Effect of different storage conditions on guggulsterone content in oleo-gum resin of *Commiphora wightii*

Suman Singh1, N Manika1, RK Verma1, GD Bagchi1*

**Abstract**

Effects of light, temperature, packaging and duration of storage was investigated on the active constituents of *Commiphora wightii* oleo-gum resin. The freshly collected oleo-gum resins were packed in borosilicate Glass (GL), polypropylene (PP) and polystyrene (PS) vials, and were stored at 10°C, 20 °C, 30 °C and 40°C respectively for eight months in dark and at 20°C, and 30°C in light. Total guggulsterone (GS), guggulsterone-E (GSE) and guggulsterone-Z (GSZ) content was estimated in the oleo-gum resin every month for eight months with the help of HPLC. Study showed that GS, and GSZ are very sensitive to high temperature (>40 °C) and light and deteriorate very quickly. While, GSE content showed an increase at this temperature. Among the studied vials, air tight dark colored GL vials were observed to retain total GS and GSZ content for longer period. Since, total GS / GSZ are mainly responsible for medicinal properties of ‘Guggul’ oleo-gum resin; therefore, for better efficacy of the drug, it should be kept at low temperature (10 °C) in dark air tight Glass containers. At this condition, the oleo-gum resin shows only 16.04% loss in total GS and 9.23% loss in GSZ content after six months of storage. The study has demonstrated proper commercial storage conditions of the drug for longer use without losing its efficacy.

**Keywords**: *Commiphora wightii*, Storage, Guggulsterone, Borosilicate glass, Polypropylene, Polystyrene.

**Introduction**

Herbal medicines are commonly used by different communities of the world. In developing countries, these are extensively used for primary health care. During the last decade, these medicines have shown resurgence even in the developed countries because of their time tested efficacy, safety and lesser side effects. Currently, herbal medicines are very high in demand throughout the world and have excellent export value. However, it has been observed that several of the herbal drugs lack standard quality control profile including their shelf life. This acts as a barrier for their wider application. Oleo-gum resin of *Commiphora wightii* (Arnott) Bhandari (Burseraceae), commonly known as ‘Guggul’, is one of such drug, which is extensively used in the treatment of arthritis, obesity and inflammation in the traditional systems of medicines in India and in several other countries [1]. This species is distributed from northern Africa to central Asia and is commonly known as ‘Indian bdellium tree’. It prefers arid and semi-arid climates and is tolerant of poor soil. In India; it is distributed mainly in the drier areas of Rajasthan, Gujarat, Madhya Pradesh and Karnataka. The oleo-gum resin (Guggul) is tapped from the stem bark of the tree and due to its excessive tapping, the plants were reported to be dying and their natural populations have considerably deteriorated in Rajasthan and Gujarat states [2]. In India, this species is now being considered as one of the threatened species [3]. The oleo-gum resin obtained from the plant is a complex mixture of resin (61%), gum (29.3%) and a small amount of essential oil (0.6%) [4]. The essential oil contains myrcene, dimyrcene and polymyrcene as its major constituents [5]. The gum fraction contains mainly sugars such as -arabinose, D-galactose, L-flucose and D-galacto pyranose [6-8]. The resin fraction contains medicinally important bio-active molecules like guggulsterones, guggersterols, cembrene and mukulol etc [9-11]. Oleo-gum-resin of *C. wightii* has been first time demonstrated for its hypolipidemic activity on rabbit model [12-14]. Later, this activity was also tested and reported in other animal models [15-17]. Guggulpid, a market product from the exudates of *C. wightii*, has been observed to possess hypolipidaemic activity [18]. It markedly inhibits liver cholesterol biosynthesis [19]. Later pharmacological studies showed that the pure guggulsterone isomers possess pronounced hypolipidemic activity, reduced blood cholesterol level significantly and possess cardioprotective properties [20, 21]. Guggulsterone-Z reported to mediate by its interaction with an array of nuclear receptors including endocrine steroid receptors and metabolic lipid receptors. It has been identified as an antagonist at the nuclear receptor farnesoid x receptor, a key transcriptional regulator for the

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maintained of cholesterol and bile acid homeostasis [22, 23].
Guggulsterones also exhibited anti-inflammatory activity and were
found as potent inhibitors of nuclear factor-κB, a key regulator for
inflammatory responses [24-26]. Guggulsterone-Z has been
reported to inhibit the proliferation of a number of human cancer
cell types like leukemia, head and neck carcinoma, multiple
myeloma, lung carcinoma, melanoma, breast carcinoma, ovarian
carcinoma including many drug resistant cancer cells like bleo-vac-
resistant leukemia, dexamethasone- resistant multiple myeloma
and doxorubicin-resistant breast cancer cells [27-29]. Oleo-gum-
resin of the plant also reported to stimulate the thyroid function
[30]. Therefore, guggulsterones have been identified as an
important ingredient of C. wightii oleo-gum resin, which is
responsible for its main activities. Oleo-gum resin of C. wightii
is used in India and other countries in powdered form or in the form
of formulations combined with several other herbs for added
beneficial effects [31]. However, shelf life of this drug is not known.
In the present study, an attempt has been made to examine the
effect of light, temperature and storage containers on the
guggulsterone content of the oleo-gum resin. The study will provide
information on the duration up to which this important herbal drug
can be stored for use.

Materials and Methods

Plant material

Oleo-gum resin of C. wightii was collected from the naturally
growing plants near Jaipur, Rajasthan, during December 2009.
Samples were collected in air tight Glass vials and kept in a cool
cage packed with ice. The samples were then carried to the
experimental laboratory at CIMAP, Lucknow immediately for initial
chemical analysis. Samples (50 mg each) were then packed in
different vials (Glass-GL, polypropylene-PP and polystyrene-PS).
The samples were randomly divided into two groups. First group
were stored in complete darkness, while, the second group was
kept in light during storage periods. Samples, which were stored
in dark, were kept at four temperature conditions (i.e. 10°C, 20°C,
30°C and 40°C). While the samples, which were stored in light,
were kept at two temperature conditions (i.e. 20°C, 30°C).
The Glass vials (GL) used for storing were 3 mm in thickness; 4cm
X 2cm in size and with Teflon cap. Polypropylene (PP) vials were 4
mm in thickness and 4cm X 1.5cm in size. While, the polystyrene
(PS) vials were 2 mm in thickness and 4cm X1.5cm in size. For
each treatment, there were three replicates. After storage for 2, 4,
6 and 8 months, small amount of the oleo-gum resin was taken out
from each treatment and was evaluated for guggulsterone content.

Standard and Sample Preparation

Standard solutions of guggulsterones were prepared by accurately
weighing quantities of guggulsterone-E and guggulsterone-Z (1 mg
± 1 μg) into separate 10 ml volumetric flasks, dissolving each
sample in 3 ml of ethyl acetate (EtOAc) and diluting to volume with
methanol. Accurately weighed resin (50 mg) was placed in a 10-ml
volumetric flask, dissolved with 2 ml of ethyl acetate, and the
volume adjusted with methanol.

HPLC analysis

General parameters that apply throughout in both the
methodologies include: Waters Spherisorb ODS2 reversed-phase
column (18 150mmx3.4mmx4.6 mm) (Alltech, Deerfield, IL, USA);
20 μl / injection sample size and UV monitoring of eluent at 245
nm. Acetonitrile (A): Water (B) was the mobile phase in 70:30
ratios and flow-rate was kept at 1.0 ml/min.

Effect of storage on total guggulsterone (GS) content in
Dark

In Glass vials, deterioration of GS content was less in the oleo-gum
resin as compared to PP and PS vials. Maximum deterioration of
GS was, however, observed in the samples kept in PS vials. It was
noticed that in both Glass and PP vials, deterioration of GS was
less up to six months of storage and after this there was rapid
deterioration. On the other hand, oleo-gum resin stored in PS vials,
exhibited less loss till four months of storage but after that there
was rapid loss in GS content (Table 1). Oleo-gum resin stored in
GL vials at 10°C in dark exhibited least deterioration in total GS
content. After two months of storage, loss was only 10.35% and up
to six months there was only 16.04% loss in total GS content.
However, after six months the loss became rapid and after eight
months, total loss in GS content was 43.07%. As the storage
temperature increased (20-40°C), loss in total GS content also
increased. Initially, after two months of storage, at 20, 30 and 40°C
temperatures, loss in total GS were 2.12, 2.55 and 3.13 times more
respectively than at 10°C. However, as the storage time increased,
gap of loss between 10°C and higher storage temperature
decreased. After six months loss at 20-40°C ranged between
32.03-36.63%. However, after six months, it was between 49.8-
56.22%. Accordingly, total GS was observed to be less at 40°C
than 20°C and 30°C. Like Glass, PP vials also exhibited similar trend that is up to initial
six months there was less loss, but after that loss increased.
However, as compared to Glass vials, the loss in total GS content
was more in PP vials stored in dark. After two months of storage,
loss at 10°C was 12.93%. However, at 20, 30 and 40°C the loss
was 1.8, 2.8 and 2.9 times more respectively than at 10°C. After six
months of storage, at 10°C loss was 27.78% but at 20, 30 and 40°C
the loss was 1.2, 1.59 and 1.58 times more respectively than at
10°C. While after eight months of storage at 10°C, the loss in GS
content in the oleo-gum resin was observed to be quite high
(46.04%) and at higher temperatures, loss was still higher. At 20,
30, 40°C temperatures, the loss in GS content was 1.2, 1.5 and
1.49 times more than the oleo-gum resin stored at 10 °C. As observed in GL vials in this case also loss was slightly lower at 40 °C than 30 °C after eight months of storage.

In the oleo-gum resin stored in PS vials, the loss of GS content was observed to be quite high even at lower temperatures in dark. After two months of storage, at 10 °C, the loss was 22.89%. While at 20 °C, 30 °C, 40 °C, the loss was 1.7, 1.95, 2.06 times more respectively. However, in contrary to GL and PP vials, in this case deterioration in GS content between six and eight months of storage, there was 75.81% reduction in total GS (Table-1).

Table 1 Degradation of guggulsterone content in the oleo-gum resin of *C. wightii* after storage in different conditions

<table>
<thead>
<tr>
<th>Light / Dark conditions</th>
<th>Type of containers and temperature for storage</th>
<th>Two months (mean±SD)</th>
<th>Four months (mean±SD)</th>
<th>Six months (mean±SD)</th>
<th>Eight months (mean±SD)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark</td>
<td>Glass - 10 °C</td>
<td>0.7560±0.0022</td>
<td>0.7340±0.0015</td>
<td>0.7080±0.0018</td>
<td>0.4801±0.0008</td>
<td>43.07</td>
</tr>
<tr>
<td></td>
<td>Glass - 20 °C</td>
<td>0.6580±0.0014</td>
<td>0.6190±0.0005</td>
<td>0.5732±0.0016</td>
<td>0.3941±0.0006</td>
<td>53.27</td>
</tr>
<tr>
<td></td>
<td>Glass - 30 °C</td>
<td>0.6204±0.0040</td>
<td>0.5998±0.0059</td>
<td>0.5496±0.0005</td>
<td>0.3692±0.0012</td>
<td>56.22</td>
</tr>
<tr>
<td></td>
<td>Glass - 40 °C</td>
<td>0.5695±0.0015</td>
<td>0.5672±0.0007</td>
<td>0.5344±0.0009</td>
<td>0.4233±0.0008</td>
<td>49.80</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -10 °C</td>
<td>0.7342±0.0025</td>
<td>0.7214±0.0023</td>
<td>0.6909±0.0020</td>
<td>0.4550±0.0015</td>
<td>46.04</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -20 °C</td>
<td>0.6427±0.0004</td>
<td>0.6022±0.0015</td>
<td>0.5755±0.0031</td>
<td>0.3674±0.0022</td>
<td>56.43</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -30 °C</td>
<td>0.5352±0.0014</td>
<td>0.5161±0.0005</td>
<td>0.4706±0.0034</td>
<td>0.2602±0.0019</td>
<td>69.15</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -40 °C</td>
<td>0.5250±0.0074</td>
<td>0.5181±0.0011</td>
<td>0.4720±0.0039</td>
<td>0.2640±0.0011</td>
<td>68.70</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 10 °C</td>
<td>0.6502±0.0018</td>
<td>0.5513±0.0060</td>
<td>0.3550±0.0012</td>
<td>0.2669±0.0012</td>
<td>68.35</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 20 °C</td>
<td>0.5151±0.0032</td>
<td>0.4934±0.0012</td>
<td>0.2444±0.0010</td>
<td>0.2161±0.0009</td>
<td>74.38</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 30 °C</td>
<td>0.4663±0.0070</td>
<td>0.4024±0.0008</td>
<td>0.2410±0.0018</td>
<td>0.2108±0.0094</td>
<td>75.00</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 40 °C</td>
<td>0.4453±0.0039</td>
<td>0.3691±0.0012</td>
<td>0.2660±0.0037</td>
<td>0.2040±0.0017</td>
<td>75.81</td>
</tr>
<tr>
<td>Light</td>
<td>Glass - 20 °C</td>
<td>0.6482±0.0058</td>
<td>0.6083±0.0024</td>
<td>0.5432±0.0076</td>
<td>0.3544±0.0072</td>
<td>57.97</td>
</tr>
<tr>
<td></td>
<td>Glass - 30 °C</td>
<td>0.6170±0.0004</td>
<td>0.5433±0.0019</td>
<td>0.5281±0.0021</td>
<td>0.3090±0.0016</td>
<td>63.36</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -20 °C</td>
<td>0.6154±0.0026</td>
<td>0.5270±0.0009</td>
<td>0.5151±0.0004</td>
<td>0.3070±0.0003</td>
<td>63.60</td>
</tr>
<tr>
<td></td>
<td>Polypropylene -30 °C</td>
<td>0.5040±0.0004</td>
<td>0.4971±0.0006</td>
<td>0.4371±0.0015</td>
<td>0.2243±0.0012</td>
<td>73.40</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 20 °C</td>
<td>0.5123±0.0007</td>
<td>0.4873±0.0009</td>
<td>0.2417±0.0026</td>
<td>0.2110±0.0002</td>
<td>74.98</td>
</tr>
<tr>
<td></td>
<td>Polystyrene - 30 °C</td>
<td>0.4513±0.0009</td>
<td>0.4011±0.0009</td>
<td>0.2331±0.0004</td>
<td>0.2021±0.0027</td>
<td>76.04</td>
</tr>
</tbody>
</table>

Guggulsterone content (%) in fresh oleo-gum resin: 0.8432±0.0006

Effect of storage on total guggulsterone (GS) content in light

When the oleo-gum resins of *C. wightii* stored in light, loss in GS content was observed to be more than its storage in dark. At 20 °C and 30 °C, in Glass vials, the loss in total GS content was 23.13 and 26.83% respectively after two months of storage, which was marginally (1.16% and 0.04% respectively) higher than the GS of oleo-gum resin stored in dark. In light also, there was rapid deterioration in GS content between six and eight months of storage and after eight months, total loss was 57.97% and 63.36% at 20 °C and 30 °C respectively, which was 4.70% and 7.14% respectively higher than the oleo-gum resin stored in dark. Oleo-gum resin, when stored in light in PP vials, the loss in GS content was 27.02% and 40.23% at 20 °C and 30 °C respectively after two months. In this case also there was rapid loss in GS content between six and eight months of storage and after eighth month, the loss became 63.60% and 73.40% at 20 °C and 30 °C respectively, which again showed marginal increase in reduction than the samples kept in dark. On the other hand, oleo-gum resins stored in light in PS vials exhibited maximum loss in GS content. After two months of storage, the loss was 39.25% and 46.47% at 20 °C and 30 °C respectively. However, in this case greater loss was between fourth and sixth months. After six months, loss in total GS content was 71.34% and 72.36% at 20 °C and 30 °C respectively. However, after six months loss was relatively low. When this observation was compared with the oleo-gum resin stored in dark, it was noticed that loss was almost the same (Table-1). This shows that during the storage, temperature and light both play important role in deterioration of total GS content in the oleo-gum resin of *C. wightii*. Air tight GL vials were found to be better storage vessel than PP and PS containers. It was observed that in Glass and PP containers, GS exhibits less deterioration in six months but on storage in PS containers, the compound starts deteriorating after only four months. At 10 °C, GS exhibited least deterioration.

Effect of storage on guggulsterone-E (GSE) in dark
In dark and at lower temperature the loss in GSE content was low and as the storage temperature was increased from 10°C to 40°C, the loss became more. In GL vials at 10°C, there was 12.88% decrease in GSE content after two months of storage. The loss gradually increased and after eight months, the loss became 52.28%. While at 20°C, 30°C and 40°C the loss was 15.16%, 18.19% and 24.25% respectively after two months storage in GL vials. Like 10°C, loss in GSE content also increased at 20°C and 30°C and it became 63.64% and 67.43% respectively after eight months. But at 40°C, this trend became opposite and GSE content actually increased in the oleo-gum resin from 0.1% to 0.116% (Table-2).

**Table 2 Degradation of Guggulsterone E and Z on storage in dark condition**

<table>
<thead>
<tr>
<th>Type of containers</th>
<th>Temp. (°C)</th>
<th>Guggulsteron-E (%) after storage for different duration (months)*</th>
<th>Reduction of GS-E (%)</th>
<th>Guggulsterone Z (%) after storage for different duration (months)*</th>
<th>Reduction of GS-Z (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>10</td>
<td>0.115 0.107 0.088 0.063</td>
<td>52.28</td>
<td>0.641 0.627 0.62 0.417</td>
<td>38.95</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.112 0.106 0.081 0.048</td>
<td>63.64</td>
<td>0.549 0.513 0.492 0.346</td>
<td>49.34</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.108 0.104 0.071 0.043</td>
<td>67.43</td>
<td>0.512 0.495 0.478 0.326</td>
<td>52.27</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.1 0.103 0.112 0.116</td>
<td>12.13</td>
<td>0.469 0.464 0.418 0.302</td>
<td>55.78</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>10</td>
<td>0.113 0.109 0.087 0.06</td>
<td>54.55</td>
<td>0.621 0.611 0.522 0.395</td>
<td>42.17</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.106 0.099 0.089 0.045</td>
<td>65.91</td>
<td>0.536 0.503 0.486 0.322</td>
<td>52.86</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.097 0.093 0.086 0.043</td>
<td>67.42</td>
<td>0.438 0.423 0.393 0.217</td>
<td>68.23</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.093 0.102 0.109 0.111</td>
<td>15.91</td>
<td>0.432 0.416 0.363 0.153</td>
<td>77.6</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>10</td>
<td>0.107 0.101 0.084 0.061</td>
<td>53.79</td>
<td>0.543 0.45 0.271 0.206</td>
<td>69.84</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.102 0.094 0.058 0.038</td>
<td>71.21</td>
<td>0.413 0.399 0.186 0.178</td>
<td>73.94</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.092 0.085 0.059 0.035</td>
<td>73.48</td>
<td>0.374 0.317 0.182 0.175</td>
<td>74.38</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.094 0.106 0.113 0.115</td>
<td>12.88</td>
<td>0.351 0.263 0.153 0.088</td>
<td>87.12</td>
</tr>
</tbody>
</table>

* Fresh oleo-gum resin sample contains Guggulsteron-E- 0.132%, Guggulsteron-Z- 0.683%

On storage in GL vials the loss in GSE content was also less as compared to PP and PS vials. Storage in PP vials, at 10°C, exhibited 14.4% loss. While at 20°C, 30°C and 40°C, the loss was more, i.e. 19.7%, 26.52% and 29.55% respectively. After eight months of storage, loss at 10°C, 20°C and 30°C became 54.55%, 65.91% and 67.43% respectively. However, at 40°C, like the GL vials in PP vials the content of GSE increased and after eight months storage, the total loss was noted to be only 15.91%.

<table>
<thead>
<tr>
<th>Type of containers</th>
<th>Temp. (°C)</th>
<th>Guggulsteron-E (%) after storage for different duration (months)*</th>
<th>Reduction of GS-E (%)</th>
<th>Guggulsterone Z (%) after storage for different duration (months)*</th>
<th>Reduction of GS-Z (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>20</td>
<td>0.113 0.117 0.121 0.123</td>
<td>6.82</td>
<td>0.535 0.492 0.422 0.231</td>
<td>66.18</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.108 0.115 0.117 0.128</td>
<td>3.03</td>
<td>0.509 0.426 0.411 0.181</td>
<td>73.50</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>20</td>
<td>0.099 0.102 0.113 0.116</td>
<td>12.12</td>
<td>0.516 0.425 0.402 0.191</td>
<td>72.03</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.095 0.107 0.118 0.121</td>
<td>8.33</td>
<td>0.409 0.39 0.319 0.103</td>
<td>84.92</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>20</td>
<td>0.101 0.105 0.112 0.117</td>
<td>11.36</td>
<td>0.411 0.382 0.128 0.094</td>
<td>86.24</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.081 0.091 0.123 0.126</td>
<td>4.55</td>
<td>0.37 0.31 0.11 0.076</td>
<td>88.87</td>
</tr>
</tbody>
</table>

* Fresh oleo-gum resin sample contains Guggulsteron-E- 0.132%, Guggulsteron-Z- 0.683%

Effect of storage on guggulsterone-E (GSE) in light

On storage in light at 20°C and 30°C, it was observed that GSE content in the oleo-gum resin reduced initially from the fresh samples in two months of storage and subsequently on further storage it increased. This may be due to enzymatic action, which is gets activated in presence of light and suitable temperature. After two months of storage in Glass vials, GSE content was observed to...
be 0.113% at 20°C and 0.108% at 30°C, which shows that there were 14.0% and 18.19% reduction respectively from the fresh oleo-gum resin. However, after further storage, GSE content gradually increased and after eight months of storage, it became 0.123% at 20°C and 0.128% at 30°C, which was only 6.82% and 3.03% less than the fresh oleo-gum resin. Similar observation was noted on storage in light in PP and PS vials. However, initial loss in GSE content was more in these vials as compared to GL vials and the loss also increased with the increase in temperature. However, as the storage time increase, the loss actually reduced because the GSE content in the oleo-gum resin increased. Thus, after eight months of storage in PP vials at 20°C and 30°C the loss was only 12.13% and 8.34% respectively. While, in PS vials, the loss was 11.37% and 4.55%, respectively. This demonstrates that at higher temperature (30°C) loss was less as compared to lower (20°C) temperature, indicating that at 30°C, the enzyme becomes more active than at 20°C, and this prevents deterioration in GSE content.

**Effect of storage on guggulsterone-Z (GSZ) in dark**

GSZ content is usually 3-7 times more than GSE in the oleo-gum resin of *C. wightii*. In the present fresh samples of oleo-gum resin, average GSZ content was 0.683%. On storage, GSZ content deteriorated less in dark than in light (Table 1). Loss in GSZ content was lowest when stored in GL vials followed by PP and PS vials. However, in GL and PP vials loss was comparatively less during the initial six months of storage after that there was fast deterioration in GSZ content. While in PS vials, the loss was more between fourth and sixth months.

After two months of storage, in GL vials at 10°C, the loss was only 6.15% and as the temperature and duration of storage increased, the loss in GSZ content also increased. After two months, at 20°C, 30°C and 40°C the decrease was 19.62%, 25.04% and 31.34% respectively. While after four, six and eight months storage at 10°C, the decrease in GSZ content was 8.2%, 9.23% and 38.95% respectively. At 20°C, after four, six and eight months of storage loss were 24.9%, 27.97% and 49.35% respectively. While, at 30°C after same period of storage, the loss was 27.53%, 30.02% and 52.27% respectively. At 40°C, the loss was utmost after four, six and eight months of storage and it was 32.07%, 38.80% and 55.79% respectively.

In PP vials, at 10°C, loss in GSZ content was 9.08% after two months of storage, while after four, six and eight months, the loss was 10.55%, 32.58% and 42.17% respectively. At 20°C after two months, loss was 21.53%, whereas after four, six and eight months, the loss was 26.36%, 28.85% and 52.86% respectively. At 30°C, the loss was still higher. After two months of storage at this temperature the loss was 35.88%, whilst after four, six and eight months; the loss was 38.07%, 42.46% and 68.23% respectively. However, among the considered temperatures, maximum loss in GSZ content was observed at 40°C. At this temperature, loss was 36.75% after two months and after four, six and eight months; the loss was 39.10%, 46.86% and 77.60% respectively.

Maximum loss in GSZ content in the oleo-gum resin was observed after storage in PS vials. However, at 10°C, the loss was minimum. After two months storage, it was 20.50% while after four, six and eight months; the loss was 34.12%, 60.33% and 69.84% respectively. As expected, storage under increasing temperatures, exhibited higher loss in GSZ content. At 40°C, loss after two months storage was 48.61% and after four, six and eight months, the loss was 61.50%, 77.60% and 87.12% respectively.

**Effect of storage on guggulsterone-Z (GSZ) in light**

In contrast to GSE, a deteriorating effect was observed on GSZ after storage of oleo-gum resin in light. As observed in dark, in light also loss was low at lower temperature and high at higher temperature. As the storage time increased, the loss was also observed to increase. Storage in GL vials exhibited minimum loss in GSZ content followed by PP and PS vials. At 20°C, loss in GSZ in GL vials after two months storage was 21.67%, while in PP and PS vials the loss was 24.46% and 39.83% respectively. On the other hand, at 30°C, loss in GL vials after same period of storage was 25.48% and in PP and PS vials, the loss was 40.12% and 45.83% respectively. The loss also increased as the storage time increased during the storage in both the temperatures and after eight months of storage loss was observed to be quite high. At 20°C, loss in GSZ content in GL vials was 66.18% and at 30°C, it was 73.50%. While in PP vials, the loss was 72.04% and 84.92% at 20°C and 30°C respectively. On the other hand in PS vials, the loss was 86.24% and 88.88% at 20°C and 30°C respectively.

The result of the study indicated that total GS, GSE and GSZ content of *C. wightii* oleo-gum resin exhibit deterioration in dark, light and all temperature (10-40°C) conditions. It is interesting to note that after storage in dark under high temperature (40°C) conditions, guggulsterone-E content increased in the oleo-gum resin as the storage time increased, while in light at all the examined temperature conditions (20°C and 30°C), its content increased as the storage time increased. Although, increase in GSE content in the oleo-gum resin does not have much medicinal significance as it has not reported to be medicinally important, therefore, it does not enhance the medicinal property of the oleo-gum resin. Increase in GSE may be due to some enzymatic activity in the oleo-gum resin, which may be getting activated at higher temperature and presence of light. On the other hand GSZ, which is medicinally important, decreases as the duration of storage and storage temperature increased.

**Conclusion**

Decrease in active constituent of any medicinal product commonly reduces its efficacy. Therefore, it is important to determine their optimum storage condition and time, to know the period up to which the drug may be stored without losing much of their efficacy. For guggul samples, ideal storage container was found to be dark air tight Glass vials, which should be kept at ±10°C. At this condition, oleo-gum resins of *C. wightii* can be kept for around six months, without much loss in total GS and GSZ content.
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Authors contributions

Suman Singh: Sample collection and storage.
N. Manika and R. K. Verma: Chemical analysis of the samples.
G. D. Bagchi: Manuscript writing and corresponding author.

Conflicts Of Interest

Authors declare no conflicts of interest.

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