Morphological, phytochemical and biological screening on three Egyptian species of *Fagonia*

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Abstract: Selection of the genus *Fagonia* (zygophyllaceae) attracted the attention of many scientists due to the presence of many active constituents of pharmaceutical importance. Vegetative and reproductive organs of three species of *Fagonia* growing wild in Egypt (*Fagonia arabica* L. var. *viscidissima* Maire, *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f var. *indica*) were described in this study. There were many morphological differences in vegetative organs of the three species; such as length, surface and color of the plant, stem (length of internodes) and leaves (length of petioles, length of stipules, leaf lamina, shape of leaflets lamina, leaflets size, leaflets apex). There were also many morphological differences in reproductive organs of these species; such as flowers (size, length of pedicel), sepals (shape, size, duration, aestivation, surface), petals (shape, size, duration, color, aestivation), gynaecium (length of styles), fruits (color, size, persistence of calyx on the fruit) and seeds (shape). Preliminary phytochemical screening on shoot systems of *Fagonia arabica* L. var. *viscidissima* Maire., *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f var. *indica* revealed the presence of many differences in the presence / absence character and amounts of carbohydrates and/or glycosides, saponins, tannins, sterols and/or triterpenoids, alkaloids, cardiac glycosides, flavonoids, chlorides, sulphates, irodoids, cyanogenic glycosides and coumarins in different parts of shoot systems of plants under investigation. Powdered samples of shoot systems of the studied species of *Fagonia* were investigated for their antioxidant activity. Antioxidant activity exerted by *F. bruguieri* (double integration area = 1.419 e + 06" = 14.19 e + 05") superior that of the other two species" *F. arabica* and *F. indica"* (double integration area = 9.691 e + 05 and 9.013 e + 05 respectively).
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Key words: *Fagonia*, morphology, phytochemical screening, antioxidant activity, ESR instrument.

Introduction

Genus *Fagonia* is represented in Egypt by 18 species (Tackholm, 1974), but it was represented by 15 species in Boulos, 2000. *Fagonia* L. occurs in warm and arid regions of all continents except Australia (El-Hadidi, 1966). Species of *Fagonia* were taxonomically and ecologically studied in different studies (Basto, 2002; Sharma and Gehlot, 2003; Mohamed *et al*., 2004; Sher *et al*., 2004; Carlquist, 2005 and Navaroo *et al.*, 2006). *Fagonia* species were extensively studied by many workers regarding their medicinal uses, since these plants were antitumor, antioxidant, analgesic, astringent, febrifuge and prophylactic against small-pox agents, species of *Fagonia* were also used for the treatment of cancer in the indigenous system, fever, asthma, urinary discharges, toothache, stomach troubles and kidney diseases (Ahsan *et al*., 2007 and Satpute *et al*., 2009). Species of *Fagonia* have been found to contain saponins (Abdel- Khalik *et al.*, 2001), alkaloids (Sharawy and Alshammari, 2009), terpenoids (Perrone *et al.*, 2007), sterols (Shoeb *et al.*, 1994), flavonoids (Ibrahim *etal.*, 2008), proteins and amino acids (Sharma *et al*., 2010), coumarins Zhan *et al.*, 2008), trace elements (Fatima *et al*., 1999).

Our work aims to spot on morphological, chemical, antioxidant activity differences between three species of *Fagonia (F. bruguieri, F. arabica* and *F.indica*).

Materials and Methods

Plant materials:

Samples of *Fagonia bruguieri* Dc, *Fagonia arabica* L. var. *viscidissima* Maire. and *Fagonia indica* Burm f var. *indica* were collected from Quatamia- Suez desert road (150 Km away from Suez City). All the samples were authenticated by comparison with voucher specimens in the herbarium of Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt, where voucher specimens were deposited.

Methods:

Morphological description of samples:

Samples of *F. arabica* L. *var. viscidissima* Maire. *F. bruguieri* Dc. and *F. indica* Burm f *var. indica (F. parviflora* Boiss.) were described according to keys of morphological description of Hutchinson, 1973 and Vasishta, 1986.

Preliminary phytochemical screening on shoot systems of *F. arabica* L.*var. viscidissima* Maire., *F. bruguieri* Dc. and *F.indica* Burm f *var. indica (F. parviflora* Boiss.):

Flavonodis (Mabry *et al.*, 1970); Anthraquinones (Farnsworth *et al.*, 1969); Tannins (Trease and Evans, 1978); Alkaloids (Shellard, 1957); Saponins (Hungund and Pathak, 1971); Carbohydrates and / or Glycosides (Stank *et al.*, 1963); Irodoids (Weiffering, 1966); Coumarins (Feigl, 1960); Chlorides and Sulphates (Islam *et al.*, 1993); Sterols and / or Triterpenes (Claus, 1967 and Schmidt, 1964); Cardiac glycosides (Balbaa *et al.*, 1981) and sublimable substances (Afifi, 1972). The previously mentioned substances were investigated for their presence / amount within different plant parts and different obtained calli of *Fagonia arabica* L. var. *viscidissima* Marie, *Fagonia indica* and *Fagonia bruguieri* Dc., to select the promised one regarding its chemical composition.

Antioxidant activity of shoot systems of *Fagonia arabica* L. *var. viscidissima* Maire., *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f *var. indica (F. parviflora* Boiss.):

Antioxidant activity of powdered samples of shoot systems of *F. bruguieri*, *F. arabica* and *F. indica* indicated by free radicals was estimated in the Central Lab Unit, National Research Centre, using ESR instrument (Electron Spin Resonance) under conditions described in Table (1).

Table(1): Conditions of determination of antioxidant activity of shoot systems of *F. bruguieri, F. arabica* and *F. indica* indicated by free radicals using ESR instrument (Electron Spin Resonance).

Microwave frequency (HZ)	**9.802 e + 09**
Microwave power (W)	**0.00202637**
Receiver gain	**60**

Results and Discussion

A- Morphological description of *Fagonia arabica* L. var. *viscidissima* Maire., *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f var. *indica*:

Morphological studies of *Fagonia arabica* L. var. *viscidissima* Maire. , *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f var. *indica* (Table:2 and Photos:1-3) showed that, *F. indica* is the tallest one of the three plants; *F. indica* is glabrous plant, while the two other species are glandular plants; *F. arabica* is dark green, while the two other species are pale green; stem erect in the case of *F. arabica*, procumbent in *F. bruguieri*, prostrate in *F. indica* ; *F. arabica* has long internodes (1.6 - 3 cm),while the length of internodes in *F. bruguieri* and *F. indica* are 0.5-2 cm and 0.9-2 cm respectively; length of *F. arabica* petioles reached to 0.6 cm for 3- foliolate ; all the leaves are 1-foliolate in case of *F. indica*, while *F. arabica* and *F. bruguieri* have 1 and 3 foliolate leaves; *F. indica* has the broadest leaflets, while *F. bruguieri* has the longest leaflets; leaf apex is mucronulate in the case of *F. indica* only; *F. indica* carries the largest flowers; calyx is ovate in case of *F. bruguieri*; *F. arabica* carries the longest sepals, while *F. indica* carries the broadest ones; sepals are caduceus in case of *F. arabica*, while persistent in *F. bruguieri* and *F. indica* (on young fruits only); aestivation of sepals is imbricate in case of *F. bruguieri* ; *F. arabica* has the longest persistent petals; aestivation of petals is quncuncial in *F. bruguieri* only, imbricate in case of the two other species ; fruits have erect beaks in case of *F. indica*, while fruits are pendulous in case of the two other plants ; *F. arabica* has the largest fruits, followed by *F. indica* and *F.bruguieri*; calyx is caducous in *F. arabica*, while persistent in *F. bruguieri* and *F. indica* (on young fruits only). These results were agreed with observations of other workers such as Tackholm, 1974 and Bolous, 2000.

Table (2): Morphological description of *Fagonia arabica* L. var. *viscidissima* Maire. , *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f var. *indica*.

Morphological characters	***Fagonia arabica* L. var. *viscidissima* Maire.**	***Fagonia bruguieri* Dc.**	***Fagonia indica* Burm f var. *indica* (*Fagonia parviflora* Boiss.)**
Whole plant			
1-Habit	Growing wild	Growing wild	Growing wild
2-Habitat	Perennial with woody base	Perennial with woody base	Perennial with woody base
3-Length of the plant	**20 - 55 cm**	**25 - 40 cm**	**45 - 55 cm**
4-Surface	**Glandular, pubescent, often with adhering sand grains**	**Glandular**	**Glabrous (only the juvenile parts hairy)**
5- Color	**Dark green**	**Pale green**	**Pale green**
A-Vegetative organs ***Roots**	Tap root	Tap root	Tap root
****Stems**	**Erect**, branched, woody, solid, terete, glandular, striate; nodes swollen, whitish green; internodes long (1.6 - 3 cm)	**Procumbent,** many branched, brittle, terete, glandular, striate; nodes swollen, whitish green; internodes short (0.5 - 2 cm)	**Prostrate or Ascending**, highly branched, woody, solid, nearly terete in cross – section, glandular, striate; nodes swollen, whitish green; internodes long (0.9- 2 cm)
*****Leaves**			
1-Mode of insertion	Cauline	Cauline	Cauline
2-Presence or absence of petioles	**Petiolate (0.2 cm for 1-foliolate, 0.6 cm for 3-foliolate)**	**Petiolate (0.1 cm)**	**Petiolate (short petioles "0.1 cm", with a distinct joint between petiole and plade).**
3-Presence or absence of stipules	**Stipular spines, longer than leaves (1-2 cm)**	**Stipular spines (0.5 – 2 cm), spreading or slightly recurved**	**Stipular spines, longer than leaves, of unequal length range between 0.9 –2.1cm', selender, acicular**
4-Phyllotaxy	Opposite (superposed)	Opposite (superposed)	Opposite (superposed)
5- Leaf lamina	**Compound, palmate, lower leaves 3-foliolate, the upper 1- foliolate or 3- foliolate**	**Compound, palmate, lower leaves 3-foliolate, the upper 1-foliolate**	**Compound, palmate, leaves all 1-foliolate**
6-Leaflets			
6-a-Shape of leaflets lamina	**Narrowly elliptic - oblong to linear**	**Oblong to lanceolate,**	**Narrowly elliptic to lanceolate**
6-b- Leaflets size	**T dimensions of 1-foliolate leaflets arare 0.2 z× long, 0.6 cm broad, while di dimensions of 3-foliolate lealeaflets are 0.0.3x0.9 cm**	**Leaflets 0.6 - 0.9 cm long, 0.5 - 2 cm broad**	**Leaflets 0.6 - 1×0.1- 0.3 cm**
6-c- Leaflets margin	Entire	Entire	Entire
6-d- Leaflets apex	**Mucronate**	**Mucronate**	**Mucronulate**
6-e- Leaflets base	Acute	Acute	Acute
6-f- Texture of lamina	Succulent (thick)	Succulent (thick)	Succulent (thick)
6-g- Leaflets surface	Glandular	Glandular	Glandular
6-h- Leaflets venation	Reticulate	Reticulate	Reticulate
6-i- Duration of leaflets	Persistent	Persistent	Persistent
B-Reproductive organs			
***Inflorescences**	Axillary, solitary	Axillary, solitary	Axillary, solitary

****Flowers**	**1.3- 1.5 cm** diam. at anthesis, ebracteate, pedicellate (0.5-0.6 cm long), complete, regular, perfect, actinomorphic, bisexual, hypogenous, pentamerous	**0.8 - 1 cm** diam. at anthesis, ebracteate, pedicellate (0.2-0.5cm), complete, regular, perfect, actinomorphic, bisexual, hypogenous, pentamerous	**1-1.2 cm** diam. at anthesis,ebracteate, pedicellate (0.4 - 0.6 cm), complete, regular, perfect, actinomorphic, bisexual, hypogenous, pentamerous
1-Calyx (Sepals) a- Number b- Shape c- Size d-Texture e- Duration f-Color g-Aestivation h-Surface	 5, free (Chorisepalous) Broadly lanceolate to ovate **3-4 × 10 - 12 mm** Succulent (thick) **Caducous** yellowish green **Quncuncial** **Glandular**	 5, free (Chorisepalous) Ovate **2×4 mm** Succulent (thick) **Persistent** yellowish green **Imbricate (ascending)** **Hairy**	 5, free (Chorisepalous) Lanceolate **0.3 cm long and 15 mm, wide** Succulent (thick) **Persistent on young fruit only** yellowish green **Quncuncial** **Hairy**
2-Corolla (Petals) a- Number b- Shape c- Size d-Texture e- Duration f-Color g-Aestivation h-Surface	 5, free, clawed (Choripetalous) **Broadly lanceolate to ovate** **8-9 mm** Herbaceous **Persistent** **Mauve to violet** **Imbricate (ascending)** Glabrous	 5, free, clawed (Choripetalous) **Ovate** **5-6 mm** Herbaceous **Caducous** **Pink** **Quncuncial** Glabrous	 5, free, clawed (Choripetalous) **Lanceolate Twice as long as sepals** **(0.6 cm)** Herbaceous **Caducous** **Mauve** **Imbricate (descending)** Glabrous
3-Androecium (Stamens) a-Number b-Shape of filaments c-Fixation of anthers to the filament	 10, free, distinct in two whorls, inserted on a disc Filaments filiform, without appendages Fixation of anthers to the filaments is of versatile type	 10, free, distinct in two whorls, inserted on a disc Filaments filiform, without appendages Fixation of anthers to the filaments is of versatile type	 10, free, distinct in two whorls, inserted on a disc Filaments filiform, without appendages Fixation of anthers to the filaments is of versatile type
4-Gynaecium (Carpels)	Ovary sessile, 5-celled, pentacarpellary, syncarpous, ovules 2 at the base of each cell (axile placentation), style persistent (1.5-2 mm long), united into a column, 5 angled, stigma simple, caducous	Ovary sessile, 5-celled, pentacarpellary, syncarpous, ovules 2 at the base of each cell (axile placentation), style persistent (2 mm long), united into a column, 5 angled, stigma simple, caducous	Ovary sessile, 5-celled, pentacarpellary syncarpous, ovules 2 at the base of each cell (axile placentation), style persistent (2 mm long), united into a column, 5 angled, stigma simple, caducous
***** Fruits** a-Color b- Shape c- Size d- Texture **e-** persistence of calyx on the fruit	 **Green** Septicidal capsule, pentagonous, deeply 5- lobed, splitting along the axis into 5 carpels, **pendulus** **5x6-7 mm** minutely pubscent **Caducous**	 **Pale green** Septicidal capsule, pentagonous, deeply 5- lobed, splitting along the axis into 5 carpels, **pendulus** **3x3- 4 mm** minutely pubscent **Persistent**	 **Pale green** Septicidal capsule, pentagonous, deeply 5- lobed, splitting along the axis into 5 carpels, **erect** **4x4 mm** minutely pubscent **Persistent on young fruit only**
******Seeds**	**Ovate, compressed flat, with mucilaginous coat**	**Ovate, tuberculate, compressed flat, with mucilaginous coat**	**Ovate or ovate-oblong, compressed flat, with mucilaginous coat**

Photo (2) : *F. bruguieri* (Surface view)

Photo (3): *F. indica* (Surface view).

Photo (1): *F. arabica* beside the wall surrounded by *Pharagmites australis* and *Bassia muricata* (surface view)

B-Preliminary phytochemical screening on shoot systems of *Fagonia arabica* L. *var. viscidissima* Maire. , *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f *var. indica (F. parviflora* Boiss.*):*

Preliminary phytochemical screening on shoot systems of *Fagonia arabica* L. *var. viscidissima* Maire. , *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f *var. indica (F. parviflora* Boiss.) (Tables: 3-5) revealed that, *F. arabica* leaves, stems and fruits have high amounts of saponins, while cardiac glycosides are present in high amounts in leaves and stems; fruits and flowers are devoid of tannins, while sulphates are not found in fruits, both stems and flowers are devoid of irodoids; the remaining constituents are found in the remaining parts of the four parts of shoot systems of the plant in week to moderate amounts, tannins are present in high amounts in flowers, all parts of shoot systems of *F. bruguieri* are devoid of anthraquinones; leaves, flowers and fruits are devoid of saponins; stems are devoid of chlorides and sulphates; fruits and stems are devoid of irodoids; the remaining constituents are found in the remaining parts of the four parts of shoot systems of the plant in week to moderate amounts. *F. indica* stems and fruits have high amounts of saponins; leaves and flowers have high amounts of tannins; leaves, flowers and fruits have high amounts of cardiac glycosides; stems are devoid of irodoids; the remaining constituents are found in the remaining parts of the four parts of shoot systems of the plant in week to moderate amounts. Regarding complete shoot systems of *Fagonia arabica* and *Fagonia indica* they contain high amounts of saponins and cardiac glycosides so the similarity between them is not only in morphological characters but also in phytochemical screening . While *F. bruguieri* shoot system contains high amount of tannins, *Fagonia indica* shoot system contains high amount of tannins also, so the similarity between them is not only in morphological characters but also in phytochemical screening.

These results agreed with others who found that species of *Fagonia* contain saponins (Abdel-Khalik *et al.*, 2001), alkaloids (Sharawy and Alshammari, 2009), terpenoids (Perrone *et al.*, 2007), sterols (Shoeb *et al.*, 1994), flavonoids (Ibrahim *et al.*, 2008), proteins and amino acids (Sharma *et al.*, 2010), coumarins (Zhan *et al.*, 2008), trace elements (Fatima *et al.*, 1999).

Table (3): Preliminary phytochemical screening on shoot systems of *F. arabica* (Stems/ Leaves / Flowers/ Fruits).

Experiment	Stems	Leaves	Flowers	Fruits	Shoot system
1- Carbohydrates and / or Glycosides	+	+	+	+	+
2- Saponins	++	+++	+	++++	++++
3- Tannins	+	++	-	-	+
4- Sterols and / or Triterpenoids	+	+	+	+	+
5- Alkaloids	+	+	+	+	+
6- Cardiac glycosides	++	+++	+	+	+++
7- Flavonoids	+	+	+	+	+
8- a- Chlorides	+	+	+	+	+
8-b- Sulphates	+	+	+	-	+
9- Anthraquinones	+	+	+	+	+
10- Irodoids	-	+	-	+	+
11- Cyanogenic glycosides	+	+	+	+	+
12- Coumarins	+	+	+	+	+

Table (4): Preliminary phytochemical screening on shoot systems of *F. bruguieri* (Stems/ Leaves / Flowers/ Fruits).

Experiment	Stems	Leaves	Flowers	Fruits	Shoot system
1- Carbohydrates and / or Glycosides	+	+	+	+	+
2- Saponins	+	-	-	-	+
3- Tannins	+	-	++	+	++
4- Sterols and / or Triterpenoids	+	+	+	+	+
5- Alkaloids	+	+	+	+	+
6- Cardiac glycosides	+	+	+	+	+
7- Flavonoids	+	+	+	+	+
8- a- Chlorides	-	+	+	+	+
8- b- Sulphates	-	+	+	+	+
9- Anthraquinones	-	-	-	-	-
10- Irodoids	-	+	+	-	+
11- Cyanogenic glycosides	+	+	+	+	+
12- Coumarins	-	+	+	+	+

Table (5): Preliminary phytochemical screening on shoot systems of *F. indica* (Stems/ Leaves / Flowers/ Fruits).

Experiment	Stems	Leaves	Flowers	Fruits	Shoot system
1- Carbohydrates and / or Glycosides	+	+	+	+	+
2- Saponins	+++	++	+	++++	++++
3- Tannins	++	++++	+++	+	++++
4- Sterols and / or Triterpenoids	+	+	+	+	+
5- Alkaloids	+	+	+	+	+
6- Cardiac glycosides	+	+++	++	++	+++
7- Flavonoids	+	+	+	+	+
8- a- Chlorides	+	+	+	+	+
8- b- Sulphates	+	+	+	+	+
9- Anthraquinones	+	+	+	+	+
10- Irodoids	-	+	+	+	+
11- Cyanogenic glycosides	+	+	+	+	+
12- Coumarins	+	+	+	+	+

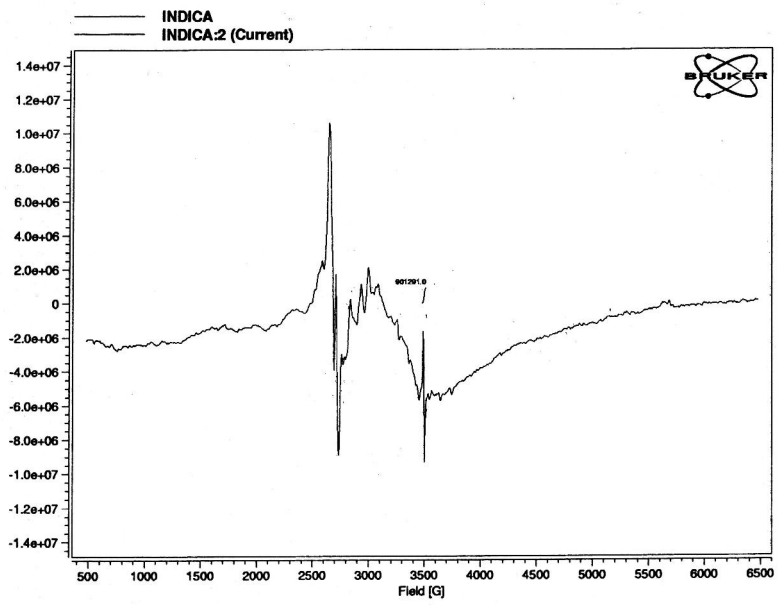
- = The active principle under investigation was not found.
+ = Weak to moderate amounts of the active principle under investigation was found.
++, +++ and ++++ = high amounts of active principle under investigation were found.

***C*-Antioxidant activity of *Fagonia arabica* L. *var. viscidissima* Maire., *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f *var. indica* (*F. parviflora Boiss.*):**

Data in Table (6) and Figures (1-3) revealed that, *F. bruguieri* was the most antioxidant agent, followed by *F. arabica*, while *F. indica* was the least antioxidant agent. Results of *F. indica* and *F. arabica* shoot systems regarding antioxidant activity revealed that, they are nearly similar this may be due to their similarities regarding morphological and phytochemical characters. These results agreed with Rawal *et al.*, 2004 who found that *Fagonia cretica* has antioxidant contents that makes it a potential choice as therapeutic neuroprotective agents. So our previous and following studies has/will directed to using tissue culture technique for producing (*in vitro)* active constituents that made these plants highly antioxidant agents.

Table (6): Antioxidant activity of shoot systems of *Fagonia arabica* L. *var. viscidissima* Maire. , *Fagonia bruguieri* Dc. and *Fagonia indica* Burm f *var. indica* (*F. parviflora Boiss.*).

Species	Double integration area
F. bruguieri	**1.419 e + 06 (= 14.19 e + 05)**
F. arabica	**9.691 e + 05**
F. indica	**9.013 e + 05**



TITLE INDICA:2

DATASET TYPE Manipulated 1D Real, Intensity(Field)

AXIS STRUCTURE Field: indexed

AXIS DATA FORMAT Intensity: double
Field: double

AXIS RANGE Field [G]: 3477.07 to 3512.26, 7 pts
width 35.1906, center 3494.66

AVAILABLE PARAMETERS

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Field Mod. Frequency [Hz]	100000
Microwave Frequency [Hz]	9.80288e+09
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MANIPULATION HISTORY (for complete history, use 'ddBES3T')

Input Dataset 'INDICA'

Operations Performed prInteg
prInteg

Last Processing Report:

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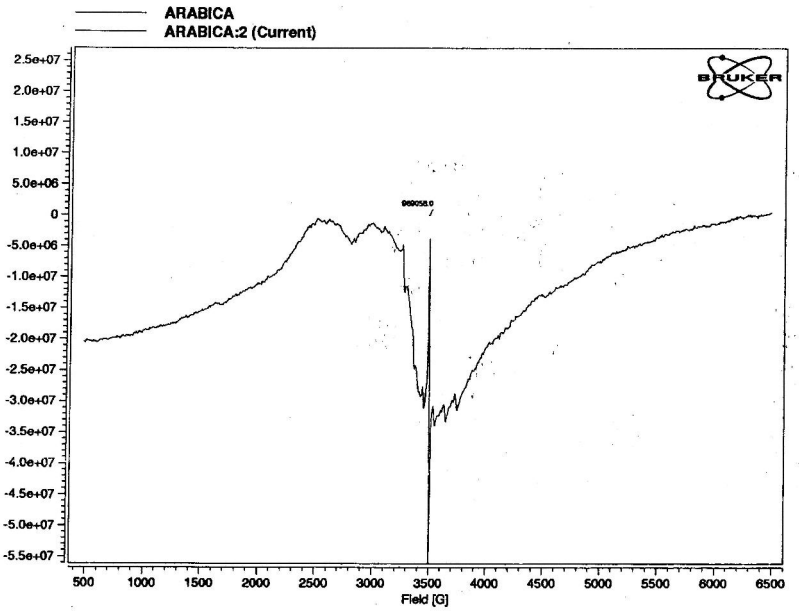
Figure (1)



TITLE ARABICA:2

DATASET TYPE Manipulated 1D Real, Intensity(Field)

AXIS STRUCTURE Field: indexed

AXIS DATA FORMAT Intensity: double
Field: double

AXIS RANGE Field [G]: 3477.07 to 3512.26, 7 pts
width 35.1906, center 3494.66

AVAILABLE PARAMETERS

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Microwave Power [W]	0.00202637
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Receiver Time Constant [s]	0.00512
Receiver Phase [deg]	0.0
Receiver Harmonic	1
Receiver Offset [%FS]	0.0

MANIPULATION HISTORY (for complete history, use 'ddBES3T')

Input Dataset 'ARABICA'

Operations Performed prInteg
prInteg

Last Processing Report:

xmin	xmax	area
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Figure (2)

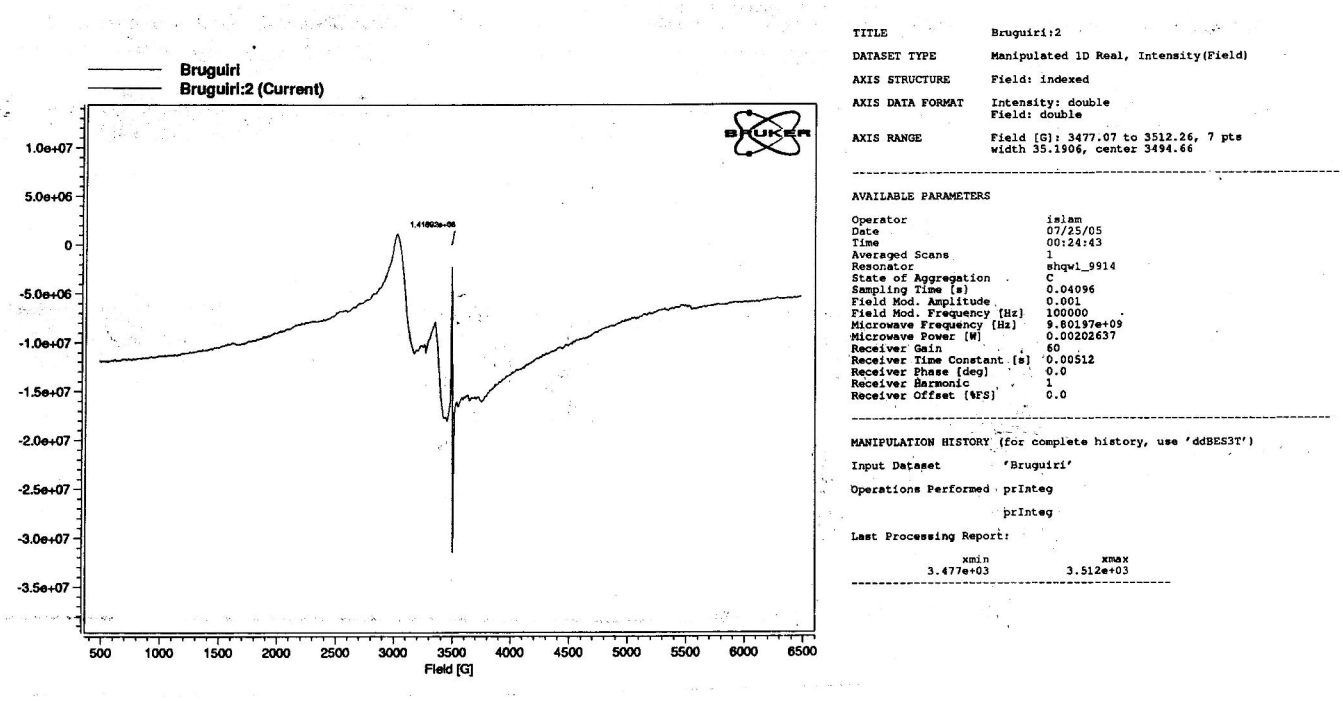

Figure (3)

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