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# Chemical constituents and antimicrobial activity of essential oils from *Pogostemon cablin* (Blanco) Benth. and *Coriandrum sativum* L. from Vietnam

**Nguyen Phuong Hanh, Nguyen Quoc Binh, Dinh Thi Thu Thuy and Isiaka Ajani Ogunwande**

**Abstract**
In the present communication, the compositional pattern and antimicrobial activity of hydrodistilled essential oils from the leaf of *Pogostemon cablin* (Blanco) Benth., of the family Lamiaceae and the aerial parts of *Coriandrum sativum* L. belonging to the family Umbelliferae growing in Vietnam were reported. The main constituents of *P. cablin* essential oil were mainly sesquiterpenes represented by patchoulol (32.0%), α-guaiene (14.9%), α-bulnesene (14.2%), seychellene (8.2%), α-patchoulene (5.5%), and β-patchoulene (5.2%). However, linalool (34.2%), (2*E*)-decenal (14.9%), (2*E*)-dodecanal (10.8%), (2*E*)-decen-1-ol (7.1%), n-tetradecanol (5.7%), and decanal (4.5%) were the main constituents of the essential oil of *C. sativum*. Only the essential oil of *C. sativum* displayed moderate activity against *Bacillus subtilis* ATCC 6633 with minimum inhibitory concentration (MIC) value of 64.0 µg/mL, and median lethal concentration ($IC_{50}$) value of 35.08±2.57. The essential oils of both *P. cablin* and *C. sativum* could not inhibit the growth of *Escherichia coli* ATCC 25922, and *Candida albicans* ATCC 10231.

**Keywords** *Pogostemon cablin*, *Coriandrum sativum*, essential oil, *Bacillus subtilis*

## 1. Introduction
*Pogostemon cablin* (Blanco) Benth. Is a species of flowering plant in the family Lamiaceae, commonly called the mint? The plant grows as a bushy perennial herb, with erect stems reaching up to 75 cm in height and bearing small, pale pink-white flowers [1]. Some of the phytochemical compounds of *P. cablin* include 3α-hydroxypatchoulol 3-O-β-d-glucopyranoside, 15-hydroxypatchoulol 15-O-β-d-glucopyranoside, and rubusoside [2]. *P. cablin* Benth. An aromatic plant species yields essential oil with immense industrial as well as pharmaceutical applications. Reports on the chemical compounds of essential oils from this species around the world are known. Table 1 indicates the major constituents previously identified in the essential oils [3-4, 7-16]. The essential oils of *P. cablin* have also demonstrated some biological activities of importance. Both *P. cablin* flower and leaf essential oils exhibited weak to strong antimicrobial activities, substantial antioxidant activity, anti-inflammatory activity, anti-cholinesterase activity and anti-diabetic ability [3]. The essential oil and its two major compounds, namely patchoulol and phloroacetophenone, exhibited contact toxicity and repellent activities against *Tribolium castaneum*, *Lasioderma serricorne*, and *Liposcelis bostrychophila* [4]. There are reports describing the larvicidal and pupicidal activities of the essential oil of *P. cablin* against *Aedes albopictus* [5]. The sesquiterpenes of *P. cablin* were reported to be responsible for the antifungal and anti-oxidant activities [6]. It is interesting to note that patchouli alcohol (32–38%), α-bulnesene and α-guaiene were identified as as major constituents of the previously analysed essential of *P. cablin* from Vietnam [7]. A review of the chemical compositions and pharmacological activities of essential oils from *P. cablin* was published recently [17].
Coriander (*Coriandrum sativum* L.) belonging to the family Umbelliferae/Apiaceae is an erect annual herb with pronounced taproot, and slender branching stems up to 20-70 cm in height. The leaves are lanceolate, green or dark green, glabrous on both surfaces and are variable in shape and lobed. The flowers are borne in small umbels, white or light pink, asymmetrical, with the petals pointing away from the centre. The coriander seed is almost ovate globular dry schizocarp with two mericarps, and multiple longitudinal ridges on the surface possessing a sweet, slightly pungent flavor [18]. The plant has a long history as a culinary herb being the

source of aroma compounds and essential oils with biologically active components possessing antibacterial, antifungal and antioxidant activities. *C. sativum* is useful in food preparation (as a flavouring agent and adjuvant) and preservation as well in preventing food borne diseases and food spoilage. Various authors have reported the chemical components of essential oils of *C. sativum* from other parts of the world [18-22] except Vietnam (Table 1). The yield of *C. sativum* essential oils and its chemical composition undergoes changes during ontogenesis which affects the aroma of the plant. The composition of *C. sativum* fruits essential oils varied at different stages of maturity and from one geographical region to another [22]. The *C. sativum* fruit EO (15 µL/disc) exhibited antibacterial effect against *E. coli*, *P. aeruginosa* and *Salmonella typhi* (*S. typhi*) with the diameter of zone of inhibition of 25, 10 and 18 mm, respectively [23]. The essential oil of *C. sativum* exhibited antibacterial activity with minimum inhibitory concentration (MIC) of 4.2 µL/mL to most bacterial strains [24]. The essential oil displayed anti-candial action against *Candida* spp., with MIC in the range of 15.6-31.2 µg/mL [22].

In continuation of our research on the chemical compositions and biological potentials of essential oils from Vietnamese flora [25-29] we report herein the results of our investigations on *P. cablin* and *C. sativum* harvested in Vietnam.

**Table 1:** Representative compositions of essential oils from *P. cablin* and *C. sativum*

| Plant parts | Origin | Chemical compositions | References |
|---|---|---|---|
| ***Pogostemon cablin*** | | | |
| flowers and leaves | India | Patchouli alcohol (27.52%, 44.52%) and caryophyllene (18.23%, 12.86%) | [3] |
| aerial parts | China | Patchoulol (51.1%), phloroacetophenone (23.5%) and β-patchoulene (7.3%). | [4] |
| leaves | Vietnam | patchouli alcohol (32–38%), α-bulnesene and α-guaiene | [7] |
| aerial-parts (leaves, inflorescence and whole aerial-parts | India | patchouli alcohol (42.2–57.7%), α-bulnesene (9.0–15.2%), α-guaiene (6.4–17.9%), seychellene (3.4–6.9%), pogostol (0.3–5.0%) and (E)-caryophyllene (2.1–3.6%) | [8] |
| root | ‘’ | Pogo stone (70.2%), norpatchoulenol (5.3%) and β-pinene (4.5%) | [8] |
| commercial oil | Asia | *allo*aromadendrene | [9] |
| leaves | India | α- and β-patchoulene, patchouli alcohol (patchoulol), β-caryophyllene, α-guaiene, seychellene and selinene + | [10] |
| leaves and flowers | China | pogostone and patchouli alcohol + | [11] |
| Leaves | India | patchouli alcohol content of T1 essential oil (36.63%) and T2 (30.33%) | [12] |
| * | | α-guaiene, α-bulnesene, α-patchoulene and seychellene + | [13] |
| * | India | pogostone, pogostol, and (Z)-thujopsene + | [14] |
| * | India | patchouli alcohol content (37.94%) | [15] |
| * | ‘’ | patchouli alcohol + | [16] |
| ***Coriandrum sativum*** | | | |
| seed | Europe | linalool (58.0–80.3%), γ-terpinene (0.3%–11.2%), α-pinene (0.2%–10.9%), p-cymene (0.1%–8.1%), camphor (3.0%–5.1%) and geranyl acetate (0.2%–5.4%) | [18] |
| flowers | India | benzofuran,2,3-dihydro (15.4%), hexadecanoic acid, methyl ester (10.32%) 2,4a-epioxy-3,4,5,6,7,8,-hexahydro-2,5,5,8a-tetramethyl-2h-1-benzofuran (9.35%), 2-methyoxy-4-vinylphenol (8.8%)2,3,5,6-tetrafluroanisole (8.62%) 2,6-dimethyl-3- aminobenzoquinone (6.81%) dodecanoic acid (5%) | [19] |
| leaves | Brazil | decanal (19.09%), (2*E*)-decenal (17.54%), 2-decen-1-ol (12.33%) and cyclodecane (12.15%), cis-2-dodecena (10.72%), Dodecanal (4.1%), dodecan-1-ol (3.13%) | [20] |
| ‘ | ‘’ | Linalool (72.7%), γ-terpinene (8.8%), α-pinene (5.5%), camphor (3.7%), limonene (2.3%), geranyl acetate (1.9%) and p-cymene (1.5%) | [21] |
| fruits | India (a) | geranyl acetate (46.27%), linalool (10.96%), nerol (1.53%), neural (1.42%) | [22] |
| ‘’ | (b) | linalool (76.33%), cis-dihydrocarvone (3.21%), geranyl acetate (2.85%) | ‘’ |
| ‘’ | (c) | linalool (87.54%), cis-dihydrocarvone (2.36%) | ‘’ |

* parts not known; + quantitative data not known; (a) First stage (immature fruits); (b) Middle stage (intermediate fruits); (c) Final stage (mature fruits)

## 2. Materials and methods

### 2.1 Plant materials

The leaves of *P. cablin* and aerial parts of *C. sativum* were collected from cultivated plants in Hanoi, Vietnam in February (*C. sativum*) and April (*P. cablin*) 2022. The identification of the samples was done by Hanh NP. at the Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, Hanoi, Vietnam, where voucher specimen, NPH1.2022 and NPH2.2022, respectively were deposited for future reference.

### 2.2 Essential oil extraction

The fresh leaves of *P. cablin* (1100 g) and aerial parts of *C. sativum* (1200 g) were cleaned, chopped and subjected to hydro-distillation in a Clevenger-type apparatus for 4 h. The obtained essential oil was preserved in a dark sealed tube under refrigeration prior to analysis as done previously [26-29].

### 2.3. Gas chromatography-Mass spectrometry (GC/MS-FID) analysis

GC/MS analyses were carried out using an Agilent GC7890A system with Mass Selective Detector (Agilent 5975C). An HP-5MS fused silica capillary column (60 m ×0.25 mm i.d. × 0.25 µm film thickness) was used. Helium was the carrier gas with a flow rate of 1.0 mL/min. The inlet temperature was 250 $^0$C and the oven temperature program was as follows: 60 $^0$C to 240 $^0$C at 4 $^0$C/min. The split ratio was 100:1 and the injection volume was 1 µL. The MS analysis was carried out at interface temperature 270$^0$C, MS mode, E.I. detector voltage 1258 eV, and mass range 35-450 Da at 4.0 scan/s. FID analysis was carried out using the same chromatographic conditions. The FID temperature was 270 $^o$C. The retention indices (RI) were experimentally determined using the *n*-alkanes ($C_8$-$C_{20}$) analyzed under the same GC-conditions.

The identification of volatile components was based on

comparison of their retention indices; retention times and mass spectra with those obtained from authentic standards and/or mass spectral libraryof the GC–MS data system (W09N08), the NIST Chemistry Web Book [30], and the Adams data base [31].

### 2.4. Screening of antimicrobial activity

The antimicrobial activity of the essential oils was evaluated using 3 strains of Gram-positive test bacteria including *Bacillus subtilis* (ATCC 6633) *Escherichia coli* (ATCC 25922), and a yeast *Candida albicans* (ATCC 10231). The ATCC strains were obtained from American Type Culture Collection. The bacterial culture medium (MHB -Mueller Hinton Broth, TSB - Try Pti Soy Broth was purchased from Merck. Test samples were dissolved by DMSO 100% and deionized water to provide a range of concentrations (256.0, 64.0, 16.0 and 4.0 µg/mL). Microbacteria were kept remaining at -80 ºC. Before assay, they were activated by culture medium and, adjusted the concentration to $5\times10^{5}$ CFU/mL. 10 µL of each concentration of each test sample combined with 190 µL of microbacterial solution in 96-well plate which were further incubated at 37 ºC within 16-24h. The experiment was triplicated. Positive controls were wells with a bacterial suspension in growth medium, and culture medium without bacteria as a negative control. Ampicillin was used as a reference compound. The results were described as the absorption at 590 nm and calculated by raw data software following below equations as described previously [26-29]:

% inhibition = $(OD_{control\ (+)} - OD_{test\ agent})/(OD_{control(+)} - OD_{control\ (-)}) \times 100\%$

$$IC_{50} = High_{Conc} - \frac{(High_{Inh\%} - 50) \times (High_{Conc} - Low_{Conc})}{High_{Inh\%} - Low_{Inh\%}}$$

Where the $IC_{50}$ value was the concentration of compound exhibiting inhibitory fifty percentage of bacterial growth under the assay conditions. OD: Optical density; control (+): Only cells in medium without antimicrobial agent; test agent: corresponds to a known concentration of antimicrobial agent; control (-): Culture medium without cells. High Conc/Low Conc: Concentration of test agent at high concentration/low concentration; High INH%/Low INH%:% inhibition at high concentration/% inhibition at low concentration

## 3. Results & Discussion

### 3.1. Chemical compositions of the essential oils

The yield of the essential oil of *P. cablin* was 1.8%. From Table 2, 24 compounds accounting for 97.0% of the oil contents were identified in the essential oil. This comprised of monoterpene hydrocarbons (0.2%), oxygenated monoterpenes (0.4%), and sesquiterene hydrocarbons (60.3%) and oxygenated sesquiterpenes (36.1%). The main constituents of the essential oil were mainly sesquiterpenes represented by patchoulol (32.0%), α-guaiene (14.9%), α-bulnesene (14.6%), seychellene (8.2%), α-patchoulene (5.5%), and β-patchoulene (5.2%). Monoterpene compounds were identified in insignificant quantity. A comparative analysis of the present study with a previous report on the compositional pattern of essential oil of *P. cablin* showed some interesting observations. Firstly, previously published articles on essential oils of *P. cablin* [3, 4, 7-16] have reports lesser contents of monoterpene compounds. In addition, high contents of patchouli alcohol and derivatives as seen in this study, were also the main compounds of the essential oils of previous reports on essential oils of *P. cablin* [3, 4, 7-16]. Moreover, other sesquiterpene compounds such as α-guaiene, α-bulnesene, and seychellene were also reported in previous studies on essential oils of *P. cablin* [7, 8, 10, 13]. The abundant of patchouli alcohol as well as the presence of α-bulnesene and α-guaiene in the present study on *P. cablin* confers similarity with the previously analysed essential oil of *P. cablin* from Vietnam [7]. It can be postulated there seems to be homogeneity in the chemical compositions of essential oils of *P. cablin* from Vietnam and other parts of the world. The essential oil of *P. cablin* from Vietnam by virtue of its high patchouli alcohol, α-guaiene, and α-bulnesene conform to the ISO value.

**Table 2:** Compounds present in the leaf in the essential oil of *P. cablin*

| Sr. No | Retention time (min) | Compounds [a] | RI[b] | RI[c] | % composition |
|---|---|---|---|---|---|
| 1 | 13.51 | Limonene | 1034 | 1030 | 0.2 |
| 2 | 15.82 | Linalool | 1101 | 1100 | 0.2 |
| 3 | 24.33 | δ-Elemene | 1348 | 1347 | 0.3 |
| 4 | 24.88 | m-Eugenol | 1364 | 1363 | 0.2 |
| 5 | 26.03 | β-Patchoulene | 1399 | 1393 | 5.2 |
| 6 | 26.16 | *cis*-β-Elemene | 1403 | 1401 | 0.9 |
| 7 | 27.02 | Cycloseychellene | 1431 | 1429 | 0.8 |
| 8 | 27.23 | β-Caryophyllene | 1437 | 1437 | 3.3 |
| 9 | 27.71 | α-Guaiene | 1453 | 1451 | 14.9 |
| 10 | 28.11 | Seychellene | 1466 | 1468 | 8.2 |
| 11 | 28.32 | α-Humulene | 1472 | 1472 | 0.6 |
| 12 | 28.51 | α-Patchoulene | 1478 | 1477 | 5.5 |
| 13 | 28.62 | δ- Patchoulene | 1482 | 1479 | 2.4 |
| 14 | 28.71 | Germacrene D | 1498 | 1498 | 0.5 |
| 15 | 29.14 | β-Selinene | 1505 | 1503 | 0.2 |
| 16 | 29.36 | Aciphyllene | 1514 | 1517 | 2.8 |
| 17 | 29.62 | α-Bulnesene | 1523 | 1527 | 14.6 |
| 18 | 30.31 | 7-*epi*-α- Selinene | 1537 | 1537 | 0.1 |
| 19 | 31.67 | Norpatchuolenol | 1583 | 1581 | 1.0 |
| 20 | 33.32 | 3-iso-Thujopsanone | 1641 | 1643 | 0.6 |
| 21 | 34.31 | Pogostol | 1675 | 1675 | 2.0 |
| 22 | 34.51 | Zizanal | 1683 | 1685 | 0.3 |
| 23 | 34.74 | Patchoulol | 1691 | 1691 | 32.0 |

| | | | | | |
|---|---|---|---|---|---|
| 24 | 35.75 | (*E*,*E*)-Farnesol | 1728 | 1730 | 0.2 |
| Total | | | | | 97.0 |
| Monoterpene hydrocarbons (Sr. No. 1) | | | | | 0.2 |
| Oxygenated monoterpenes (Sr. No. 2,4) | | | | | 0.4 |
| Sesquiterpene hydrocarbons (Sr. No. 3, 5-19) | | | | | 60.3 |
| Oxygenated sesquiterpenes (Sr. No. 20-25) | | | | | 36.1 |

[a] Elution order on HP-5MS column; [b] Experimental retention indices; [c] Literature retention indices on HP-5MS column as seen in NIST; Sr. No, serial number

From Table 3, it is clearly seen that 29 constituents amounting to 93.8% of the essential oil contents were identified in *C. sativum.* The yield of the essential oil was 0.45%.The oil constituents consist of diverse classes of compounds including monoterpene hydrocarbons (3.6%), oxygenated monoterpenes (36.4%), unsaturated alcohols (8.9%), saturated alcohols (7.5%), saturated aldehydes (13.4%), fatty acids (7.0%), alkane (0.9%) and alkanone (0.1%). The main constituents of the essential oil were linalool (34.2%), (2*E*)-decenal (14.9%), (2*E*)-dodecanal (10.8%), as well as (2*E*)-decen-1-ol (7.1%), n-tetradecanol (5.7%), and decanal (4.5%). A review of essential oil of *C. sativum* [18, 21, 22, 32] indicated the abundant of linalool in majority of the samples. However, the abundant of other compounds especially decanal, (2*E*)-decenal, 2-decen-1-ol, *cis*-2-dodecenal, dodecanal, and dodecan-1-ol amongst others have been reported [19, 20, 32]. The presence of unsaturated aldheydes was responsible for the aroma source of the essential oil of *C. sativum* [32]. The seemingly low content of α-pinene, γ-terpinene, linalool, the absence of myrcene, limonene, camphor, α-terpineol, geraniol and geranyl acetate means that the studied essential of *C. sativum* do not conform with the International Standard Organization (ISO) [32].

**Table 3:** Constituents identified in the essential oil of *C. sativum*

| Sr. No | Retention time (min) | Compounds [a] | RI[b] | RI[c] | % composition |
|---|---|---|---|---|---|
| 1 | 8.15 | (*Z*)-Hex-3-en-1-ol | 851 | 846 | 0.1 |
| 2 | 9.28 | n-Nonane | 899 | 898 | 0.9 |
| 3 | 10.49 | α-Pinene | 939 | 932 | 2.4 |
| 4 | 11.88 | β-Pinene | 984 | 980 | 0.2 |
| 5 | 12.46 | n-Octanal | 1003 | 1002 | 0.4 |
| 6 | 13.35 | o-Cymene | 1029 | 1024 | 0.5 |
| 7 | 14.51 | γ-Terpinene | 1063 | 1056 | 0.5 |
| 8 | 14.70 | n-Octanol | 1068 | 1068 | 0.5 |
| 9 | 15.00 | *trans*-Linalool oxide (furanoid) | 1077 | 1076 | 0.2 |
| 10 | 15.50 | 2-Nonanone | 1091 | 1089 | 0.1 |
| 11 | 15.54 | *cis*-Linaool oxide (furanoid) | 1093 | 1093 | 0.3 |
| 12 | 15.90 | Linalool | 1103 | 1101 | 34.2 |
| 13 | 15.98 | Nonanal | 1105 | 1103 | 0.2 |
| 14 | 18.25 | n-Nonanol | 1170 | 1170 | 0.1 |
| 15 | 19.55 | Decanal | 1207 | 1210 | 4.5 |
| 16 | 21.23 | Geraniol | 1256 | 1254 | 0.4 |
| 17 | 21.55 | (2*E*)-Decenal | 1265 | 1263 | 14.9 |
| 18 | 21.72 | (2*E*)-Decen-1-ol | 1270 | 1272 | 7.1 |
| 19 | 21.79 | n-Decanol | 1272 | 1273 | 2.4 |
| 20 | 23.03 | Undecenal | 1309 | 1309 | 0.7 |
| 21 | 25.17 | n-Undecanol | 1373 | 1373 | 0.2 |
| 22 | 25.52 | Geranyl acetate | 1384 | 1384 | 1.3 |
| 23 | 26.39 | Dodecanal | 1411 | 1411 | 2.0 |
| 24 | 28.27 | (2*E*)-Dodecanal | 1471 | 1471 | 10.8 |
| 25 | 28.32 | (2*E*)-Dodecen-1-ol | 1472 | 1472 | 1.5 |
| 26 | 29.57 | Tridecanal | 1513 | 1513 | 0.2 |
| 27 | 31.34 | (2*E*)-Tridecen-1-al | 1572 | 1573 | 0.5 |
| 28 | 32.59 | Tetradecanal | 1615 | 1615 | 1.0 |
| 29 | 34.32 | n-Tetradecanol | 1667 | 1678 | 5.7 |
| Total | | | | | 93.8 |
| Monoterpene hydrocarbons (Sr. No. 3,4,6,7) | | | | | 3.6 |
| Oxygenated monoterpenes (Sr. No. 9,11,12,16,22) | | | | | 36.4 |
| Unsaturated alcohols (Sr. No. 1,18,21,25) | | | | | 8.9 |
| Saturated alcohols (Sr. No. 8,14,15,19) | | | | | 7.5 |
| Alkane (Sr. No. 2) | | | | | 0.9 |
| Alkanone (Sr. No. 10) | | | | | 0.1 |
| Saturated aldehydes (Sr. No. 5,13,23,24) | | | | | 13.4 |
| Unsaturated aldehydes (Sr. No. 17,20,27) | | | | | 16.1 |
| Fatty acids (Sr. No. 26, 28,29) | | | | | 7.0 |

[a] Elution order on HP-5MS column; [b] Experimental retention indices; [c] Literature retention indices on HP-5MS column as seen in NIST; Sr. No, serial number

**Table 4:** Antimicrobial activity of the essential oils

| Species | Parameters (µg/ml) | Microorganisms | | |
|---|---|---|---|---|
| | | ***Bacillus subtilis*** | ***Escherichia coli*** | ***Candida albican*** |
| *Coriandrum sativum* | $IC_{50}$ | 35.08 ± 2.57 | >256 | >256 |
| | MIC | 64 | >256 | >256 |
| *Pogostemon cablin* | $IC_{50}$ | >256 | >256 | >256 |
| | MIC | >256 | >256 | >256 |

### 3.2 Antimicrobial activity of the essential oils

Table 4 showed the antibacterial and anti-candidal activities of essential oils of *P. cablin* and *C. sativum*. Only the essential oil of *C. sativum* displayed moderate activity against *B. subtilis* with MIC value of 64.0 µg/mL, and $IC_{50}$ value of 35.08±2.57 µg/mL. The essential oils of *P. cablin* and *C. sativum* could not exhibit significant antimicrobial and anti-candidal activities, with MIC and $IC_{50}$ value 256.0 µg/mL. The observed activities are lesser than previously reported for both essential oil samples. Much of the biological activities attributed to *C. sativum* fruit essential oils have been mainly due to linalool [32]. Several other compounds have contributed significantly to the observed antimicrobial potentials of *C. sativum* [22-24]. The studied essential oil of *C. sativum* showed selective antimicrobial activity in accordance with data previously reported for *E. coli* [32], *C. albicans* [32], and *B. subtilis* [33, 34].

## 4. Conclusions

This study showed that the compositional patterns of hydrodistilled essential oils from *P. cablin* and *C. sativum* of Ha Noi, Vietnam, were in tandem with previously reported data from other parts of the world. However, *C. sativum* essentia oil displayed moderate antibacterial activity towards *B. Subtilis*, contrary to previously investigated oil samples. The investigated essential oil of *P. cablin* from Vietnam by virtue of its major chemical compounds conforms to the value laid down by ISO. However, the essential oil of *C. sativum* essential oil does not conform to ISO due to the absence of several monoterpene compounds.

## 5. References


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