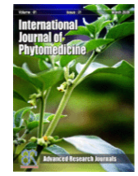
International Journal of Phytomedicine 5 (2013) 62-68
http://www.arjournals.org/index.php/ijpm/index



Original Research Article

ISSN: 0975-0185

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

Suman Singh[1], N Manika[1], RK Verma[1], GD Bagchi[1]*

*Corresponding author:

GD Bagchi

[1]Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), PO. CIMAP, Lucknow-226015, India..

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 10ºC, 20 ºC, 30 ºC and 40ºC respectively for eight months in dark and at 20ºC, and 30ºC 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 ºC) 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 ºC) 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, guggulsterols, 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]. Guggulipid, 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 maintenance 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 bleevac-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. 10ºC, 20ºC, 30ºC and 40ºC). While the samples, which were stored in light, were kept at two temperature conditions (i.e. 20ºC, 30 ºC).
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.
Oleo-gum resins of *C.wightii,* stored in air tight Glass (GL), polypropylin (PP) and polysterene (PS) vials in light / dark and temperature conditions were evaluated after 2,4,6 and 8 months of storage. Some part of the oleo-gum resins were taken out from the vials and tested for total guggulsterone (GS), guggulsterone-E (GSE) and guggulsterone- Z (GSZ) contents with the help of HPLC and the results were shown in Tables 1-3.

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% and after eight months, it was between 49.8-56.22%. However, loss in 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 loss in GS content was more between four and six months of storage. After six months loss again becomes low. At 10 C, loss in GS content after six months storage was observed to be 57.9%. While at 20 C, 30 C, 40 C, the loss was 71.02%, 71.42% and 68.46% respectively. As expected, initial loss in GS content was quite high (47.19%) after only two months storage at 40 C, but after that reduction was comparatively less and after 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

Light / Dark conditions	Type of containers and temperature for storage	Guggulsteron content (%) after storage for different duration*				
		Two months (mean±SD)	Four months (mean±SD)	Six months (mean±SD)	Eight months (mean±SD)	Reduction
Dark	Glass - 10ºC	0.7560±0.0022	0.7340±0.0015	0.7080±0.0018	0.4801±0.0008	43.07
	Glass - 20 ºC	0.6580±0.0014	0.6190±0.0005	0.5732±0.0016	0.3941±0.0006	53.27
	Glass - 30 ºC	0.6204±0.0040	0.5998±0.0059	0.5496±0.0005	0.3692±0.0012	56.22
	Glass - 40 ºC	0.5695±0.0015	0.5672±0.0007	0.5344±0.0009	0.4233±0.0008	49.80
	Polypropylin-10 ºC	0.7342±0.0025	0.7214±0.0023	0.6090±0.0020	0.4550±0.0015	46.04
	Polypropylin-20 ºC	0.6427±0.0004	0.6022±0.0015	0.5755±0.0031	0.3674±0.0022	56.43
	Polypropylin-30 ºC	0.5352±0.0014	0.5161±0.0005	0.4706±0.0034	0.2602±0.0019	69.15
	Polypropylin- 40 ºC	0.5250±0.0074	0.5181±0.0011	0.4720±0.0039	0.2640±0.0011	68.70
	Polystyrene - 10 ºC	0.6502±0.0018	0.5513±0.0060	0.3550±0.0012	0.2669±0.0012	68.35
	Polystyrene - 20 ºC	0.5151±0.0032	0.4934±0.0012	0.2444±0.0010	0.2161±0.0009	74.38
	Polystyrene - 30 ºC	0.4663±0.0070	0.4024±0.0008	0.2410±0.0018	0.2108±0.0094	75.00
	Polystyrene - 40 ºC	0.4453±0.0039	0.3691±0.0012	0.2660±0.0037	0.2040±0.0017	75.81
Light	Glass - 20 ºC	0.6482±0.0058	0.6083±0.0024	0.5432±0.0076	0.3544±0.0072	57.97
	Glass - 30 ºC	0.6170±0.0004	0.5433±0.0019	0.5281±0.0021	0.3090±0.0016	63.36
	Polypropylin-20 ºC	0.6154±0.0026	0.5270±0.0009	0.5151±0.0004	0.3070±0.0003	63.60
	Polypropylin-30 ºC	0.5040±0.0004	0.4971±0.0006	0.4371±0.0015	0.2243±0.0012	73.40
	Polystyrene - 20 ºC	0.5123±0.0007	0.4873±0.0009	0.2417±0.0026	0.2110±0.0002	74.98
	Polystyrene - 30 ºC	0.4513±0.0009	0.4011±0.0009	0.2331±0.0004	0.2021±0.0027	76.04

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 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

Type of containers	Temp. (ºC)	Guggulsteron-E (%) after storage for different duration (months)*				Red. of GS-E (%)	Guggulsterone Z (%) after storage for different duration (months)*				Red. of GS-Z (%)
		2	4	6	8		2	4	6	8	
Glass	10	0.115	0.107	0.088	0.063	52.28	0.641	0.627	0.62	0.417	38.95
	20	0.112	0.106	0.081	0.048	63.64	0.549	0.513	0.492	0.346	49.34
	30	0.108	0.104	0.071	0.043	67.43	0.512	0.495	0.478	0.326	52.27
	40	0.1	0.103	0.112	0.116	12.13	0.469	0.464	0.418	0.302	55.78
Polypropylene	10	0.113	0.109	0.087	0.06	54.55	0.621	0.611	0.522	0.395	42.17
	20	0.106	0.099	0.089	0.045	65.91	0.536	0.503	0.486	0.322	52.86
	30	0.097	0.093	0.086	0.043	67.42	0.438	0.423	0.393	0.217	68.23
	40	0.093	0.102	0.109	0.111	15.91	0.432	0.416	0.363	0.153	77.6
Polystyrene	10	0.107	0.101	0.084	0.061	53.79	0.543	0.45	0.271	0.206	69.84
	20	0.102	0.094	0.058	0.038	71.21	0.413	0.399	0.186	0.178	73.94
	30	0.092	0.085	0.059	0.035	73.48	0.374	0.317	0.182	0.175	74.38
	40	0.094	0.106	0.113	0.115	12.88	0.351	0.263	0.153	0.088	87.12

* 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 also the content of GSE increased and after eight months storage, the total loss was noted to be only 15.91%.

In PS vials, loss in GSE content was more, as compared to GL and PP vials. At 10 C, there was 18.94% loss after two months of storage and as the storage temperature increased, there was more loss in GSE content. At 20 C, 30 C, 40 C, the loss was 22.73%, 30.31%, 28.79% respectively. After eight months of storage, at 10 C, 20 C and 30 C, the loss was 53.79%, 71.22% and 73.49% respectively. However, at 40 C, the loss was only 12.88%. This showed that at high temperature, content of GSE actually increased from 0.093% to 0.111%.

Table 3. Degradation of Guggulsterone E and Z on storage in light conditions.

Type of containers	Temp. (ºC)	Guggulsteron-E (%) after storage for different duration (months)*				Reduction of GS-E (%)	Guggulsteron-Z (%) after storage for different duration (months)*				zReduction of GS-E (%)
		2	4	6	8		2	4	6	8	
Glass	20	0.113	0.117	0.121	0.123	6.82	0.535	0.492	0.422	0.231	66.18
	30	0.108	0.115	0.117	0.128	3.03	0.509	0.426	0.411	0.181	73.50
Polypropylene	20	0.099	0.102	0.113	0.116	12.12	0.516	0.425	0.402	0.191	72.03
	30	0.095	0.107	0.118	0.121	8.33	0.409	0.39	0.319	0.103	84.92
Polystyrene	20	0.101	0.105	0.112	0.117	11.36	0.411	0.382	0.128	0.094	86.24
	30	0.081	0.091	0.123	0.126	4.55	0.37	0.31	0.11	0.076	88.87

* 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, sixth 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 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% at20 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.

Acknowledgements

The authors are thankful to the Director, CSIR-Central Institute of Medicinal and Aromatic plants, Lucknow for providing the facilities to carry out the present work. One of the authors (N Manika) is thankful to Council of Scientific and Industrial Research (CSIR) for the award of Fellowship.

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.

References

[1]. Nadkarni AK. The Indian Materia Medica, Popular Book Depot, Bombay, India.; 1954. p. 167-70.

[2]. Anonymous. The Wealth of India – A dictionary of Indian Raw Materials and Industrial products, vol. II, (First supplement series), Council of Scientific and Industrial Research, New Delhi.; 2004.p.162-163.

[3]. Kumar S, Singh J, Shah NC, Ranjan V. Indian medicinal and aromatic plants facing genetic erosion, Central Institute of Medicinal and Aromatic Plants, Lucknow, India.; 1997. p. 78-81.

[4]. Dutt AT, Ghosh S, Chopra RN. The chemical investigation of the gum resin of *Balsamodendron mukul*, Indian J Med Res. 1942; 30(2): 331-334.

[5]. Ashram B. Essential oil from the resin of *Commiphora mukul* Hook. ex Stock., J Indian Chem Soc. 1950; 27: 436-440.

[6]. Bose S, Gupta KC. Structure of *Commiphora mukul* gum, part 1, Nature of the sugar present and the structure of the aldobiouronic acid, Indian J Chem. 1964a; 2: 57-58.

[7]. Bose S, Gupta KC. Structure of *Commiphora mukul* gum, part 2, Structure of the degraded gum, Indian J Chem. 1964b; 2:156-158.

[8]. Bose S, Gupta KC. Structure of *Commiphora mukul* gum, part 3, Methylation and periodate oxidation studies, Indian J Chem. 1966; 4: 87.

[9]. Patil VD, Nayak UR, Dev S. Chemistry of Ayurvedic crude drug I, Guggulu (resin from *Commiphora mukul*), 1. Steroidal constituents, Tetrahedron. 1972; 28(2): 2341-2352.

[10]. Patil VD, Nayak UR, Dev S. Chemistry of Ayurvedic crude drug II, Guggulu (resin from *Commiphora mukul*), 2. Diterpenoid constituents, Tetrahedron. 1973a; 29(2): 341-348.

[11]. Patil VD, Nayak UR, Dev S. Chemistry of Ayurvedic crude drug, III, Guggulu (resin from *Commiphora mukul*), 3. Long chain aliphatic tetrols, a new class of naturally occurring lipids, Tetrahedron. 1973b; 29(11): 1595-1598.

[12]. Satyavati GV, Dwarakanat C, Tripathi SN. Experimental studies on the hypocholesteromic effect of *Commiphora mukul* (Guggul), Indian J Med Res. 1969; 57: 1950-1962.

[13]. Satyavati GV. Gum Guggul (*Commiphora mukul*): The success story of an ancient insight leading to modern discovery, Indian J Med Res. 1988; 87: 327-35.

[14]. Satyavati GV. Guggulipid: A promising hypolipidemic agent from gum guggul (*Commiphora wightii*). Econ Med Plant Res. 1991; 5: 48-82.

[15]. Baldwa VS, Bhasin V, Ranka PC, Mathur KM. Effect of *Commiphora mukul* (Guggul) in experimentally induced hyperlipedemia and atherosclerosis, J Ass Physicians of India. 1981; 29: 13-17.

[16]. Dixit VP, Joshi S, Sinha R, Bhargava SK, Varma M. Hypolipidemic activity of guggul resin (*Commiphora mukul*) and garlic (*Allium sativum*) in doGS (*Canis familiaris*) and monkeys (*Presbytis entellus entellus*), Biochem Exp Biol.1980; 16: 421-424.

[17]. Khanna DS, Agarwal OP, Gupta SK, Arora RB. A biochemical approach to anti-atherosclerotic action of *Commiphora mukul*, an Indian indigenous drug in Indian domestic pigs (*Sus scrofa*), Indian J. Med. Res. 1969; 57: 900-906.

[18]. Nityanand S, Kapoor NK. Effect of guggul steroids on cholesterol biosynthesis in rats, Indian J Biochem Biophy. 1978; 15: 77.

[19]. Orten JM, Neuhaus OW. Human biochemistry, CV Mosby Company, St Louis, MO.; 1982. p. 85.

[20]. Bajaj AG, Dev S. Chemistry of Ayurvedic crude drugs, V. Guggulu (resin from *Commiphora mukul*), 5: some new steroidal components and stereochemistry of guggulsterol-1 at C-20 and C-22, Tetrahedron. 1982; 38(19): 2949-2954.

[21]. Chander R, Rizvi F, Khanna AK, Prated R. Cardio protective activity of synthetic guggulsterone (E and Z isomers) in isoproterenol induced myocardial ischemia in rats: a comparative study, Indian J Clinical Biochem. 2003; 18(2): 71-79.

[22]. Wu J, Xia C, Meier J, Li S, Hu X and Lala DS. The hypolipidemic natural product guggulsterone acts as an antagonist of the bile acid receptor, Molecular Endocrinology. 2002; 16: 1590-1597.

[23]. Cai SY, Boyer JL. FXR: A target for cholestatic syndromes, Expert Opinion on Therapeutic Targets. 2006; 10: 409-421.

[24]. Shishodia S, Aggarwal BB. Guggulsterone inhibits NF-Kappa B and I kappa B alpha kinase activation, suppresses expression of anti-apoptotic gene products and enhances apoptosis, J Biol Chem. 2004; 279: 47148-47158.

[25]. Ichikawa H, Aggarwal BB. Guggulsterone inhibits osteo clstogenesis induced by receptor activator of nuclear factor-kappa B legend and by tumor cells by suppressing nuclear factor-kappa B activation, Clinical Cancer Res. 2006; 12: 662-668.

[26]. Cheon JH, Kim JS, Kim JM, Kim N, Jung HC, Sing IS. Plant sterol guggulsterone inhibits nuclear factor kappa B signaling in intestinal epithelial cells by blocking I kappa B kinase and ameliorates acute murine colitis, Inflam Bowel Disease, 2006;12: 1152-1161.

[27]. Shishodia S, Sethi G, Ahn KS, Aggarwal BB. Guggulstrone inhibits tumor cell proliferation, inducs S-phase arrest and promotes apoptosis through activation of c-junc terminal kinase suppression of AKT pathway and down regulation of anti apoptotic gene products, Biochem Pharmacology. 2007; 74: 118-130.

[28]. Marte BM, Downward JP. KB/AKT: connecting phosphoinositide 3-kinase to cell survival and beyond, Trend Biochem Sci.1997; 22: 355-358.

[29]. Wang X, Greilberger J, Ledinski G, Kager G, Paigen B, Urgens G. The hypolipidemic natural product *Commiphora mukul* and its component guggulsterone inhibit oxidative modification of LDL, Arteriosclerosis. 2004; 172(2): 239.

[30]. Panda S, Kar A. Guggulu (*Commiphora mukul*) potentially ameliorates hypothyroidism in female mice, Phytother Res. 2005; 19: 78-80.

[31]. Mishra SA. Bhaishjaya, Surbharti Prakashan, Varanasi, India.; 1996. p. 193.