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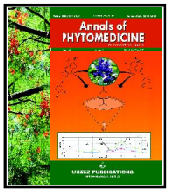

Original article

Antidiabetic, antioxidant and anti-inflammatory activity of medicinal plants collected from nearby area of Junagadh, Gujarat

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Abstract

The present study was planned to carry out phytochemical analysis and to evaluate *in vitro* antidiabetic, antioxidant and anti-inflammatory activities of different extracts of six medicinal plants collected from the nearby area of Junagadh, Gujarat, India, *viz., Luffa echinata* Roxb. (fruit), *Operculina turpethum* (L.) Silva Manso (leaf), *Sphaeranthus indicus* L. (fruit), *Cressa cretica* L. (leaf), *Corchorus depressus* L. (root) and *Cassia absus* (seed). An *in vitro* antidiabetic activity was evaluated by alpha-amylase and alpha-glucosidase inhibition methods, antioxidant activity by DPPH (2, 2-diphenyl-1- picrylhydrazyl) assay and anti-inflammatory activity by albumin denaturation assay. Hydro-alcoholic and methanolic extracts of *L.echinata*, water extract of *C.cretica* and methanolic and hydro-alcoholic extracts of *C. depressus* showed significant inhibition either of alpha-amylase or alpha-glucosidase or both *in vitro* at various concentrations. Hydro-alcoholic and methanolic extracts of *L. echinata* fruit and hydro-alcoholic and methanolic extracts of *S. indicus* fruit showed significant *in vitro* antioxidant effect. Water extract of *O. turpethum* leaf showed significant anti-inflammatory activity by preventing albumin denaturation *in vitro*. Phytochemical analysis revealed the presence of glycosides, flavonoids, alkaloids, tannins and steroids in different extracts of medicinal plants which might be responsible for significant *in vitro* antidiabetic, antioxidant and anti-inflammatory activities. Identification and isolation of active substances from such plants and *in vivo* efficacy evaluation will be helpful for further validation of pharmacological activities of these medicinal plants.

Key words: Medicinal plants, antidiabetic, antioxidant, anti-inflammatory, *in vitro* assays

1. Introduction

According to the WHO, 88% population of about 198 countries in the world use traditional medicines. Many countries have formulated a policy on conventional medicine (WHO, 2019). Saurashtra region of Gujarat is a large biodiversity region with several medicinal plants. Since a long time, these medicinal plants are used in the ethnoveterinary practices as well as in the ailments of human or animals (Bhatt *et al.,* 2019a). The main advantages of medicinal plants are, they are economical, readily available and has no side effects. Many medicinal plants from Saurashtra region are reported to have antidiabetic, antibacterial, anti-inflammatory and antioxidant effects (Kaneria *et al.,* 2009; Modi *et al.,* 2019; Patel *et al.,* 2019).

Medicinal plants are having an antidiabetic action exerted with different mechanisms like inhibition of blood glucose level by maintaining various enzymes like alpha-amylase and alpha-glucosidase (Modak *et al.,* 2007). Many degenerative diseases such as coronary heart disease, inflammation, stroke, diabetes mellitus and cancer occur due to the high level of free radicals in the body. Diabetes is a major degenerative disorder which is listed as an incurable disease as per World Health Organisation (WHO, 2018). Phytochemicals like flavonoids, phenolic compounds, phenolic acids, *etc.*, are known to have strong antioxidant action. These kinds of phytochemicals are found in many medicinal plants (Bhatt *et al.,* 2019b). Antioxidant activity of plants is attributed *via* simple redox reactions which occur in various biochemical processes by saturating lone-pair from free radicals, also called reactive oxygen species (ROS) (Brown and Rice-Evans, 1998; Scalbert *et al.,* 2005). Inflammation is a response which occurs due to damage to the body by physical or chemical agents. It is characterised by pain, redness, swelling, heat and lack of function (Tortora and Sandra, 1993). Many synthetic drugs like indomethacin, aspirin, ibuprofen, diclofenac and aceclofenac have potent anti-inflammatory action, but due to significant side effects like kidney failure, damage to the liver and upper GIT bleeding, many drugs are either banned or less used for long term treatment (Patidar *et al.,* 2014). Medicinal plants are a rich source of a variety of phytochemicals like saponin, triterpenoid, flavonoids, alkaloids, which possess anti-inflammatory action *via* different mechanisms like inhibition COX enzymes, albumin denaturation and protease inhibition (Fawole *et al.,* 2010; Modi *et al.,* 2019).

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Six medicinal plants (*Luffa echinata* Roxb., *Operculina turpethum* (L.) Silva Manso, *Sphaeranthus indicus* L., *Cressa cretica* L., *Corchorus depressus* L., and *Cassia absus* L.) were selected in the present study. Traditionally, *Luffa echinata* is used in jaundice, *Operculina turpethum* as purgative, *Sphaeranthus indicus* in hepatic and gastric disorders as well as a blood purifier, *Cressa cretica* as an expectorant, *Corchorus depressus* in wound healing and *Cassia absus* as blood-purifier and used in various skin disorders (Khare, 2007). Limited or no studies have been reported for antidiabetic, antioxidant and anti-inflammatory activity of aqueous, hydro-alcoholic and methanolic extracts of above mentioned plants. Therefore, the plants have been selected for the evaluation of the antidiabetic, antioxidant and anti-inflammatory activity through *in vitro* assays.

2. Materials and Methods

2.1 Collection and processing of plant material

All the plant materials were collected from the surroundings of Junagadh, Gujarat, India and identified and authenticated by Pharmacognosist (Table 1). A specimen of each plant material was deposited in the Department of Veterinary Pharmacology and Toxicology, Veterinary College, JAU, Junagadh. Specimen voucher numbers are mentioned in Table 1. Collected plant materials were washed with tap water and dried in an oven at 45°C. The material was grounded, and the fine powder was stored in an air-tight container until use.

Table 1: List of medicinal plants used for the study

Sr. No.	Name of plantwith herbarium number	Family	Vernacular name (Gujarati)	Part of plant used
1	*Luffa echinata* Roxb. (JVC/VPT/SP/PS/01/2016)	Cucurbitaceae	Kukadvel	Fruit
2	*Operculina turpethum* L. Silva Manso (JVC/VPT/SP/PS/02/2016)	Convolvulaceae	Nasotar	Leaf
3	*Sphaeranthus indicus* L. (JVC/VPT/SP/PS/03/2016)	Compositae	Gorakhmundi	Fruit
4	*Cressa cretica* L. (JVC/VPT/SP/PS/04/2016)	Convolvulaceae	Rudanti	Leaf
5	*Corchorus depressus* L. (JVC/VPT/SP/PS/05/2016)	Tiliaceace	Bahufali	Root
6	*Cassia absus* L. (JVC/VPT/SP/PS/06/2016)	Caesalpiniaceae	Chimed	Seed

2.2 Preparation of extracts

All powders were used to prepare different solvent extracts (water, methanol and hydro-alcoholic) by maceration. The hydro-alcoholic extract from each powder was prepared using methanol and water with the ratio of 80:20. The extracts were obtained by dissolving 25 grams of the powder in 250 ml of each solvent for 24 h, then contents were filtered through Whatman filter paper no.1, and the filtrate was evaporated for dryness (Sarker *et al.,* 2006). The test extracts in sufficient quantities were prepared and stored at -20°C for further use. The per cent extractability (yield) of plants was calculated by the formula: [Total amount of dried extract x 100 / Total amount of raw powder taken]. The physical characteristics of all extracts were also recorded.

2.3 Phytochemical screening and total phenolic content

Qualitative phytochemical screening was performed for each extract as per standard procedures (Harborne, 1998). All the chemicals of analytical grades were used for qualitative analysis of different phytochemical constituents in different extracts of plants as per standard methods (Iqbal *et al.,* 2015). For total phenolic content assay, 250 l of extract solution was allowed to react with 2 ml Folin-Ciocalteu (FC) reagent (previously diluted 1:10) and 1 ml solution (75 g/l) of sodium carbonate. The mixture was allowed to stand for 1 to 2 h. Extinction was recorded at 760 nm in a spectrophotometer. Tests were performed in triplicate. Total phenolic content (TPC) was expressed as milligrams of gallic acid equivalents (GAE) (Encarnacao *et al.,* 2015).

2.4 *In vitro* antidiabetic activity

2.4.1 Alpha-amylase inhibition assay

Alpha-amylase inhibition was evaluatedby Dinitro Salicylic acid (DNS) method, 500 µl extracts (10, 25, 50, 75, 100, 200 µg/ml) or standard solution (Acarbose 1 mg/ml in distilled water) were prepared in buffer solution. The mixture was added with 500 µl α-amylase (from malt) solution and 1 ml starch solution. The mixture was mixed properly and put the reaction mixture in an incubator for 5 to 10 min. DNS reagent (1 ml) was added into the reaction mixture, and immediately test-tubes were put in boiled water for 3 min. The test tubes with mixture were cooled at room temperature and added with 6 ml distilled water. The extinction of mixture was read at 540 nm in UV spectrophotometer. The control solution was prepared by adding all reagents except test or standard (Wan *et al.,* 2013).

2.4.2 Alpha-glucosidase inhibition assay

One hundred and twenty micro litters of different extract (200,400,600,800,1000 µg/ml) or standard solution (Acarbose 1 mg/ml in distilled water) were prepared in buffer solutions, were taken in 96-well plate having a transparent and flat bottom. Twenty micro litres of α-glucosidase (from *Saccharomyces cerevisiae*) solution (1U/ml) was added and incubated for 15 min. After incubation, to initiate the reaction, 20 µl p-Nitrophenyl α-D-Glucoside (pNPG) solution was added and again incubated for 15 min till the development of yellow colour in the reaction mixture. To terminate the reaction, 80 µl 0.1 M Na_2CO_3 solutions were added, and extinction of the reaction mixture was read at 405 nm in the UV spectrophotometer (Zhipeng *et al.,* 2012).

2.4 *In vitro* antioxidant activity

2.4.1 DPPH (2, 2-diphenyl-1-picrylhydrazyl) scavenging activity

Extract solution (1 mg/ml) was prepared by dissolving 30 mg of aqueous extract in 30 ml Milli-Q water. The hydro-alcoholic extract was dissolved by incorporating 10% DMSO as a solvent. Suitable dilutions were made from this stock solution with Milli-Q water only. Three ml extracts (10, 25, 50, 75, 100, 200 µg/ml) or standard

solution (Ascorbic acid 1 mg/ml) were prepared in distilled water. One ml of 0.1 mM DPPH solution (4 mg in 100 ml methanol) was added. The solution was kept for 30 min at room temperature until the colour changed from violet to yellowish violet to yellow. Extinction at 517 nm in spectrophotometer was recorded. A blank solution containing distilled water and DPPH alone (Control) were also prepared, and spectra were recorded for control purpose. Tests were performed in triplicate (Senguttuvan *et al.,* 2014).

2.5 *In vitro* anti-inflammatory activity

2.5.1 Albumin denaturation inhibition assay

One millilitre of test extract (100, 200, 300, 400, 500 µg/ml) or standard solution (Aspirin 1 mg/ml) were prepared in buffer. 1 ml (0.1%) of bovine albumin fraction and 1 ml Tris-HCl buffer pH 7.8 solution were added. This solution was incubated for 20 min and allowed to heat at 72°C in a water bath for 4 min, then cooled at room temperature. Extinction was measured at 660 nm using a blank solution (Buffer). Control solution contained 1 ml distilled water with 1 ml (0.1%) bovine albumin fraction and 1 ml buffer solution (Williams *et al.,* 2008; Alhakmani *et al.,* 2014).

2.6 Statistical analysis

All numerical data are expressedas mean ± Standard Error (SE). Selected data have been analyzed by one-way ANOVA, followed by the Duncan Multiple Range Test (DMRT) to compare the differences in means.

3. Results

3.1 Physical characteristics and phytochemical screening

Per cent yield and appearance of each extract presented in Table 2. It was found that, in most cases, water extract gave more per cent yield as compared to other extracts. However, hydro-alcoholic extracts also gave good yield due to the incorporation of water in the preparation of extracts. Qualitative phytochemical screening was performed for each extract which is mentioned in Table 3.

Table 2: Per cent yield and appearance of the different extracts of medicinal plants

Sr. No.	Name of plant	Extract	Code	Appearance	Yield (%)
1	*Luffa echinata*	HAE	LEHA	Yellowish-brown	9.45
		ME	LEM	Dark green	8.89
		WE	LEW	Dark brown	7.03
2	*Operculinaturpethum*	HAE	OTHA	Dark brown mass	4.70
		ME	OTM	Dark Green mass	3.65
		WE	OTW	Brownish-yellow solid	11.9
3	*Sphaeranthus indicus*	HAE	SIHA	Dark brown mass	7.04
		ME	SIM	Yellowish-brown mass	7.82
		WE	SIW	Yellowish-brown	8.64
4	*Cressacretica*	HAE	CCHA	Yellowish-brown	16.86
		ME	CCM	Dark green	14.85
		WE	CCW	Dark brown	16.24
5	*Corchorusdepressus*	HAE	CDHA	Dark brown mass	7.60
		ME	CDM	Dark yellow mass	5.00
		WE	CDW	Black solid	4.70
6	*Cassia absus*	HAE	CAHA	Dark brown	13.18
		ME	CAM	Yellowish-brown	1.72
		WE	CAW	Dark brown	14.56

HAE: Hydro-alcoholic extract, ME: Methanol extract; WE: Water extract; Extract codes are used in figures

3.2 *In vitro* antidiabetic activity

The data of per cent inhibition of alpha-amylase by various extracts of plants and acarbose are depicted in Figure 1. The methanol extract of *C. depressus* produced significantly (p<0.05) higher inhibition up to 61.97 ± 0.81 per cent of alpha-amylase at 500 µg/ml concentration as compared to per cent inhibition of acarbose 52.69 ± 2.16 per cent. Water extract of *C. cretica* and hydro-alcoholic extract of *C. absus* showed inhibition up to 56.65 ± 0.70 and 56.52 ± 0.92 per cent, respectively at 500 µg/ml concentration. However, the inhibition by both these extracts was found comparable to inhibition by acarbose which indicates well antidiabetic activity of these plant extracts *via* inhibition of alpha-amylase. The per cent inhibition of alpha-amylase by *L. echinata* methanol, *O. turpethum* methanol, *C. cretica* water, *C. depressus* water and *C. absus* hydro-alcoholic extracts at lower concentrations were also comparable to that of acarbose.

The data of per cent inhibition of alpha-glucosidase by various extracts of plants and acarbose are depicted in Figures 2 and 3. In case of alpha-glucosidase inhibition assay, hydro-alcoholic extract of *L. echinata* fruit and water extract of *C. cretica* leaf showed inhibition up to 78.70 ± 0.25 and 80.60 ± 0.35 per cent which were significantly (p<0.05) higher than per cent inhibition of acarbose (76.91 ± 0.47 per cent) at 1000 µg/ml.

3.3 *In vitro* antioxidant activity

The data of per cent inhibition of DPPH (2, 2-diphenyl-1-picrylhydrazyl) by various extracts of plants and ascorbic acid are depicted in Figures 4 and 5. The hydro-alcoholic extract of *L. echinata*, methanolic extract of *S. indicus*, hydro-alcoholic extract of *C. cretica* exhibited the significantly higher antioxidant activity than per cent inhibition of ascorbic acid (77.08 ± 0.31 per cent).

Table 3: Phytochemical screening of different extracts of medicinal plants

Sr. No.	Name of plant	Type	ALK	GLY	SP	FLV	STR	CHO	TN
1	*Luffa echinata*	HAE	-	+	-	+	+	-	+
		ME	-	-	-	+	+	+	+
		WE	-	+	-	+	-	+	+
2	*Operculina turpethum*	HAE	-	+	-	-	-	+	+
		ME	-	+	-	+	-	-	-
		WE	-	+	+	+	-	+	+
3	*Sphaeranthus indicus*	HAE	+	+	+	+	-	+	-
		ME	+	-	-	+	+	+	-
		WE	+	+	+	+	-	+	+
4	*Cressa cretica*	HAE	-	+	+	+	-	+	+
		ME	-	-	-	+	+	+	-
		WE	-	+	-	+	-	+	+
5	*Corchorus depressus*	HAE	-	-	+	+	+	+	+
		ME	-	-	-	+	+	-	-
		WE	-	+	+	+	-	+	+
6	*Cassia absus*	HAE	+	+	+	+	-	+	-
		ME	+	-	-	+	+	+	-
		WE	+	+	+	+	-	+	+

ALK: Alkaloid, GLY: Glycoside, SP: Saponin, FLV: Flavonoid, STR: Steroid, CHO= carbohydrate/sugars TN: Tannin, HAE: Hydro-alcoholic extract; ME: Methanol extract; WE: Water extract; '+'=present; '-'=absent.

3.4 *In vitro* anti-inflammatory activity

The data of per cent inhibition of albumin denaturation by various extracts of plants and aspirin are depicted in Figure 6. Results showed that all the selected extracts showed more or less inhibition of albumin denaturation compared to aspirin at various concentrations. Aqueous extract of *O. turpethum* (500 µg/ml) showed significant (p<0.05) albumin denaturation inhibitory activity of 84.10 ± 0.34% which was comparable to that of aspirin (90.17 ± 1.28 per cent). All other selected extracts exhibited inhibition between 40 to 70 %.

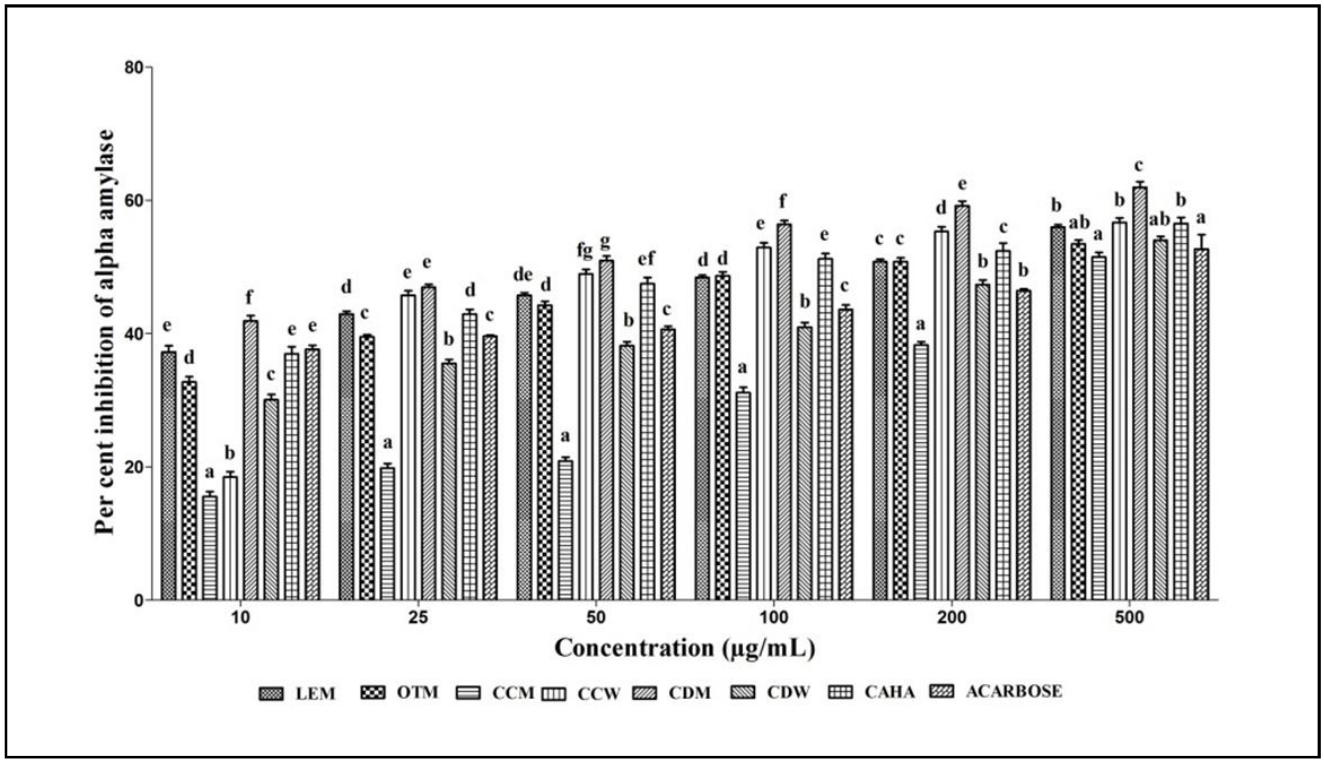

Figure 1: Per cent inhibition of alpha-amylase by various extracts of plants and acarbose. Values with different superscript were differ significantly at respective concentration (p<0.05).

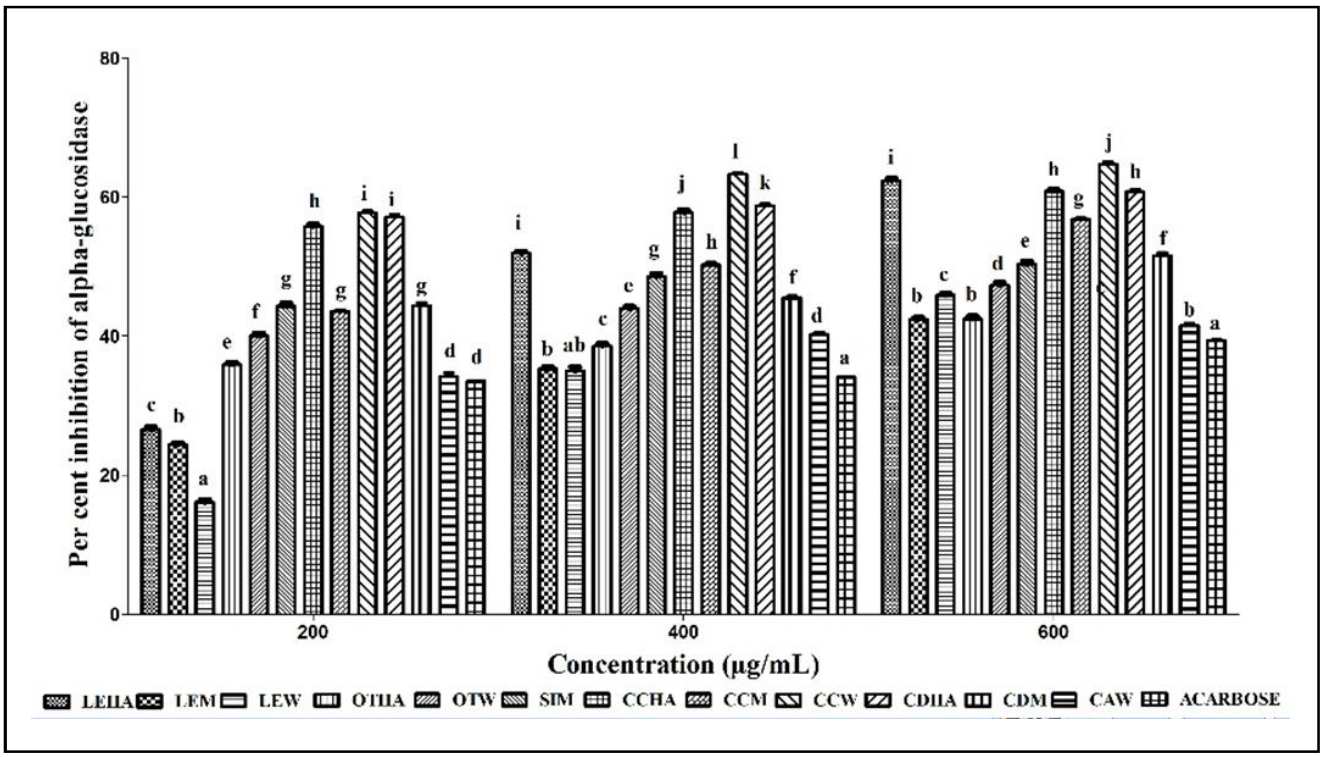

Figure 2: Per cent inhibition of alpha-glucosidase by various extracts of plants and acarbose.Values with different superscript were differ significantly at respective concentration (p<0.05).

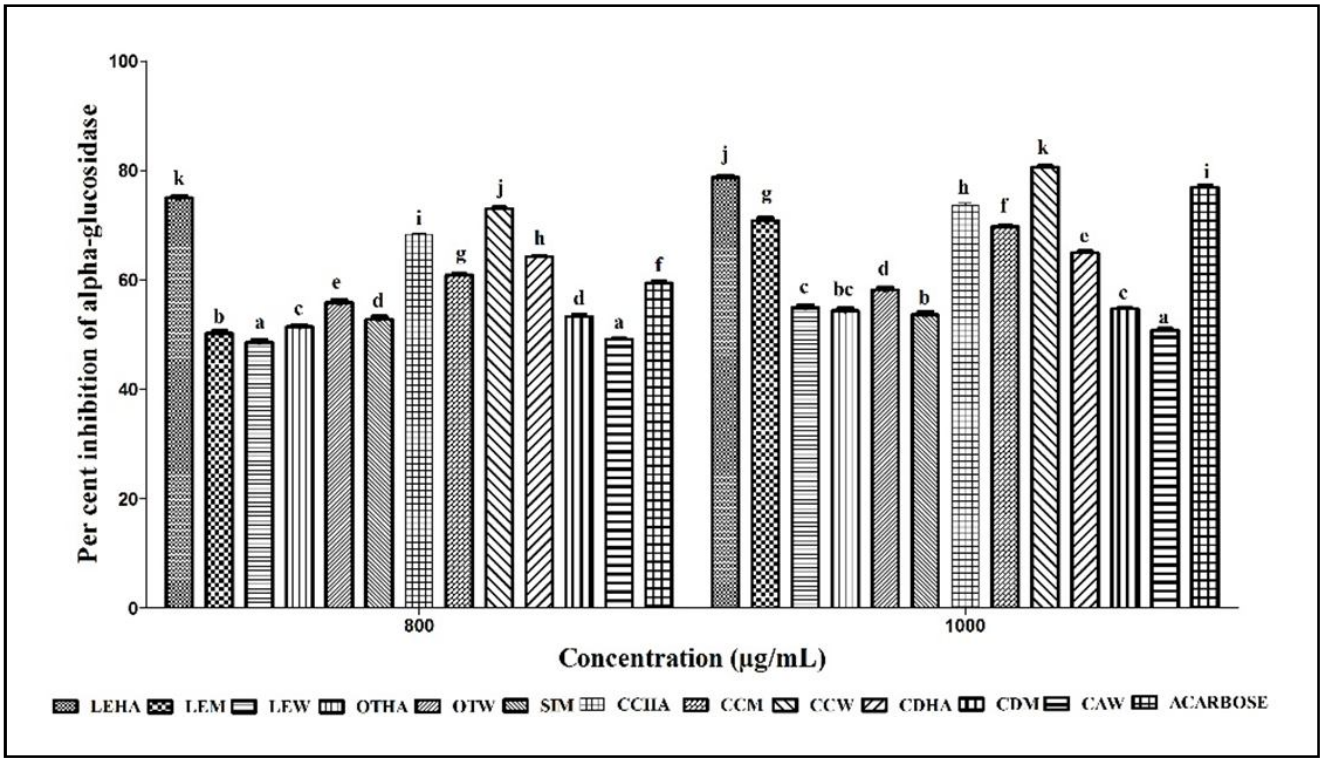

Figure 3: Per cent inhibition of alpha-glucosidase by various extracts of plants and acarbose. Values with different superscript were differ significantly at respective concentration (p<0.05).

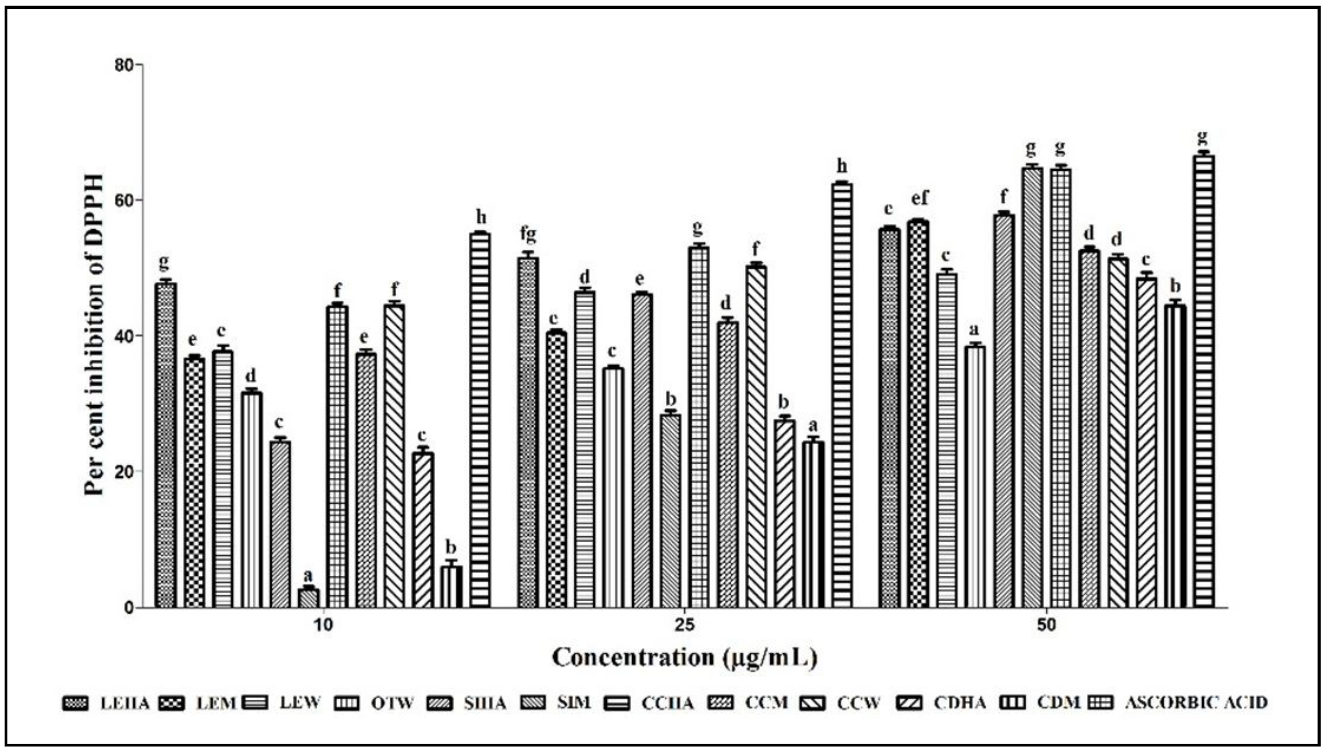

Figure 4: Per cent inhibition of DPPH by various extracts of plants and ascorbic acid. Values with different superscript were differ significantly at respective concentration ($p<0.05$).

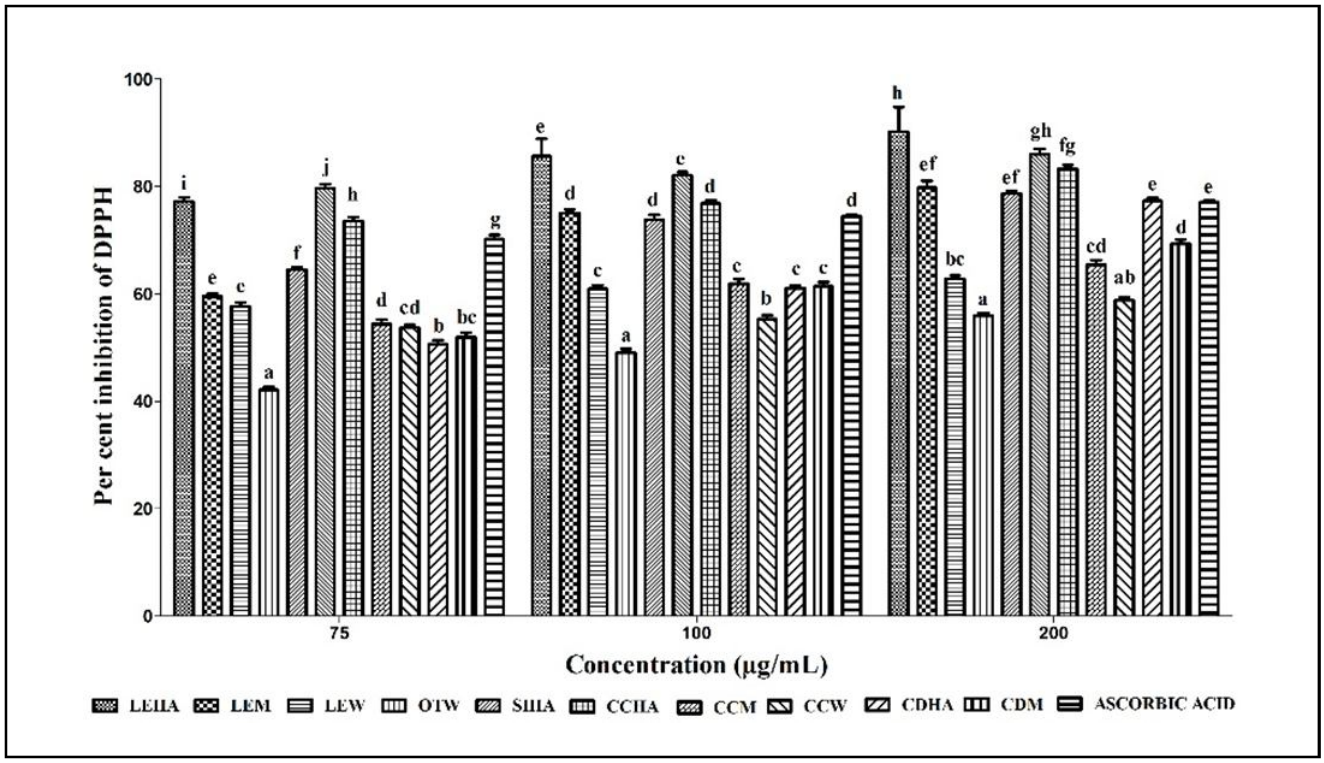

Figure 5: Per cent inhibition of DPPH by various extracts of plants and ascorbic acid. Values with different superscript were differ significantly at respective concentration ($p<0.05$).

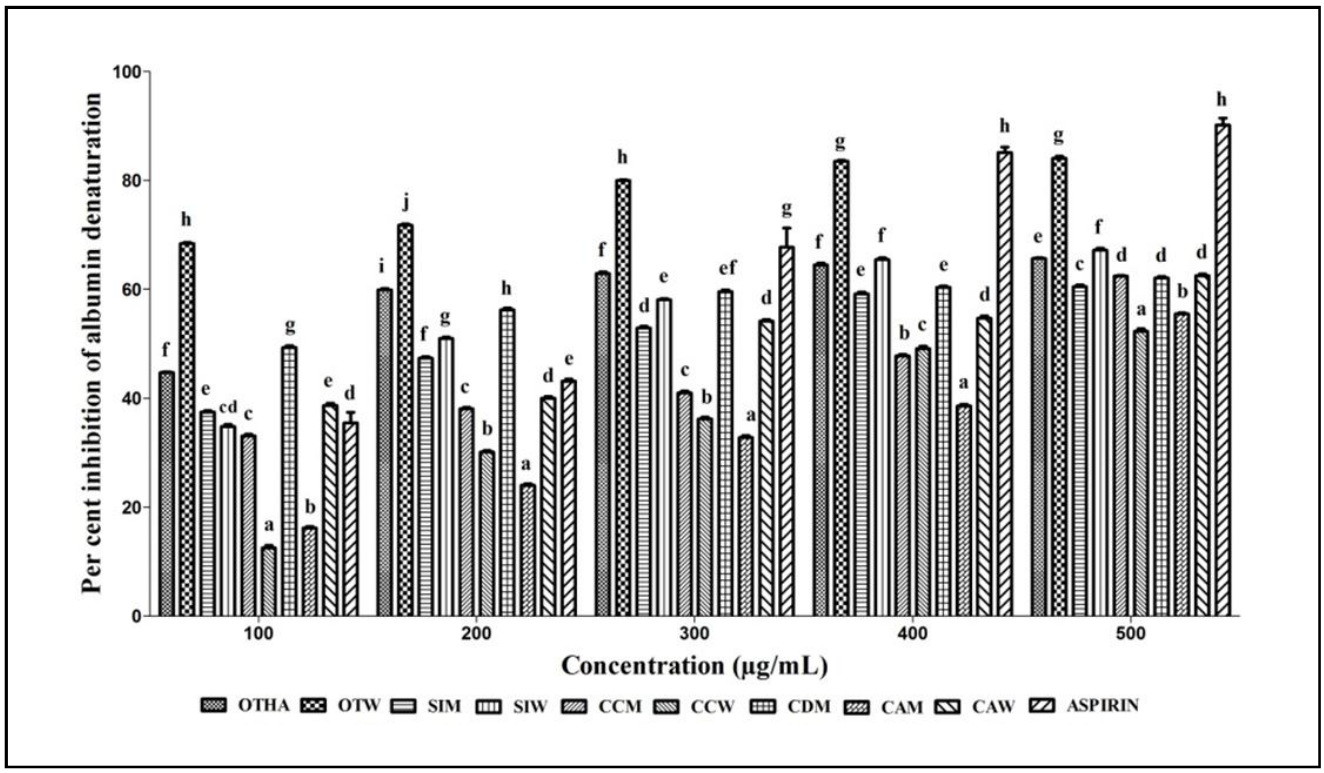

Figure 6: Per cent inhibition of albumin denaturation by various extracts of plants and aspirin. Values with different superscript were differ significantly at respective concentration (p<0.05).

4. Discussion

In a phytochemical analysis of all extracts, flavonoids were found in all the extracts except hydro-alcoholic extract of *O. turpethum*. All the extracts of *S. indicus* and *C. absus* were found to have an alkaloid. Chaksine and isochaksine, two water-soluble alkaloids have been isolated from the seed of *C. absus* (Siddqui and Ahmed, 1935). Sterols were absent in water extract of all the plants. The reason might be the presence of cyclopentanoperhydrophenanthrene ring and less solubility of phytosterols in the solvent used in the test (Moreau and Hicks, 2004).

An alpha-amylase is one of the most widely studied targets in diabetic research. An alpha-amylase is responsible for the conversion of starch molecules into simple sugar molecules which absorb in the body and raises blood glucose level (Gopinath *et al.,* 2017). Alpha-glucosidase is located in the intestinal cells, which hydrolyse carbohydrate and activates at the end of digestion. This enzyme converts complex sugar molecules into absorbable monosaccharide. Under the diabetic condition, this enzyme converts the sugar molecules and releases into blood stream, results in hyperglycaemia (da Costa *et al.,* 2019). Various phytochemicals like flavonoids, alkaloids and saponin may have alpha-glucosidase inhibitory activity and may bind with enzyme non-competitively, and so, plant extract containing these kinds of phytochemicals may exhibit antidiabetic activity *via* inhibition of alpha-glucosidase (Telagari and Hullatti, 2015).

L. echinata is a climber plant with the presence of various phytochemicals in the fruits like cucurbitacin B, C, saponin, β-sitosterol, and flavonoids. In the present study, hydro-alcoholic extract of *L. echinata* has found to inhibit the alpha-glucosidase enzyme and also the DPPH, which indicated to have an antidiabetic and antioxidant potential. Chrysoeriol is a principle flavonoid found in the fruit and has been reported with antidiabetic effect (Khare, 2007; Dludla *et al.,* 2017). Different pharmacological activities have been reported for fruits (Giri *et al.,* 2014). The principal component of fruit is cucurbitacin, a diterpene, having strong antioxidant action (Kaushik *et al.,* 2015). This finding may be supported by total phenolic content measured in the present experiment. All the extracts of *L. echinata* showed the higher amount of total phenolic content (Table 4). Hydro-alcoholic extract of *L. echinata* fruit has been reported to reduce blood glucose in alloxan-treated rats (Dogar *et al.,* 2018). In the present study, we found that the plant also has a significant effect against DPPH, which is similar to observation reported in a previous study (Sharma *et al.,* 2012). It is postulated that antioxidant activity is mainly due to the phenolic content present in the plant. As an important phytochemical bearing very reactive hydroxyl group, phenolics have attributed antioxidant action (Bidchol *et al.,* 2011; Bhatt *et al.,* 2019a). In this study, *in vitro* anti-inflammatory activity has not been seen with fruits of *L. echinata*.

C. absus is an erect annual plant used traditionally in various ailments. The seed contains unique quaternary water-soluble alkaloid, namely; chaksine and isochaksine, flavonoids like apigenin, quercetin, luteolin and hydnocarpin, glycoside like aloe-emodin and chrysophanol, phenolic compounds like coumaric acid, gentisic acid and syringic acid, triterpenes like beta-amyrin and cycloartenol. Various pharmacological activities have been reported for *C. absus* seeds. *In vitro* antidiabetic activity of *C. absus* seed is reported for only

chloroform, methanol extract and various fractions against alpha-amylase (Hussain *et al.,* 2015) but not evaluated against alpha-glucosidase. In the present study, hydro-alcoholic extract of *C. absus* showed significant inhibition of alpha-amylase and alpha-glucosidase enzymes and shown to have an antidiabetic effect. In the present study, the inhibition of DPPH by extracts of *C. absus* was not remarkable. However, it has been reported that Cassia species have the antioxidant property (Jayaraman *et al.,* 2014).

O. turpethum is found to have various glycosides like turpethine, operculinosides, and various steroidal glycosides like stigmasterol (Gupta and Ved, 2017). *O. turpethum* root and stem are explored for its pharmacological actions (Gupta and Ved, 2017). No study has been reported on *in vitro* alpha-amylase and alpha-glucosidase inhibition by an extract from leaves. However, *in vitro* anti-inflammatory activity of *O. turpethum* root has been reported (Sharma and Singh, 2013). In the present study, extracts of *O. turpethum* did not produce remarkable inhibition of alpha-amylase and alpha-glucosidase. However, water extract of *O. turpethum* produced significant inhibition of albumin denaturation which may be due to aglycon moiety of the glycoside, which is in general considered as pharmacologically active (Wang *et al.,* 2018).

S. indicus is widely used for the treatment of epilepsy, mental illness, jaundice, hepatopathy, diabetes, leprosy, cough, gastropathy, helminthiasis and skin diseases. The plant is rich in alkaloid like sphaeranthine, flavanoid C-glycoside and isoflavone glycoside (Galani *et al.,* 2010). No reports on *in vitro* antidiabetic and anti-inflammatory activity of the plant have been observed. However, *in vitro* antioxidant activity of ethanol extract of *S. indicus* has been reported (Shirwaikar *et al.,* 2006; Tiwari and Khosa, 2009). In the present study, the methanolic extract of the plant showed little inhibition of alpha-glucosidase enzyme,but hydro-alcoholic and methanolic extracts showed remarkable effect in DPPH assay which indicates that the phytochemicals present in the plants have antioxidant potential. Water and methanolic extracts also showed inhibition of albumin denaturation, but the result was not significant.

C. cretica is a perennial plant found in the coastal areas of Gujarat which contains flavonoids like quercetin glucoside, rutin and various phenolic acids. Quercetin is known to have antidiabetic action (Kotadiya *et al.,* 2017). In the present study, the water extract of the plant showed good inhibition of alpha-amylase and alpha-glucosidase as compared to other extracts. The methanol extract of whole herb *C. cretica* did not show the inhibition of alpha-glucosidase as per previous report (El-Manawaty and Gohar, 2018). The hydro-alcoholic and methanolic extract showed antioxidant effect in DPPH assay, but the effect was not comparable to ascorbic acid. Water and ethanol extract of *C. cretica* leaves have been reported to have a strong antioxidant effect against various free radicals like DPPH, ferric chloride, peroxides, *etc.* (Afshari and Sayyed-Alangi, 2017). No reports have been found on *in vitro* anti-inflammatory activity of the plant. In the present study, we observed less effect against albumin denaturation indicates that the plant does not have anti-inflammatory effect.

C. depressus is traditionally used in pain, fever, sexual dysfunction and to treat gonorrhoea. From the whole plant, sitosterol glucoside, sitosterol, apigenin and luteolin, three new α-amyrin derivatives, cordepressic acid, cordepressenic acid and cordepressin have been isolated (Khan *et al.,* 1991; Khare, 2007). In the present study, methanolic and water extract of the plant showed the remarkable antidiabetic effect with inhibition of alpha-amylase only. Hydro-alcoholic and methanolic extracts of the plant also showed inhibition of alpha-glucosidase and DPPH. The dichloromethane and methanolic extracts of the *C. depressus* have also been reported to have antioxidant and antidiabetic effects (Samina *et al.,* 2017). We also observed the effect of the methanolic extract on albumin denaturation,but the effect was lesser.

Table 4: Total phenolic content (mg GAE per gram) of different extracts of medicinal plants

Sr. No.	Name of plant	Type of extract		
		HAE	ME	WE
		mg GAE per gram		
1	*Luffa echinata*	257.52 ± 7.14	363.01 ± 14.01	232.91 ± 4.39
2	*Operculina turpenthum*	24.75 ± 5.49	19.83 ± 9.67	12.80 ± 4.61
3	*Sphaeranthus indicus*	213.22 ± 3.72	100.00 ± 5.58	59.21 ± 3.07
4	*Cressa cretica*	9.28 ± 4.22	50.07 ± 7.44	40.93 ± 5.58
5	*Corchorus depressus*	42.33 ± 8.11	195.64 ± 7.34	268.78 ± 4.39
6	*Cassia absus*	45.15 ± 6.78	57.81 ± 3.22	36.71 ± 4.39

ALK: Alkaloid, GLY: Glycoside, SP: Saponin, FLV: Flavonoid, STR: Steroid, CHO= carbohydrate/sugars TN: Tannin, HAE: Hydro-alcoholic extract; ME: Methanol extract; WE: Water extract; '+'=present; '-'=absent

5. Conclusion

Hydro-alcoholic and methanolic extracts of *L. echinata* fruit, an aqueous extract of *C. cretica* leaf and methanolic and hydro-alcoholic extracts of *C. depressus* root have shown good *in vitro* antidiabetic activity. Hydro-alcoholic and methanolic extracts of *L. echinata* fruit and methanolic extract of *S. indicus* fruit showed significant *in vitro* antioxidant effect. Aqueous extract of *O. turpethum* leaf produced remarkable anti-inflammatory activity. Further, isolation and identification of active principles from these plant sources may be helpful to explore pharmacological activity.

Conflict of interest

The authors declare that there are no conflicts of interest in the course of conducting the research. All the authors had final decision regarding the manuscript and decision to submit the findings for publication.

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