VARIATION IN BIOACTIVE CHEMICALS-TOTAL PHENOLS, FLAVONOIDS, EUGENOL AND URSOLIC ACID IN LEAVES OF Ocimum Sanctum L. IN DIFFERENT SEASONS FROM DIFFERENT GEOGRAPHICAL LOCATIONS OF MADHYA PRADESH

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ABSTRACT

Phyto diversity has a considerable importance as a source of pharmaceutically active biochemicals. The medicinal plants show a marked variation in active ingredients during different seasons and different locations as these have been widely attributed to variations in environmental variables such as temperature and rainfall. The activity of medicinal plants depends upon the chemical constituents present in them. Variation in the amount may result in loss of activity and reduction the efficacy of the plants with potent traditional value drug. The results showed significant variation (P=0.05) in active components in leaves of O.sanctum collected in different seasons from different agro-climatic zones of Madhya Pradesh. The total phenols varied 0.44 – 4.25%, 2.33- 4.39% and 1.56 - 6.99% in summer, rainy and winter seasons, respectively. Maximum amount of total phenol was observed in winter season in the sample collected from Kymore Plateau and Satpura Hills. Total flavonoids ranged from 0.87-6.03%, highest in winter sample of Chhattisgarh Plains while in antioxidant activity as percent free radical scavenging activity varied 10.37- 38.06 %, 22.40- 46.48% and 30.34-60.33 % (4mg/ml) in summer, rainy and winter seasons, respectively and recorded to be maximum in Kymore Plateau and Satpura Hills in winter season. Eugenol content varied 0.01-0.25% and found to increase in winter season. Maximum quantity was obtained in the samples collected from Chhattisgarh Plains. Ursolic acid content varied 0.01-0.258%. Maximum % was observed in sample collected from Grid Region in winter season. However, in some samples collected from Jhabua Hills, Malva Plateau and Nimar Plains, ursolic acid quantity was found to be highest in summer season. The findings of the study will be useful for plant breeders to develop more productive and commercial varieties of important medicinal plant, O.sanctum and sustainable harvesting for quality produce.

INTRODUCTION

Ocimum sanctum L. (family-Labiatae), synonym Ocimum tenuiflorum, commonly known as Tulsi has been used for thousands of years for its diverse healing properties. Tulsi is also known as the “Queen of herbs”, the legendary ‘Incomparable one’ of India. This small herb is found throughout India and worshiped in temples and houses of Hindus. This is commonly known as Vishnu-Priya, Tulsi in Sanskrit, Kali- Tulsi in Hindi and Holy Basil in English. It is mentioned in CharakaSamhita for its medicinal uses. Tulsi is considered to be an adaptogen, balancing different processes in the body, and helpful for adapting to stress. Marked by its strong aroma and astringent taste, it is regarded in Ayurveda as a kind of ‘elixir of life’ and believed to promote longevity. Traditionally, O. sanctum L. is taken in many forms, as herbal tea, dried power or fresh leaf.

O. sanctum is a many branched, erect, stout and aromatic herb, about 30-60 cm high. The leaves, seeds and root of this plant have been used in indigenous Ayurvedic medicine.

Tulsi leaves are regarded as an ‘adaptogen’ or anti-stress agent and studies have shown that the leaves afford significant protection against stress (Regahunandana et al., 1995).The plant is bitter and acrid (Gupta et al., 2002). It is a popular home remedy for many ailments such as wound, bronchitis, liver or hepaticdiseases, catarrhal fever, otalgia, lumbago, ophthalmia, gastric disorders, genitourinary disorders, skin diseases, various forms of poisoning and psychosomatic stress disorders (Eshrat et al., 2001; Das and Prajapati, 2003; Vasudevan, 2006). The leaves are good for nerves, to sharpen memory andcuring ulcers and infections of mouth. It has aromatic, stomachic, carminative, demulcent, diaphoretic, diuretic, expectorant, alexiteric, vermifuge and febrifuge.
properties (Gupta et al., 2002). The plant has been evaluated pharmacologically for antimicrobial, immune modulatory, anti-stress, anti-inflammatory, antipyretic, anti-asthmatic, hypoglycemic, hypotensive and analgesic activities. Tulsi has been found to be utmost effective in various types of animal models (Chiang et al., 2005). The decoction of leaves is used against the gastritis and hepatic disorders and leaves have been reported to show strong antifungal activities against the Aspergillus species (Joglekar et al., 1959). The leaves and other parts have been shown to possess hypoglycaemic effects in experimental animals (Mitra, 1991; Kochhar et al., 2009).

The chemical composition of Tulsi is highly complex, containing many nutrients and other biological active compounds. The leaves contain an essential oil comprising of eugenol, eugenal, carvacrol, methylchavicol, limatrol and caryophyllene. The seeds contain oil composed of fatty acids and sitosterol. The leaves also contain ursolic acid and n-triaccontanol. Eugenol, its methyl ether, nerol, carvophyllene, terpinen-4-decylaldehyde, selinene, pinenes, camphen contains rosmarinic acid, thymol, linalool, methyl chavicol, citral and apiene have been identified in essential oil. (Dhar et al., 1968). Eugenol, a phenylpropanoid compound (l-allylbenzene), the active constituent present in O. sanctum has been found to be largely responsible for the therapeutic potential as an antiseptic and anaesthetic as well as in perfumes and flavorings. In India the practitioners of traditional systems of medicine have been using Tulsi for curing various ailments. However, a rational approach to this traditional medical practice with modern system of medicine is not much available.

Eugenol was found to be effective against Listeria monocytogenes, Aeromonashydrophila and autochthonous spoilage flora in microbial media (Chaieb et al., 2007). Eugenol exhibited strong antimicrobial activities against E. coli, S. aureus, Bacillus cereus, L. monocytogenes, P. aeruginosa, Salmonella typhi, and Proteus mirabilis (Gochev and Girova, 2014; Devi et al., 2010 & 2013). It has also been used in mucoadhesive tablets to treat periodontal diseases (Jadhav et al., 2004). An important characteristic of eugenol is its hydrophobicity which enhances its incorporation into the cell membrane.

Presence of eugenol attributes to its anti-oxidative property and is also thought to be responsible for inhibition of lipid peroxidation (Gupta et al., 2002). This property helps in maintaining good health and in preventing the chances occurrence of heart diseases as well as most of the other biochemical diseases because oxidative stress is the cause of such diseases (Hannan et al., 2006). The nutritional and pharmacological properties of the whole herb in natural form, as it has been traditionally used, result from synergistic interaction of many different active phytochemicals, consequently, the overall effects of Tulsi cannot be fully duplicated with isolated compound or extracts.

MATERIALS AND METHODS

Samples were collected from different agroclimatic zones (Fig.1) of Madhya Pradesh on seasonal basis (summer, rainy and winter) to collect samples of O.sanctum (Tulsi).

Total phenol content in the sample was estimated by Folin-Ciocalteau reagent (Malick and Singh, 1980).

Free Radical Scavenging Activity (Antioxidant Activity) was carried out according using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay system reported by Mensor et al. (2001). One ml of a 0.3 mM DPPH in respective solution was added to 2.5 ml solution of the extract or standard (100 μg/ml, 200 μg/ml, 300 μg/ml) and allowed to react at 20°C temperature for 20 min in the dark.

The change in colour from deep violet to light yellow was then measured at 517 nm using UV-2450 Spectrophotometer (SHIMADZU), Kyoto, Japan against extraction solvent as blank solution. The Inhibition concentration (IC50) of free radical in percent was calculated according to the following equation: Inhibition concentration (IC50) % = [{(A0-Ae)/A0}] x 100

With A0 being the absorbance of the control reaction (containing all reagents except for the extract) and A1 the absorbance of the extract. Measurements were carried out in triplicates.

$$RSA\% = \frac{A_{test} - A_{cntrl}}{A_{cntrl}} \times 100$$

Where, A_{test} - Absorbance of the control
A_{cntrl} - Absorbance of the the sample

Estimation of Ursolic acid in O.sanctum using HPTLC

It is estimated by using HPTLC (Mitali et al., 2013).

Preparation of standard solution and extraction of samples

Standard preparation: Standard solutions (100mg/ml) of ursolic acid was prepared by dissolving in methanol.

Sample preparation: 0.2 gm of sample (dried course powder) was taken in a beaker and extracted in methanol. The mixture was centrifuged and the filtrate was collected and dried. The dried filtrate was then mixed in methanol and volume was made up to 5 ml.

HPLC specifications

Instrument - CAMAG HPTLC system
Stationary phase - TLC silica gel 60 F254 precoated aluminum sheets  
Mobile phase - Toluene: Ethyl acetate: Formic acid (7.0: 1.0: 0.1, v/v/v)  
Chamber saturation time - 10 minutes  
Derivatization - Anisaldehyde-sulphuric acid and heating at 110°C for 10 minutes  
Scanning wavelength - 530 nm

**Estimation of Eugenol in Ocimum sanctum using HPTLC**

Content of *O. sanctum* leaves was estimated by using HPTLC (Khan and Sharique, 2014)

**Preparation of standard solution and extraction of samples**

Standard preparation: Standard solutions (100mg/ml) of Eugenol was prepared by dissolving in methanol.

Sample preparation: 0.5 gm of sample (dried course powder) was taken in a beaker and extracted in methanol. The mixture was centrifuged and the filtrate was collected and dried. The dried filtrate was then mixed in methanol and volume was made up to 5 ml.

**HPTLC specifications**

Instrument - CAMAG HPTLC system  
Stationary phase - TLC silica gel 60 F254 precoated aluminum sheets  
Mobile phase - toluene-ethyl acetate-formic acid, 90: 10: 01 (v/v)  
Wavelength - 280 nm  
Chamber saturation time - 10 minutes

**Statistical Analysis**

The data recorded for various parameters during the study was subjected to Analysis of Variance and computation of significance of results with SPSS (version-14) package.

**RESULTS**

*O. sanctum* leaves are rich in various secondary metabolites and play vital role in human health care. The seasonal and geographical variation in total phenol, flavonoids and antioxidant activity is shown in Table-1. The results showed significant variation (P=0.05) in active components in leaves. The total phenols varied 0.44 -4.25%, 2.33- 4.39% and 1.56 - 6.99% in summer, rainy and winter seasons, respectively. Maximum amount of total phenol was observed in winter season in the sample collected from Kymore Plateau and Satpura Hills.

**Table 1** Seasonal variation in active ingredients of *O. sanctum* among various agro-climatic regions

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Agroclimatic Zone</th>
<th>Total Phenols (%)</th>
<th>Total Flavonoids (%)</th>
<th>Scavenging activity % (4mg/ml)</th>
<th>Total Phenol (%)</th>
<th>Total Flavonoids s (%)</th>
<th>Scavenging activity % (4000µg/ml)</th>
<th>Total Phenol (%)</th>
<th>Total Flavonoids s (%)</th>
<th>Scavenging activity % (4mg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bundelkhand Zone</td>
<td>2.87±0.17</td>
<td>0.86±0.07</td>
<td>24.54±1.15</td>
<td>4.02±0.57</td>
<td>0.88±0.45</td>
<td>38.31±5.77</td>
<td>4.08±0.67</td>
<td>2.15±0.03</td>
<td>40.80±4.70</td>
</tr>
<tr>
<td>2</td>
<td>Central Narmada Valley Zone</td>
<td>1.40±0.25</td>
<td>2.03±0.05</td>
<td>22.82±13.16</td>
<td>4.39±0.23</td>
<td>1.15±0.05</td>
<td>46.49±1.83</td>
<td>2.67±0.11</td>
<td>3.16±0.13</td>
<td>43.53±3.20</td>
</tr>
<tr>
<td>3</td>
<td>Chattisgarh Plains</td>
<td>3.40±0.48</td>
<td>1.92±0.02</td>
<td>37.48±1.22</td>
<td>4.35±0.57</td>
<td>1.05±1.45</td>
<td>42.25±2.21</td>
<td>4.18±0.80</td>
<td>6.03±0.29</td>
<td>54.15±11.47</td>
</tr>
<tr>
<td>4</td>
<td>Grid Region</td>
<td>0.44±0.09</td>
<td>2.04±0.02</td>
<td>26.07±6.26</td>
<td>3.39±0.23</td>
<td>0.86±0.15</td>
<td>30.50±5.65</td>
<td>1.67±0.11</td>
<td>1.95±0.01</td>
<td>30.34±10.32</td>
</tr>
<tr>
<td>5</td>
<td>Jhabua Hills</td>
<td>3.33±0.13</td>
<td>1.48±0.05</td>
<td>33.68±5.36</td>
<td>4.19±0.43</td>
<td>1.05±0.03</td>
<td>42.70±6.42</td>
<td>6.42±1.28</td>
<td>1.30±0.32</td>
<td>47.54±3.5</td>
</tr>
<tr>
<td>6</td>
<td>Kymore Plateau and Satpura Hills</td>
<td>2.40±0.10</td>
<td>1.68±0.21</td>
<td>28.20±2.38</td>
<td>3.36±0.47</td>
<td>1.02±1.50</td>
<td>26.33±2.83</td>
<td>6.99±2.54</td>
<td>5.38±1.42</td>
<td>60.33±5.37</td>
</tr>
<tr>
<td>7</td>
<td>Malwa Plateau</td>
<td>2.20±0.38</td>
<td>2.42±0.29</td>
<td>30.39±4.21</td>
<td>2.39±0.13</td>
<td>1.09±0.43</td>
<td>31.88±8.79</td>
<td>6.32±0.37</td>
<td>2.15±0.03</td>
<td>43.91±5.96</td>
</tr>
<tr>
<td>8</td>
<td>Nimar Plains</td>
<td>2.55±0.27</td>
<td>2.27±0.25</td>
<td>31.71±3.15</td>
<td>3.37±1.57</td>
<td>1.06±0.47</td>
<td>29.8±2.77</td>
<td>5.26±0.62</td>
<td>1.55±0.12</td>
<td>33.45±2.11</td>
</tr>
<tr>
<td>9</td>
<td>Northern Hill Region of Chattisgarh</td>
<td>2.30±0.28</td>
<td>0.45±0.07</td>
<td>22.31±2.25</td>
<td>2.49±0.56</td>
<td>0.91±0.13</td>
<td>22.40±2.9</td>
<td>5.95±1.25</td>
<td>5.90±0.54</td>
<td>53.89±14.30</td>
</tr>
<tr>
<td>10</td>
<td>Satpura Plateau</td>
<td>3.21±0.19</td>
<td>1.57±0.01</td>
<td>10.37±3.55</td>
<td>2.33±1.57</td>
<td>0.88±0.36</td>
<td>24.25±2.77</td>
<td>1.56±0.17</td>
<td>3.25±0.11</td>
<td>38.74±1.05</td>
</tr>
<tr>
<td>11</td>
<td>Vindhaya Plateau Zone</td>
<td>4.25±0.26</td>
<td>0.87±0.01</td>
<td>38.06±1.45</td>
<td>4.25±0.26</td>
<td>0.87±0.01</td>
<td>40.45±1.74</td>
<td>5.06±0.32</td>
<td>4.96±0.34</td>
<td>49.87±0.45</td>
</tr>
</tbody>
</table>

Values are the mean of three observations; standard deviation

**Table 2** Variation in Eugenol content in Tulsi samples

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Agro climatic Zone</th>
<th>Summer Season</th>
<th>Eugenol%</th>
<th>Rainy Season</th>
<th>Winter Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bundelkhand Zone</td>
<td>0.048±0.01</td>
<td>0.105±0.05</td>
<td>0.119±0.01</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Central Narmada</td>
<td>0.032±0.02</td>
<td>0.051±0.03</td>
<td>0.050±0.01</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Chattisgarh Plains</td>
<td>0.107±0.00</td>
<td>0.07±0.02</td>
<td>0.248±0.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Grid Region</td>
<td>0.031±0.01</td>
<td>0.034±0.01</td>
<td>0.190±0.13</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Jhabua Hills</td>
<td>0.013±0.00</td>
<td>0.01±0.00</td>
<td>0.066±0.01</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Kymore Plateau</td>
<td>0.015±0.00</td>
<td>0.08±0.03</td>
<td>0.08±0.04</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Malwa Plateau</td>
<td>0.073±0.01</td>
<td>0.03±0.00</td>
<td>0.044±0.01</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Nimar Plains</td>
<td>0.052±0.02</td>
<td>0.02±0.00</td>
<td>0.062±0.00</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Northern Hill</td>
<td>0.06±0.01</td>
<td>0.07±0.07</td>
<td>0.06±0.01</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Satpura Plateau</td>
<td>0.077±0.01</td>
<td>0.04±0.00</td>
<td>0.085±0.01</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Vindhaya Plateau</td>
<td>0.051±0.02</td>
<td>0.036±0.00</td>
<td>0.177±0.00</td>
<td></td>
</tr>
</tbody>
</table>

Values are the mean of three observations; standard deviation
Ursolic acid content varied 0.01-0.258%. Maximum % was observed in sample collected from Grid Region in winter season. However, in some samples collected from Jhabua Hills, Malwa Plateau and Nimar Plains, ursolic acid quantity was found to be highest in summer season (Fig.5).

Plants synthesize a wide variety of chemicals that have important biological functions and used in ethano pharmacological preparations for the treatment of several diseases. Madhya Pradesh has many pharmaceutically important plants distributed in different regions and used by indigenous people since ancient time. It is well documented that the active principles and other constituents of medicinal plants fluctuate with seasons and geographic regions (Daniel, 2008).

These have been widely attributed to variations in environmental variables such as temperature and rainfall or other climatic condition. Further, the quality of medicinal plants was also found to be affected due to harvesting as well as processing methods. The present study deals with seasonal variations observed in major chemicals in leaves of *O. sanctum* from different agro climatic zones of Madhya Pradesh.

*O. sanctum* has been used for thousands of years in Ayurveda for its diverse healing properties. The results obtained in this study clearly indicate that phytochemicals are affected by the collection time and different growing locations. The growing location and collection seasons are important factors for phytochemicals viz., phenols, flavonoids, antioxidant activity, eugenol and ursolic acid variation in *O. sanctum* leaves. The total phenol and flavonoid content in *O. sanctum* collected during winter season was high compared to the ones collected during the summer and rainy seasons.

The total phenols varied 0.44 -4.25%, 2.33- 4.39% and 1.56 -6.99% in summer, rainy and winter seasons, respectively. Maximum amount of total phenol was observed in winter season in the sample collected from Chhattisgarh plains. Total flavonoids ranged from 0.87-6.03%, highest in winter sample of Chhattisgarh Plains while antioxidant activity as percent

### Table 4: Estimation of Ursolic acid in *Ocimum sanctum*

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Agroclimatic Zone</th>
<th>Summer Season</th>
<th>Rainy Season</th>
<th>Winter Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bundelkhand Zone</td>
<td>0.06±0.00</td>
<td>0.04±0.00</td>
<td>0.02±0.00</td>
</tr>
<tr>
<td>2</td>
<td>Central Narmada Valley Zone</td>
<td>0.06±0.00</td>
<td>0.04±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>3</td>
<td>Chattisgarh Plains</td>
<td>0.08±0.00</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>4</td>
<td>Grid Region</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>5</td>
<td>Jhabua Hills</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>6</td>
<td>Kymore Plateau and Satpura Hills</td>
<td>0.04±0.00</td>
<td>0.02±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>7</td>
<td>Malwa Plateau</td>
<td>0.07±0.00</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>8</td>
<td>Nimar Plains</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>9</td>
<td>Northern Hill Region of Chattisgarh</td>
<td>0.06±0.00</td>
<td>0.03±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>10</td>
<td>Satpura Plateau</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>11</td>
<td>Vindhyas Plateau Zone</td>
<td>0.03±0.00</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
</tbody>
</table>

Values are the mean of three observations: ± standard deviation

### DISCUSSION

The diverse biological activities of the herb appears to be related to their phytochemical content, belonging to three groups, phenolic di- and tri-terpenes; flavonoids and phenolic acids; and sterols amongst which ursolic acid is an important isomer of oleanolic acid, a triterpenoid compound (Liu, 1995). Ursolic acid is a very important compound due to its biological potential as an anti-inflammatory, trypanocidal, antirheumatic, antiviral, antioxidant and antitumoral agent. Keeping these facts in mind, the present investigation was conducted to study variation in bioactive chemicals in leaves of *O. sanctum* from different agro climatic zones of Madhya Pradesh.

Keeping these facts in mind, the present investigation was conducted to study variation in bioactive chemicals in leaves of *O. sanctum* from different agro climatic zones of Madhya Pradesh.

Fig.4&6 are depicted standard and samples baseline eugenol and ursolic acid, respectively, quantified using HPTLC.
freeradical scavenging activity varied 10.37- 38.06 %, 22.40-
46.48% and 30.34-60.33 % (4mg/ml ) in summer, rainy and
winter seasons, respectively and recorded to be maximum
inKymore Plateau and Satpura Hills.
The higher concentration of phenolics and flavonoids during
winter may have been due to low temperature stress as well as
maturity of the plants (Buchanan et al., 2000; Harborne&
Williams 2000; Garmash, 2005). Ifikhare et al., 2011 also
reported similar observations in Mentha longifolia and reported
maximum flavonoids in winter seasons. However, in case of O.
sanctum maximum amount of flavonoids was observed in the
plants collected from Mumbai during the summer season (5.88%).This could be due to pollution stress which increases
the flavonoid content in the plants.

These results are in accordance with the observation by
different authors in several countries. There are usually
considerable variations in the content of the major components
of basil obtained from different geographical origins (Ozek
et al.,1995). Zheljazkov et al.,2008 also reported that chemical
composition of basil varied according to the plant growing
location and some components were absent in some locations
but present in others. Such seasonal effects on biochemical and
medicinal ingredients have earlier been observed in a number
of studies in different plant species such as Mentha pulegium
(Stengele et al., 1993), Mentha spicata (Kofidis et al., 2004),
Ocimumbasilicum (Hussainet al., 2008).

Eugenol contentment varied 0.01-0.25% and found to be higher
in winter season. Maximum quantity was obtained in the
samples collected from Chhattisgarh Plains. Duttaet al., (2005) also reported variation in eugenol content from
different locations and seasons. O. sanctum grown in
India, under natural conditions (Deyand Choudhuri, 1983)
gave highest percentage of methyl eugenol and variation
recorded in different seasons.

Ursolic acid is a very important compound due to its biological
potential as an anti-inflammatory, trypanocidal, antirheumatic,
antiviral, antioxidant and antitumoral agent.

In the present study, variation in ursolic acid was observed in
samples collected from different regions and in different
seasons. Ursolic acid content varied 0.01-0.258%. Maximum % was
observed in sample collected from Grid Region in winter season.

Maximum amount of ursolic acid was observed in the plants of
O. sanctum collected from Calicut in Kerala (2.7%) and
minimum amount was observed in plants collected from
Mumbai (1.83%). Another observation made was that
maximum amount of ursolic acid was observed in plants
collected during winter, compared to plants collected in
summer.

CONCLUSION

Madhya Pradesh is bestowed with vast forest resources and
accounts for 33% of the total geographical area of state. The
medicinal plants show a marked variation in active ingredients
during different seasons and different locations as these have
been widely attributed to variations in different environmental
establishment variables and due to diverse genetic make up.
The variation in bioactive chemicals in samples from different
regions in different seasons were compared in O.sanctum,
maximum amount of total phenol, flavonoids and eugenol were
observed in winter season in the sample collected from Chhattisgarh plains (Balaghat) while ursolic acid content was
found to be maximum in sample collected from Grid Region
(Morena) in winter season. The populations with high biochemical content can be utilized for mass multiplication and genetic improvement. The assessment of seasonal variation will be useful in sustainable
collection of O.sanctum based on quality.

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Different Geographical Locations of Madhya Pradesh


