at a total time of 3 h. Thereafter, essential oil was collected into clean weighed sample bottles, from the tap in the receiver arm of the apparatus and separately refrigerated (4 ºC) till the moment of analyses as described in our previous studies (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). The process of hydrodisitllation was done in triplicate analysis.

2.4. Analysis of the oil sample

The constituents of the essential oils were analyzed comprehensively by using gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectrometry (GC/MS) techniques. GC-FID) analysis was accomplished with an HP-5890 Series II instrument equipped with a HP-Wax and HP-5 capillary columns (both 30 m x 0.25 mm, 0.25 µm film thickness), working with the following temperature program: 60 ºC for 10 min, rising at 5 ºC.min^{-1} to 220 ºC. The injector and detector temperatures were maintained at 250 ºC; carrier gas nitrogen (2 mL.min^{-1}); detector dual, FID; split ratio 1:30. The volume injected was 0.5 µL. The relative proportions of the oil constituents were percentages obtained by FID peak area normalization without the use of a response factor.

Gas chromatography-mass spectrometry (GC-EIMS) analysis was performed with a Varian CP-3800 gas-chromatograph equipped with a HP-5 capillary column (30 m x 0.25 mm; film thickness 0.25 µm) and a Varian Saturn 2000 ion trap mass detector. Analytical conditions: injector and transfer line temperature 220 ºC and 240 ºC, respectively; oven temperature programmed from 60 ºC-240 ºC at 3 ºC.min^{-1}; carrier gas helium at a flow rate of 1 mL/min.; injection volume 0.2 µL (10% *n*-hexane solution); split ratio 1:30. Mass spectra were recorded at 70 eV. The acquisition mass range was 30-300 m/z at a scan rate of 1 scan.sec^{-1}.

2.4.1. Identification of the constituents of the essential oil

The identification of the constituents of essential oil from the leaves of leaves of *G. jasminoides* was based on comparison of their retention times with those of authentic samples, comparing their linear indices relative to a series of *n*-alkanes (C_6-C_{36}). Further identifications were also made possible by the use of a homemade library of mass spectra built up from pure substances and components of known oils (NIST, 2018) and MS

Table 1

Chemical constituents of essential oils of *Gardenia jasminoides* represented in the literature.

Plant parts	Origin	Main constituents	References
Fruits	N.K	myristic acid (15.3%)	Bao et al., 2011
Flowers	N.K	linalool, myristic acid, benzyl aceate, etc. were among the volatiles present above 1%	Buchbauer et al., 1996
Flowers	China	linalool (27.7%), (*Z*)-3-hexenyl pentenoate (24.4%) and hexyl tiglate (11.4%)	Cai et al., 2008
Flowers	China	linalool (21.1%), camphene (7.2%), α-caryophyllene (6.5%), geraniol (5.7%) and α-farnesene (5.4%)	Gan et al., 2013
Flowers	China	methyl benzoate (32.3%), linalool (20.5%), *cis*-3-hexenyl tiglate (20.3%) and carveol (10.3%)	Guo et al., 1991
Flowers	China	jasmin lactone, *cis*-3-hexenol, esters of *cis*-3-hexenol, *cis*-3-hexenoic acid and tiglic acid [a]	Hattori et al., 1978
Flowers	China	linalool, β-myrcene, methyl benzoate, L-limonene, ocimene, *cis*-3-hexenyl tiglate and *cis*-3-hexenylisovalerate a	Hunag et al., 2004
Floral	N.K	farnesene, (*Z*)-3-hexenyl tiglate, (*Z*)-3-hexenyl benzoate and indole [a]	Kanlayavattanakul and Lourith, 2015
Flowers	China	farnesene (64.9%) and *cis*-ocimene (29.3%)	Liu et al., 2000
Flowers	Nigeria	α-farnesene (28.4%), linalool (22.0%), *trans*-β-ocimene (10.6%) and α-terpineol (9.0%)	Obuzor and Nwakolo, 2011
Flowers	China	palmitic acid, linoleic acid, *cis*-13-octadedienoic acid, octadedienoic acid, squalene, and vitamin E [a]	Shang et al., 2019
Flowers	China	ocimene, α-farnesene, benzoic acid methyl ester, isopropyl cyclohexane and 3,7-dimethyl 1,6-octadiene-3-alcohol propionate [a]	Tan et al., 2012
Flowers	China	squalene, ethyl linoleate, *n*-hexadecanoic acid and 9-12-octadecadienoic [a]	Wagan et al., 2018
Flowers	China	linalool (17.9%), 7-decen-5-olide (9.1%) and *cis*-3-hexenyl tiglate (6.5%)	Zhang et al., 1991

[a] Quantitative composition not available; N.K.: Not known

Fig. 1. The photograph of leaf of *G. jasminoides*.

Fig. 2. The geographical map of the sampling area within Lagos State, Nigeria Source: www.lagosgovt.gov.ng.

literature data as described in our previous reports (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). Moreover, the molecular weights of all the identified substances were confirmed by GC-CIMS, using MeOH as CI ionizing gas.

2.5. Biological studies

2.5.1. Drugs and chemicals

Carrageenan drug of analytical grade was obtained from Sigma-Aldrich Chemical Co. (St Louis, MO, USA). Ibuprofen injection (May and Baker) and diclofenac injection (Dizpharm, Nigeria Ltd.) were purchased from Lagos State University Pharmacy.

2.5.2. Animals used for the study

Wistar rats (150-200 g) of both sexes were accommodated in the Biochemistry Department Animal Facility of Lagos state University, Ojo-Lagos. The rats were kept in a metal steel cage, where they had unrestricted supply to water and standard pellet food. They were acclimatized for two weeks before commencement of experiment. The rats were assigned at random to a group of 5 consisting of 6 animals per group. To select the doses used in the experiment, rats of similar weight were grouped together to obtained average weight. The weight recorded was similar across the groups of rats. The dose was therefore determined from the weight of rats in the assigned group. The essential oil of *G. jasminoides* was dissolved in saline vehicle. Doses of 100, 200 and 400 mg.kg^{-1} were administered to the rat in that order.

All experimental procedures were conducted as approved by the Research Ethical Clearance Committee (RECC) of the University (Approval no: 012/2017/LASU/BCH).

2.5.3. Toxicity study on the essential oil of *G. jasminoides*

The leaf essential oil of *G. jasminoides* was tested for acute toxicity study as described previously. Twenty-five Wistar rats (both sexes, 150-200 g each) were used for the toxicity study as described in previous studies (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). The rats were divided into 5 animals in each group and doses of 500, 1000, 1500 and 2000 mg.kg^{-1} of the leaf essential oil of *G. jasminoides* were administered per oral route. One group received normal saline that served as a negative control (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b).

2.5.4. Evaluation of the anti-inflammatory activity of the essential oil

The method of carrageenan-induced paw edema in ratswas used. Animals in each groups were induced

subcutaneously with 0.1 mL of 1% freshly prepared carrageenan in the right hind paw treated by oral administration of vehicle (water, 10 mL.kg^{-1}; control), sodium diclofenac (10 mg.kg^{-1}; positive control) and *G. jasminoides* essential oil doses (100, 200 and 400 mg.kg^{-1}) as described in previous studies (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). Paw volume of the injected rats were measured hourly on a plethysmometer (Ugo Basile, Italy mod. 7140) commencing 1 h before (basal values) and up to 4 h following carrageenan injection. Edema was calculated as the difference (L) between injected and control paw. The area under the curve (AUC) time versus Δ paw volume was calculated for each animal and the edema was expressed as the mean±S.E.M. of AUC (Ferreira et al., 2005).

2.5.5. Determination of anti-nociceptive effect of the essential oil

The experiment was carried out according to the method described previously (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). Twenty-five mature Wistar rats of both sexes were randomly divided into 5 groups of equal rats. The animals were fasted for 12 h with provision of clean water *ad libitum*. Each rat was placed upon the heated metal plate (Hot plate) maintained at the temperature of about 50-55 ºC within the restraining glass cylinder. Solution of essential oils were administered to the rats as follows: Group 1 rats received 10 mg.kg^{-1} of saline solution which serve as control experiment, while 10 mg.kg^{-1} of sodium salicylate which serves as standard control was administered to Group 2 rats. Furthermore, rats in Groups 3, 4 and 5 received 100, 200 and 400 mg.kg^{-1} of *G. jasminoides* respectively p.o.

Animal response to the heat varies and such changes includes kicking of hind foot and jumping about, licking of foot, raising the foot, holding the foot tightly to its body or shaking of the foot (Avoseh et al., 2020a,b; Ogunwande et al., 2019a,b). The reaction time was recorded 30, 60, 90 and 120 min after the administration of the treatments. The maximum reaction time was fixed at 30 s to prevent any injury to the tissues of the paws. If the reading exceeds 30 s, it would be considered as maximum analgesia.

2.6. Statistical analysis

The data represent the mean ± S.E.M. of the evaluated parameter and were analyzed for statistical significance by one-way analysis of variance (ANOVA) followed by post-hoc Bonferrotti test for the carrageenan and the hot plate test using GraphPad Prism (version 7.02, San Diego CA, USA, www.graphPad.com). The minimum levels of significance, $p < 0.05$, $p < 0.01$ and $p < 0.001$, were considered as the statistically significant difference of the means.

3. Results and Discussion

3.1. Constituents of leaf essential oil of *G. jasminoides*

Table 2 represents the nature, retention indices on HP-5 column and percent compositions of the oil. The average yield of the essential oil was 0.23% (v.w^{-1}, ±0.01), calculated on a dry weight basis. A total of 17 compounds representing 97.3% of the oil contents were identified in the colourless essential oil as seen in Table 2. The main classes of compounds found in the essential oil of *G. jasminoides* were long chain aldehydes (51.4%), oxygenated monoterpenes (21.6%) and oxygenated sesquiterpene (20.7%). The terpene hydrocarbons are less common represented by monoterpene hydrocarbons (0.8%). None of the sesquiterpene hydrocarbons could be found in the leaf essential oil of *G. jasminoides*. The compounds occurring in higher amount in the essential oil were pentadecanal **17** (49.2%), geranial **4** (12.3%), *ar*-turmerone **14** (8.2%) and 10-*epi*-γ-eudesmol **10** (6.2%).

The observed variation on the amount and the composition of the bioactive substances in the present and previous studies on *G. jasminoides* are germane due to differences in the plant part being analyzed, and according to other factors such as the extraction methods, the geographic and the growing conditions, the harvest time, etc. (Sharifi-Rad et al., 2017). Terpene compounds found in previously investigated samples (Guo et al., 1991; Zhang et al., 1991; Liu et., 2000; Obuzorand Nwakolo, 2011; Gan et al., 2013) were also the main classes of compounds in the studied oil. However, other classes of compounds such as esters (Hunag et al., 2004; Cai et a., 2008; Tan et al., 2012; Kanlayavattanakul and Lourith, 2015), aromatic derivatives (Tan et al., 2012; Wagan et al., 2018; Shang et al., 2019), aliphatic alcohols and acids (Hattori et al., 1978) that are characteristics of previously analyzed samples (Table 1) were not identified in the present study. The quantity of fatty acids in the present oil samples is noteworthy with respect to previous studies (Bao et al., 2011; Waggan et al., 2018; Shang et al., 2019), although the identities of the various fatty acids differ from one oil sample to another. In addition, pentadecanal, geranial and *ar*-turmerone, the main compounds of the leaf oil, were not reported previously as main constituents of previously analyzed flowers and fruits oil. Moreover, α-farnesene, linalool, *trans*-β-ocimene and α-terpineol, the main constituents of the flowers oil previously analyzed from Nigeria, were not identified in the leaf oil. This indicates the existence of chemical forms in the essential oils of *G. jasminoides* growing in Nigeria brought about by the different plant parts.

3.2. Toxicity effect

The acute toxicity of the essential oil which was evaluated at 500, 1000, 1500, and 2000 mg.kg^{-1} body weight showed no contrary effects on the behavioural responses in the tested rats following 14 days of observation. No mortality, size, or weight change observed. Therefore, the highest dose of 400 mg.kg^{-1} adopted to be ministered to rats in this study was considered safe.

3.3. Anti-nociceptive activity of *G. Jasminoides* essential

oil

Figure 3 below shows the effect of *G. jasminoides* essential oil on the thermal stimuli of Wistar rats. The leaf essential oil of *G. jasminoides* was tested for its anti-nociceptive activity using the hot plate method. The response of Wistar rats to heat was evaluated accordingly. This assay was used to evaluate the analgesic ability of the studied essential oil. It also depicts the strength of essential oil of *G. jasminoides* to act as an opioid antagonist. Opioid receptor antagonists block one or more of the opioid receptors in the central or peripheral nervous system. Groups of animals administered with different doses of *G. jasminoides* essential oil were compared with saline-administered groups (control). It was observed that the higher the maximum pain threshold time, the more the inhibitory capacity of *G. jasminoides* essential oil. As shown in the Fig. 3, the 100 and 400 $mg.kg^{-1}$ doses of *G. jasminoides* significantly (p <0.001) increased the latency period for the reaction duration. Conversely, the 200 $mg.kg^{-1}$ did not showed any significant inhibition.

3.4. Anti-inflammatory action of the essential oil

The results of the anti-inflammatory study are shown in Fig. 4. To evaluate the anti-inflammatory activity of *G. jasminoides* leaf essential oil, the carrageenan-induced model was adopted. The carrageenan-induced paw inflammation has been accepted as a useful phlogistic tool for investigating systemic anti-inflammatory agent. In this study, the activities of *G. jasminoides* were compared to that of the control (saline-treated groups), as shown in Fig. 4. Reduction in edema was measured hourly post-administration for four hours. The higher the reduction in edema size, the more active the *G. jasminoides* essential oil. Therefore, in this study, *G. jasminoides* at a dose of 100 $mg.kg^{-1}$ significantly reduced the edema at the 1st, 2nd, and 4th hour (p < 0.001) but showed no activity at the 3rd h. An increase of dose to 200 $mg.kg^{-1}$ revealed a non-consistent inhibitory pattern. The essential oil reduced the edema proliferation at the 1st and 4th h (p < 0.001), but showed a decline in activity at the 2nd and 3rd h (p < 0.01). The absorption and inhibitory capacity of the 400 $mg.kg^{-1}$ dose proceeds from the 1st to the 3rd h at a very high rate (p <0.001) but declined at the 4th h. The proliferation of inflammation mediators, e.g. histamine, prostaglandins, leukotrienes, oxygen- and nitrogen-derived free radicals, serotonin, and cytokines, triggered by the carrageenan-induced model is a time-dependent activity. These mediators primarily increase clotting and reduce the healing period (Juhn et al., 2008). The model is well-defined for acute inflammation. It is time-dependent, characterized by the biphasic release of mediators. This phlogistic agent evokes biphasic edema, the first phase (1 h) of which is mediated by the release of histamine and serotonin from mast cells and the second phase (2-4 h) of which involves neutrophil infiltration and the release of prostaglandin E2, cytokines (mainly IL-1β) and nitric oxide (Coura et al., 2015). Our result demonstrated that the tested doses of *G. jasminoides* essential oil significantly reduced the first phase of inflammation, while the doses inhibited the second phase of the carrageenan-induced edema at different hours.

The anti-inflammatory activity of extracts and compounds of *G. jasminoides* (Hoo et al., 2006; Hong et al., 2006; Hoong and Yang, 2013; Xiao et al., 2017) and extracts of some other species in the genus such as *Gardenia coronaria* (Chowdhury et al., 2014, *Gardenia carinata* (Appalaraju et al., 2018), *Gardenia aqualla* (Muhammad et al., 2019) and *Gardenia latifolia* (Ansari et al., 2020) have been reported. Moreover, the anti-inflammatory, anti-nociceptive and antipyretic activities of essential oils from some other plants such as *Alpinia allughas* (Kumar et al., 2017), *Globba sessiliflora* (Kumar et al., 2017), *Thuja plicata* var. Excelsa, *Alstonia boonei, Curcuma longa* and *Allium sativum* (Avoseh et al., 2020a) as well as *Mucuna pruriens* (Avoseh et al., 2020b) among others have been reported in literature. However, no such information could be seen for essential oils of *Gardenia* plants. The present results are the first of its kind on the chemical constituents, anti-inflammatory and anti-nociceptive activities of the leaf essential oil of *G. jasminoides*. The presence of monoterpenes, sesquiterpenoids and other class of compounds could be responsible for the observed anti-inflammatory and anti-nociceptive activities of the essential oil of *G. jasminoides* as previously reported (Savegnago et al., 2016). Synergistic interaction of the components of the essential oil of *G. jasminoides* could also be responsible for the observed change. However, the abundant constituents of the essential oil mainly pentadecanal, geranial, *ar*-trumerone, etc. were known previously for their pharmacological properties. Geranial exhibits significant anti-inflammatory and analgesic activities, inhibiting expression of the inflammatory mediators such as TNF-α and IL-6 secretion of macrophages, pro-IL-1β, iNOS, COX-2 and NLRP-3, phosphorylation of ERK1/2, JNK1/3, p38 and IκB e.t.c. (Mai et al., 2014; Nishijima et al., 2014; Liao et al., 2016). *ar*-Turmerone also reduced TNF-α, IL-1β, IL-6, and MCP-1 production in amyloid (Aβ) stimulated microglial cells as well as NF-κB, JNK, and p38 MAPK signaling pathways (Park et al., 2012a,b; Yang et al., 2020). Pentadecanal was thought to be responsible for the antimicrobial and cytotoxicity properties (Essien et al., 2012) of some essential oils. However, it is difficult to explain the possible mechanism of the essential oils based on the present findings; further studies are needed to elucidate the exact mechanism.

4. Concluding remarks

The chemical composition and biological activity of essential oil from the leaf of *G. jasminoides* were reported for the first time. The major compounds identified in the oil were pentadecanal, geranial, *ar*-turmerone and 10-*epi*-γ-eudesmol. In addition, the essential oil displayed considerable anti-inflammatory and anti-nociceptive activities. Our findings suggest that the essential oils of *G. jasminoides* may be useful in the prevention or treatment of inflammatory related diseases.

Table 2
Chemical constituents found in *Gardenia jasminoides* leaf oil.

Sr. No	Constituents [a]	LRI [b]	LRI [c]	Percent [d]	MI
1	Myrcene	993	992	0.8	RI, MS
2	Neral	1242	1243	4.6	RI, MS
3	Geraniol	1256	1256	3.3	RI, MS
4	Geranial	1271	1270	12.3	RI, MS, Co
5	Daucene	1381	1380 [e]	0.4	RI, MS
6	Geranyl acetate	1383	1386	1.4	RI, MS
7	Neryl acetone	1436	1435	1	RI, MS
8	(*E*)-β-Ionone	1487	1488	0.7	RI, MS
9	Caryophyllene oxide	1582	1581	2.6	RI, MS
10	Humulene epoxide II	1607	1609	0.6	RI, MS, Co
11	Tetradecanal	1614	1613	2.2	RI, MS, Co
12	10-*epi*-γ-Eudesmol	1619	1619	6.2	RI. MS, Co
13	α-Eudesmol	1653	1650	0.7	RI, MS
14	*ar*-Turmerone	1666	1658	8.1	RI, MS, Co
15	*n*-Heptadecane	1700	1700 [e]	1.1	RI, MS, Co
16	Curlone	1701	1701	2.5	RI, MS, Co
17	Pentadecanal	1716	1715	49.2	RI, MS, Co
Total				97.3	
Monoterpene hydrocarbons (Sr. No. **1**)				0.8	
Oxygenated monoterpenes (Sr. No. **2-4**, **6**)				21.6	
Oxygenated sesquiterpenes (Sr. No. **9**, **10**, **12-14**, **16**)				20.7	
Apocarotenes (Sr. No. **7**, **8**)				1.7	
Long chain aldehydes (Sr. No. **11**, **17**)				51.4	
Alkane (Sr. No. **15**)				1.1	

[a] Elution order on HP-5 column; [b] Linear retention indices on HP-5 column; [c] Literature retention indices (NIST 2018); [d] SD Standard deviation were insignificant and excluded from the Table to avoid congestion; [e] U.S. National Library of Medicine, PubChem, 2018; Sr. No: Serial number; MI: Mode of identification; RI: Retention indices, MS: Mass spectral, Co: Co-injection with known compounds

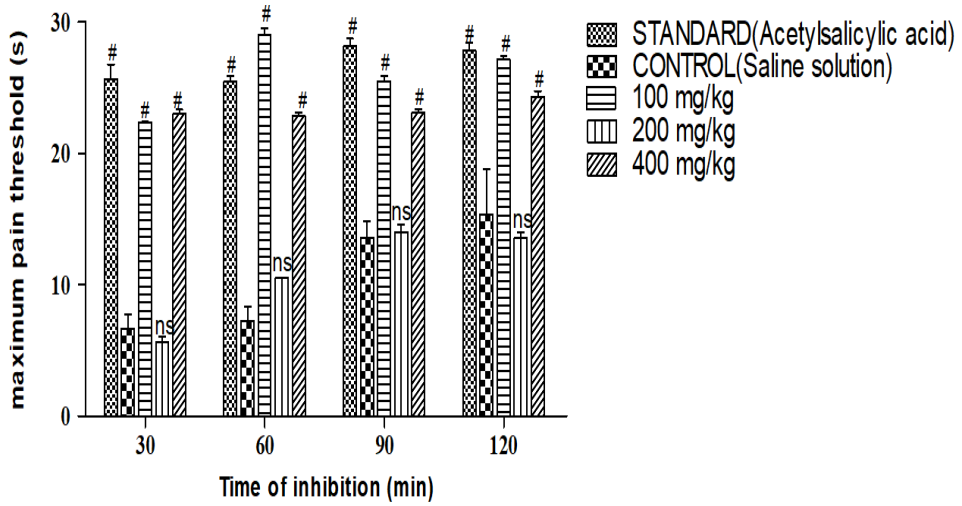

Fig. 3. Effect of the essential oils of *G. jasminoides* on hot place-induced anti-nociceptive. Control, standard and *G. jasminoides* represent 1 mL saline solution, 100 mg/kg of aspirin injection and 100, 200 and 400 mg of *G. jasminoides* leaves essential oil, respectively. #p < 0.001, ns= non-significant, p<0.5 statistically compared to the control.

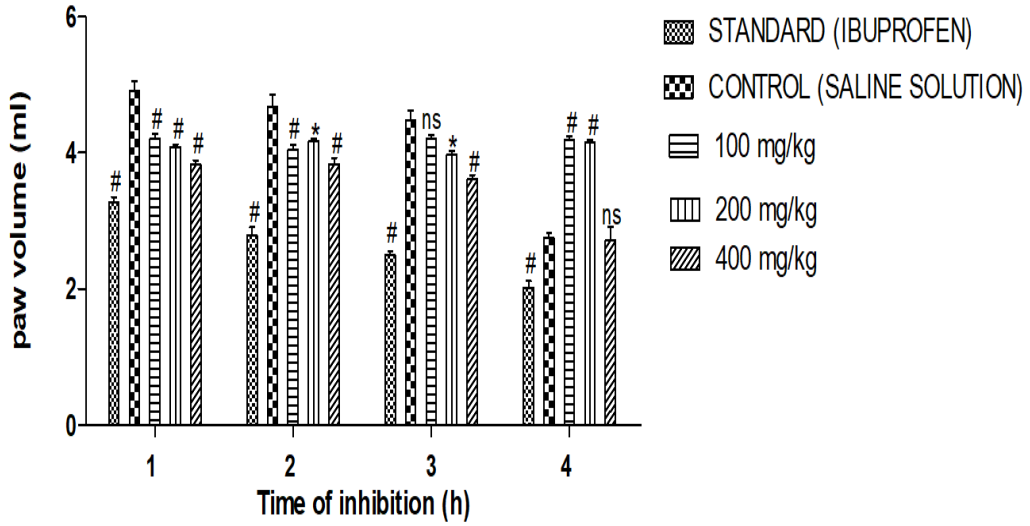

Fig. 4. Effect of leaf essential oil of *G. jasminoides* on carragenan-induced inflammation. Control, standard and *G. jasminoides* represent 1 mL saline solution, 100 mg/kg of dichlofenac injection and of 100, 200 and 400 mg/kg of *G. jasminoides* leaf essential oil respectively. *p < 0.01, #p < 0.001, ns= Non-significant statistically compared to control.

Conflict of interest

The authors declare that there is no conflict of interest.

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