Review Article

BORAGO OFFICINALIS LINN. AN IMPORTANT MEDICINAL PLANT OF MEDITERRANEAN REGION: A REVIEW.

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ABSTRACT

The plant Borage (*Borago officinalis* L.) family-Boraginaceae, also known as "starflower" is an annual herb originating in Syria, but naturalized throughout the Mediterranean region, as well as Asia Minor, Europe, North Africa, and South America. Traditionally borage was cultivated for culinary and medicinal uses, although today commercial cultivation is mainly as an oilseed which contains gamma-linolenic acid and other fatty acids. Naturopathic practitioners uses of borage for regulation of metabolism and the hormonal system, and consider it to be a good remedy for PMS and menopause symptoms such as the hot flash. Borage is sometimes indicated to alleviate and heal colds, bronchitis, and respiratory infections in general for its anti-inflammatory and balsamic properties. The flowers can be prepared in infusion to take advantage of its medicinal properties. The oleic and palmitic acid of borage may also confer a hypocholesterolemic effect. In Unani system of medicine the plant is very popular as Gaozaban and used in various khameeras for cardioprotection.

Keywords: *Borago officinalis*, Borage, γ-Linolenic acid, Gaozaban.

INTRODUCTION

The drug consists of dried leaves of *Borago officinalis* Linn. (Boraginaceae). An erect, spreading hispid annual biennial plant. The plant found mostly in Mediterranean region, Europe, Northern Asia, it is also report to be planted in Indian gardens. The plant occurs during November to January. In India plant is sparsly distributed in Northen estern Himalayas from Kashmir to Kumaon at altitudes of 3,500-4,500m[1].

Figure 1: *Borago officinalis.*

Botanical Name: *Borago Officinalis* Linn.
Synonym: Starflower
Other Names
Arabic: Lisan-us-Saur
Persian: Gaozaban
English: Borage
Gujarati: Gaozaban
Hindi: Gojiva
Urdu: Gaozaban[1].

BOTANICAL DESCRIPTION

Macroscopic: Leaf is simple, obovate or ovate in shape, with an obtuse apex and crenate margin, the upper leaves are sessile or shortly stalked while the lower ones exhibit a decurrent petiole. The leaves have dark green upper surface with greyish green lower due to the prickly hairs[1].

Microscopic: The upper epidermis of lamina is covered with a thin, smooth cuticle and consists of one layer of polygonal cells with almost straight anticlinal walls. Stomata occur fairly frequently and are mainly anisocytic type, some are animocytic. Covering trichomes are numerous, they are unicellular, straight having cellulose walls and tapering apices. The lumen is visible throughout the entire length, the base is somewhat swollen and may contain crystalline inclusions. Glandular trichomes consist of a unicellular stalk and a unicellular, sub-spherical head. The midrib has a typical dicotyledonous structure, the diameter of the central bundle increase from the apex to the base of the leaf. Large trichomes have their base surrounded by several small and the walls are sometimes warty. These types of trichomes are not as frequent as those with at the bulbous base. The cortex contains one or two rows of hypodermal collenchymas below the upper epidermis and above lower epidermis. The endodermal sheath is consisting of a single layer of cells containing starch grains. In transverses section this layer is horse-shoe shaped. The mristele is sub-spherical in shape and well defined in transverses section. The pericycle consists of a well defined area of collenchyma above the xylem and below the phloem. The transeverse section through the petiole is similar to that of the mid-rib with a exception that cells are slightly large due to the

increase in size of the total structure. Some trichomes contain crystalline deposits in their bases[1].

Powder microscopy: The powdered drug is light brown with greenish tinge and has cucumber like odour and taste. On microscopic study it contain various glandular and non-glandular unicellular trichomes, palisade and spongy mesophylls, collenchymas, and thin layer parenchymatous cells. The tracheidal vessels with annual and spiral thickenings are also seen scattering with epidermal fragments[1].

Chemical constituents: The primary chemical constituents of Borage leaves and flowers include mucilage, tannin, saponins, essential oil, alkaloid (pyrrolizidine), vitamin C, calcium and potassium[1].

Phytochemistry:

The glycosylated pyrrolizidine alkaloid, thesinine-4′-*O*-β-D-glucoside, has been isolated from the aqueous methanol extract of dried, defatted seeds of *Borago officinalis*[2]. Δ6-desaturation of [^{14}C] linoleoyl-CoA or [^{14}C] oleoyl-CoA leading to the synthesis of γ-linolenic acid was studied in vitro with microsomal fractions from developing seeds of *Borago officinalis*. Time course of the reaction, effects of protein and precursor concentrations and nucleotide requirements were examined. These parameters allowed to improve the in vitro Δ6-desaturation assay. It was observed that the precursors were acylated mainly in phophatidylcholine, dyacylglycerol and triacylglycerol, and then desaturated. NADH was absolutely required when [^{14}C] oleoyl-CoA was the percursonr, but not when [^{14}C] lionleoyl-CoA was the precursor although it stimulated the reaction. The in vitro Δ6-desaturate activity was found mainly in phosphatidylcholine, associated with enriched endoplasmic reticulum membranes (ER) from embryos. No activity was observed in ER from seed coat or seedling. During maturation of the seeds, Δ6-desaturase reached its highest activity 14 to 16 days after pollination[3]. An octadecatetraenoic acid was present as a major fatty acid component of the leaf lipids of borage. Gas chromatography-mass spectrometry of its picolinyl esters gave unsaturation centres at carbons Δ^6, Δ^9, Δ^{12}, and Δ^{15} and confirmed its identity as stearidonic acid (SDA; octadecatetraenoic acid, C18:4,$\Delta^{6,9,12,15}$. The chloroplast galactolipids, monogalactosyldiacyglycerol (MGDG) and digalactosyldiacylglycerol (DGDG) were particularly rich in SDA. SDA was absent, however, from the plastid phospholipid, phosphatidylglycerol (PG). Stereochemical analysis of the fatty acids in leaf MGDG and phosphatidylcholine (PC) showed that both SDA and γ-linolenic acid (GLA) were almost exclusively located at carbon *sn*-2 of these complex lipids. In time-course studies with excised seed cotyledons induced to green by light treatment, SDA appeared in the galactolipids before its detection in PC suggesting that its major site of synthesis in the leaf was prokaryotic and largely located in the chloroplasts. Borage seed microsomes, which have high Δ^6 desaturase (Δ^6des) activity, catalysed the synthesis of SDA from exogenously supplied α-linolenic acid (ALA). Linseed cotyledons which have an active Δ^{15}des, on the other hand, could not convert exogenously supplied GLA to SDA. These observations suggest that SDA is formed from ALA via Δ^6des activity at carbon sn-2 of MGDG and not from GLA and subsequent Δ^{15}-desaturation[4]. Solvent winterization of seed oil and free fatty acids (FFAs) was employed to obtain γ-linolenic acid (GLA; 18:3ω6) concentrates from seed oils of two Boraginaceae species, *Borago officinalis*. Different solutions of seed oils and FFAs from these two oils at 10%, 20% and 40% (w/w) were crystallized at 4°C, −24°C and −70°C, respectively, using hexane, acetone, diethyl ether, isobutanol and ethanol as solvents. Best results were obtained for *B. officinalis* FFAs in hexane, reaching a maximum GLA concentration of 58.8% in the liquid fraction (LF)[5]. The similarities between Δ^{12}- and Δ^{15}- fatty acyl desaturase sequences were used to construct degenerate primers for PCR experiments with cDNA transcribed from mRNA of developing borage seeds. Screening of a borage seed cDNA library with an amplified DNA fragment resulted in the isolation of a full-length cDNA corresponding to a deduced open-reading frame of 446 amino acids. The protein showed high similarity to plant Δ^8-sphingolipid desaturases as well as to the Δ^6-fatty acyl desaturase from *Borago officinalis*. The sequence is characterized by the presence of a N-terminal cytochrome b_5 domain. Expression of this open-reading frame in *Saccharomyces cerevisiae* resulted in the formation of Δ^8-*trans*/*cis*-phytosphingenines not present in wild-type cells, as shown by HPLC analysis of sphingoid bases as their dinitrophenyl derivatives. GLC-MS analysis of the methylated di-*O*-trimethylsilyl ether derivatives confirmed the presence of Δ^8-stereoisomers of C_{18}- and C_{20}-phytosphingenine. Furthermore, Northern blotting showed that the gene encoding a stereo-unselective Δ^8-sphingolipid desaturase is primarily expressed in young borage leaves[6].

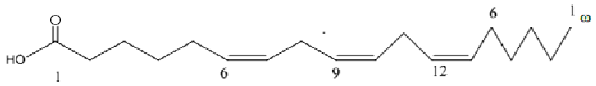

Figure 2: Gamma-Linolenic Acid.

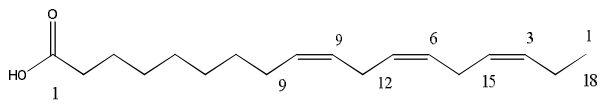

Figure 3: Alpha-Linolenic Acid.

PHARMACOLOGY

Gastrointestinal, Respiratory and Cardiovascular Activity

The crude leaves extract of *Borago officinalis* were investigated for its antispasmodic, bronchodilator, vasodilator and cardio-depressant activities to rationalize some of the traditional uses. Bo.Cr which was tested positive for flavonoids, coumarins, sterols and tannins produced a concentration-dependent relaxation of

spontaneous and K+ (80 mM)-induced contractions in isolated rabbit jejunum preparations, suggestive of Ca++ antagonist effect, which was confirmed when pretreatment of the tissue with Bo.Cr produced a rightward shift in the Ca++ concentration-response curves like that caused by verapamil. In rabbit tracheal preparations, Bo.Cr relaxed the carbachol (1 µM) and K+-induced contractions. Verapamil also produced non-specific inhibitory effect. In rabbit aorta preparations, Bo.Cr exhibited vasodilator effect against phenylephrine and K+-induced contractions similar to verapamil. When tested in guinea-pig atria, Bo.Cr caused inhibition of both atrial force and rate of contractions. These results suggest that the spasmolytic effects of Bo.Cr are mediated possibly through Ca++ antagonist mechanism, which might explain the traditional use of *Borago officinalis* in hyperactive gastrointestinal, respiratory and cardiovascular disorders[7].

Anti-oxidant Activity

Borage seeds (*Borago officinalis* L.) were sampled in Amdoun region (North of Tunisia) during their ripening stage in order to analyse their phenolic compounds and to ascertain their antiradical scavenging activity. The harvesting time effect on some physical properties of borage seed was significant. The increase of dry weight (from 10 to 90%) during ripeness was correlated negatively with that of moisture content (from 90 to 10%). Seed phenolic contents ranged from 2.45 to 10.98 mg GAE/g DW. HPLC analysis permitted to identify nine phenolic acids during seed maturation with the predominance of rosmarinic, syringic and sinapic acids. Total phenolic contents and IC_{50} values in seed during their maturation, allowed to conclude that antioxidant activity does not depend on the high content of total phenolics but on the phenolic composition[8].

An evaluation of the capacity of a lyophilized water extract of borage leaves to delay the lipid oxidation process in dry fermented sausages enriched with ω-3 PUFAs has been performed. Lyophilized extract (340 ppm) showed an antioxidant capacity equivalent to 200 ppm of a butylhydroxyanisol (BHA) and butylhydroxytoluene (BHT) mixture. Two batches of dry fermented sausages enriched in ω-3 PUFA were developed. One of them was supplemented with a synthetic antioxidants mixture (200 ppm of BHA + BHT) and the other one with natural antioxidants (340 ppm of lyophilized water extract of borage leaves). Furthermore, a traditional formulation of this type of dry fermented sausage (Control), was also manufactured. The natural extract gave rise to lower amount of volatile compounds (including hexanal), than the mixture of synthetic antioxidants (2202 and 2713 ng dodecane/g dry matter, respectively). TBARS and Cholesterol Oxidation Products (COPs) did not show significant differences between products with different antioxidants. The sensorial analysis showed that lyophilized water extracts of borage leaves did not affect the sensorial properties of the products. From the economical and safety standpoints, the use of a by-product (borage leaves) and water as extracting solvent are valuable alternatives for obtaining natural antioxidants to be added to dry fermented sausages enriched in ω-3 PUFA[9].

An ethanolic extract of borage meal was fractionated (fractions I–VI) on a Sephadex LH-20 column. All fractions tested positive for phenolics, but were negative for condensed tannins. Silica gel thin-layer chromatography (TLC) of fractions allowed the location of one and two strong antioxidative spots in fractions I and IV, respectively. Other fractions produced spots containing either weak antioxidative compounds or compounds with low concentrations. High performance liquid chromatography of the three major TLC spots in fractions I and IV showed the presence of one phenolic compound in each spot. Ultraviolet, proton nuclear magnetic resonance and proton-proton correlation spectroscopies, as well as electron impact-mass spectrometry, allowed the identification of three phenolic acids, namely rosmarinic acid in fraction I, and syringic and sinapic acids in fraction IV. These three compounds contributed to 3.9% of the dry mass of the crude extract whereas their total contribution in the meal was 0.6% (w/w)[10].

Borage meal exerted a concentration-dependent antioxidant activity in a meat model system. At 2% (w/w), it inhibited ($p \leq 0.05$) 2-thiobarbituric acid-reactive substances (TBARS), hexanal and total volatile formation in meat by 26.5, 30.5 and 18.6%, respectively. Antioxidant compounds in the meal were concentrated at optimum extraction conditions (in 52% ethanol at 74°C for 62 min) predicted by response surface methodology (RSM). The resulting extract inhibited ($p \leq 0.05$) the coupled oxidation of β-carotene and linoleate in a β-carotene-linoleate system. The system containing extract at a level providing 200 ppm phenolics retained 81% of the initial β-carotene after 2 h of assay whereas the control retained only 11%. Inhibition ($p \leq 0.05$) of TBARS, hexanal and total volatile formation in a meat system containing 200 ppm extract ranged from 18.9 to 88.3%, depending upon the concentration being tested. The extract inhibited ($p \leq 0.05$) conjugated diene, hexanal and total volatile formation in bulk corn oil (8.3–49.6% inhibition) and corn-oil-in water emulsion (5.2–32.2% inhibition). Hydrogen peroxide, hydroxyl radical and superoxide radical-scavenging properties of the extract were somewhat less than, but comparable to, those observed for *trans*-sinapic acid at similar concentrations of phenolics. At 200 ppm, a 100% quenching of the hydroxyl radical and superoxide radical was evident. The extract scavenged 29–75% of the hydrogen peroxide in assay media after 10 min of assay as compared to 3% reduction in the control[11].

Polyphenols content (as catechin equivalents) and tocopherol content were determined in borage defatted meal and borage oil, respectively. In addition, antioxidant activity of extracts obtained from borage defatted meal was evaluated. A cold pressing process was used for the extraction of *Borago officinalis* oil, resulting in a defatted

meal (by-product). Polyphenols from this defatted borage meal were extracted using several solvents. An extract containing highly soluble solids and phenolic compounds with antioxidant activity (as free radical-scavenging, DPPH) was obtained when methanol was used. The tocopherol content was higher in oil extracted by cold pressing than in oil extracted with petroleum ether as organic solvent. An enzymatic treatment was applied (45 °C, 20% moisture, 0.25% E/S ratio, 1:1 Olivex:Celluclast enzymatic mixture) previously to borage oil extraction, which improved the antioxidant content in the borage defatted meal by three-folds, as compared to the values obtained by a nonenzyme-aided process[12].

An edible film plasticized with glycerol and sorbitol was successfully prepared from a sole skin gelatin. Some physico-chemical properties of the films (water vapour permeability, water solubility, opacity) were similar to those from a commercially acquired catfish skin gelatin, whereas the breaking force was significantly lower (11.4 ± 2.1 *vs.* 28.1 ± 3.1 N) and the breaking deformation significantly higher (18.1 ± 1.0 *vs.* 14.5 ± 2.1%). A borage extract was prepared and its antioxidant properties (total phenolics, reducing ability by the FRAP assay, radical scavenging capacity by the ABTS assay, iron (II) chelation activity) were determined. The incorporation of the borage extract into the films gave rise to a pronounced increase of their antioxidant properties irrespective of the gelatin origin, with minor modifications of their physico-chemical properties: decrease of the breaking force and increase of film opacity. The antioxidant properties of films incorporated with borage extract were higher than those of films incorporated with α-tocopherol and BHT[13].

The rapid evaluation of antioxidant activity of crude borage (*Borago officinalis* L.) extract was determined by using DPPH free radical method. This borage extract resulted in a rapid decrease of the absorbance and showed very high hydrogen-donating capacity towards the 2,2′-diphenyl-1-picrylhydrazyl (DPPH) radical. A new HPLC-DPPH on-line method was applied for a screening of several radical scavenging components in this borage extract as well as for quantitative analysis. This on-line HPLC-DPPH method was developed using a methanolic solution of DPPH-stable radical. The HPLC-separated analytes reacted post-column with the DPPH solution in methanol. The induced bleaching was detected as a negative peak photometrically at 515 nm. The separation of antioxidative components was carried out by gradient HPLC with mobile-phase composition ranging from 2% to 80% acetonitrile with 2% acetic acid in water, UV detection was carried out at 280 nm. The HPLC analysis of borage extract revealed the presence of several radical scavenging components in the borage extract. The results obtained from the chromatograms suggest that some compounds present in the extract possess high radical quenching ability. The dominant antioxidative compound in the crude extract of borage leaves was identified as rosmarinic acid[14].

Other reported work

Agricultural

Recently, borage (*Borago officinalis* L.) has been the subject of increasing agricultural interest because of the potential market for gamma linolenic acid (GLA), an unusual fatty acid extracted from the seed. GLA is an omega-6 essential fatty acid which has been identified as having several beneficial therapeutic effects such as treatment of atopic eczema, diabetes, cyclic mastalgia, heart disease, arthritis, and multiple sclerosis. Increased interest in production of the crop in western Canada brought about a need for suitable agronomic management practices because very little research information is available for this area. Field studies were conducted in central Alberta in 1998 and 1999 on a black Malmo silt loam soil to evaluate the effects of planting date and nitrogen fertility level on borage total above-ground biomass (TDW), grain yield, harvest index, and seed oil GLA content. All possible combinations of two planting dates (early vs. late) and four nitrogen fertility rates (0, 20, 40, and 80 kg N ha^{-1}) were established. The plots were arranged in a randomized complete block design. Plots were harvested twice during each growing season. In general, early planting resulted in significantly higher TDW, grain yield, and harvest index. Nitrogen fertility level had no significant effect on TDW and grain yield, whereas increasing nitrogen fertility rate tended to decrease the harvest index in 1999. The lack of response to nitrogen could be caused by a high initial soil nitrogen content. Under the conditions of the experiment, early seeding is recommended. Further studies are needed to clarify the effect of nitrogen fertilization on the performance of borage crop before any recommendation can be made[15].

Extraction

Supercritical fluid extraction

The influence of different pressures of CO_2 and the addition of caprylic acid methyl ester as an entrainer was studied for the extraction process of borage seed. The increase of CO_2 pressure from 100 to 350 bar resulted in the increase in extract yield from 0.14 to 24.29% (w/w) while the changes in the extract composition were not so considerable. The highest solubility of pure caprylic acid methyl ester in dense CO_2 was determined at 100 and 300 bar (approximately 1 g of ester in 1 g of CO_2). The addition of this entrainer increased the yield of pure extract up to 47.8 times at 100 bar, 2.4 times at 200 and 300 bar. Due to the high solubility of caprylic acid methyl ester at the lower (100 bar) pressure it is easy to separate the entrainer, which constituted only 4.22% of the total borage seed extract[16].

Extraction by compressed CO_2

The extraction of borage seed oil using compressed CO_2 was studied on a pilot plant apparatus with the aim of optimise plant performance and collect data for scale-up purposes. The seeds were pre-treated by flaking them

into 0.3 mm flake prior to the extraction tests for achieving quantitative recovery of the oil. Effects of extraction pressure (200–300 bar) and temperature (10–55 °C), solvent flow rate (7.5–12 kg/h) and bed length (0.25–0.50 m) were examined. As a major factor, oil solubility in CO_2 controlled the extraction rate until 70% of the oil had been extracted, and then intraparticle resistances appear to have dictated the rate of extracting the remaining fraction of the oil. A mathematical model, based on the evidence that the oil is partially exposed to solvent after the pre-treatment of the seed, was used to correlate the experimental data. Average deviation between measured and calculated oil yields was 8%. The best-fitting values of the model parameters, namely fraction of readily accessible oil (f_k), solid phase mass transfer coefficient (k_s) and specific interfacial area (a) were 0.7, 2.8×10^{-7} m/s and 350 m^{-1}, respectively[17].

Oxidative stability

The oxidative stability of borage (*Borago officinalis* L.) oils from commercial origin or extracted by different methods (with solvents and supercritical CO_2) was determined by the Rancimat method. To delay the oxidative degradation with the aim of preserving the nutritional characteristics of borage oil, several borage—virgin olive oil blends were prepared and submitted to analysis. The results indicated that the incorporation of borage in virgin olive oil (to a level not exceeding 50 g/kg) while modifying the fatty acid profile of the resulting blends had a limited effect on the oxidative stability provided that the blends were maintained in the absence of light[18].

Biochemical

Solubilization of two membrane-bound enzymes (Δ^{12}- and Δ^{6}-desaturases) involved in the biosynthesis of polyunsaturated fatty acids (linoleic 18:2 and γ-linolenic acids γ-18:3, respectively) was performed using borage seed microsomes. Of the three detergents Triton X100, sodium deoxycholate and CHAPS, the latter was found to be the most efficient for solubilization and maintaining the two desaturase activities. Solubilization was optimal with 1% CHAPS at a detergent-membrane protein ratio equal to one. Under these conditions, only 55% of the microsomal proteins were solubilized. These results are promising for further purification of the two desaturases[19].

The ability of immobilized lipase Novozym 435, from *Candida antarctica,* to modify the fatty acid composition of borage oil (*Borago officinalis* L.) in hexane, by incorporation of docosahexaenoic acid (DHA), was studied. Response surface methodology (RSM) was used to evaluate the effects of variables, namely the amount of enzyme (100–200 U), reaction temperature (30–60 °C) and reaction time (18–30 h), on the yield (%) of DHA incorporation. Optimization of the acidolysis reaction was attempted in order to obtain a maximum yield of DHA incorporation while using the minimum amount of enzyme possible. Computer-generated contour plot interpretation revealed that an enzyme concentration of 165 units, after 25 h of reaction at 50°C, gave optimum incorporation of DHA, up to 34.1%. Analysis of variance (ANOVA) showed that 94% (R^2=0.94) of the observed variation was explained by the polynomial model. A low coefficient of variation (2.92) showed that the reproducibility of the model was satisfactory. Lack of fit analysis revealed a non-significant value for the model equation, indicating that the regression equation was adequate for predicting the degree of DHA incorporation under any combination of values of the variables. The positional distribution of DHA in modified borage oil, produced under optimum reaction conditions, was determined using pancreatic lipase hydrolysis. The results showed that DHA was fairly evenly distributed at the *sn*-2 and *sn*-1+*sn*-3 positions of the structured triacylglycerols[20].

Borage seed oil extraction using cold pressing produces a good oil quality, but it has a low-yield. In a previous study on a borage oil extraction process by cold pressing using commercial enzymes, the oil yield was enhanced in comparison to the control without enzymes. The aim of this work was to further evaluate the effect of temperature, moisture and time of enzymatic hydrolysis; and the effect of this treatment under selected conditions on the pressing stage and on product qualities. The best treatment condition with Olivex–Celluclast was 45 °C, 20% moisture over 9 h of treatment. When the extraction of the pre-treated borage meal was carried out by double pressing (20 min each) on preheated matter, 95% of the oil was recovered. The enzymatic treatment did not affect the oil quality and the residual meal was more valuable due to its lower fibre content[21].

Chemotaxonomic

A collection of 45 accessions (36 species, 20 genera) of the family Boraginaceae was evaluated for oil content, fatty acid composition, tocopherol content and composition. All the accessions contained γ-linolenic acid, the lowest content (0.7%) being found in *Cerinthe major* L. and the highest (24.4%) in *Borago officinalis* L. Three tocopherol profiles were characterized by the extremes of more than 90% of α-, δ- and γ-tocopherol, respectively. Fatty acids and tocopherols were suggested to have potential chemotaxonomic value in this family[22].

Chromatography

GC-MS

When subjected to capillary gas chromatography, picolinyl ester derivatives of fatty acids were shown to have as good chromatographic properties as the corresponding methyl esters. By using a capillary column of medium polarity (Supelcowax 10), excellent resolution with respect to chain length, degree of unsaturation and positional isomers was obtained without any serious problems with a disturbed background due to column bleed in the mass spectrometric interpretation of diagnostic ions. These features permitted a simple one-step procedure to be carried out for the characterization

of fatty acids with respect to molecular weight, number of double bonds and positional isomers. The usefulness of the technique for the identification of the fatty acids in borage seed oil (*Borago officinalis*) was demonstrated. In addition to γ-linolenic acid, the most important fatty acid in borage seed oil from a commercial standpoint, a further fourteen different fatty acids could be positively identified[23].

Gas chromatography–mass spectrometry analysis of seed Borago officinalis essential oil (EO) revealed the presence of 16 volatile components. β-Caryophyllene (26%) and p-cymene-8-ol (19.7%) represented the major components, while nonadecane (0.7%) and hexanol (0.7%) were the minor ones. The EO composition was characterized by higher abundance of oxygenated monoterpenes (27.7%), followed by sesquiterpenes (26%). Fatty acid composition showed the predominance of linoleic (35.4%), oleic (24.2%) and γ-linolenic (20.4%) acids. Polyphenols were analyzed by reversed-phase high-performance liquid chromatography after acid hydrolysis of phenolic acid esters. Six phenolic acids were identified in seed extract and rosmarinic acid was the predominant one with 1.65 mg/g dry matter weight equivalent to 33% of total phenolic acids[24].

Mineral Composition

Borage (*Borago officinalis*) is a plant commonly cultivated for consumption in Spain and other countries. The objective of this study has been to determine the proximate and mineral composition. The edible part of the plant corresponds to the basal leaf petioles. In this part, water was found to be the major constituent with an average value of 94%. Dry matter was mostly constituted by neutral detergent fiber, ash, and protein. Potassium was the major mineral element, reaching an even higher proportion than either fat or starch. Borage had also adequate levels of iron. The values obtained in this study show that borage should be included in the food composition tables within the leafy vegetable group[25].

CONCLUSION

Borago officinalis is an important medicinal plant of medeterrian region. Borage is an annual plant that grows wild in the Mediterranean countries and has been cultivated elsewhere. The primary chemical constituents of Borage leaves and flowers include mucilage, tannin, saponins, essential oil, alkaloid (pyrrolizidine), vitamin C, calcium and potassium. The plant reported to contain essential fatty acids, linoleic acid and gamma-linolenic acid. Literature survey reveals that Borage acts as a restorative agent on the adrenal cortex; in other words, it is believed to revive and renew the adrenal glands after a medical treatment of cortisone or steroids. There is a growing need for remedies that will aid the main system of medication i.e. allopathic system of medication, therefore its urgent need to do research on medicinal plants such as *Borago officinalis* to explore their medicinal value for the sake of mankind. It's suggested that the research work on *Borago officinalis* related to activities such as Cardiovascular, Anti-inflammatroy, gastrointestinal disorders may be explored.

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