THE EXTRACT OF *EUONYMUS ALATUS* SHOOT

by

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Euonymus alatus, is a common plant throughout China. Studies have shown that Euonymus alatus. can be used not only as an ornamental plant but also in medicine. In this paper, the active constituents of the Euonymus alatus. shoots collected in the field were studied to explore their development process and utilization value. By FT-IR, GC-MS, and TGA-DTG analysis of Euonymus alatus. shoot extract, it was found that Euonymus alatus. contains a large number of chemicals useful in the medical, spice, and chemical industries. It was also observed that Euonymus alatus. can be used as a bioenergy source with high utilization value.

Key words: *euonymus alatus, extract, bioenergy, FT-IR analysis, GC-MS analysis, TDA-DTG analysis*

Introduction

With increased global energy consumption, bio-energy has attracted significant attention for its clean and renewable advantages. This paper explores the utilization potential of *Euonymus alatus (Thunb.) Sieb.* branches in high value-added industries and provides a scientific basis for studying the uses of *Euonymus alatus (Thunb.) Sieb.*

Euonymus autus (Thunb.) Sieb is a shrub with 2-4 rows of broad-leaved wood [1]. This plant is a common ornamental tree [2]. It has plants all over China and is rich in resources. Many studies have shown that rutin, kaempferol and quercetin extracted from Euonymus have anti-oxidation effects and have good curative effect on diabetes [2-4]. *Euonymus alatus* also has antibacterial, anti-inflammatory, treatment of tumors, regulation of blood circulation, prevention of hyperlipidemia and other effects [5-7]. However, there is less attention and research on the branch of *Euonymus alatus*, in which the complete utility of plants has not yet been realized. In order to make better use of this bioenergy, we analyzed the composition of *Euonymus alatus*. by FT-IR, GC-MS and thermogravimetric analysis. It provides a theoretical basis for the high value-added development and utilization of *Euonymus alatus*.

Material and methods

Materials

The *Euonymus alatus (Thunb.) Sieb* samples were from the forest area of Luanchuan County, Henan Province. The collected *Euonymus alatus.* shoots were pulverized into

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powder form. Then, the fine powder was sieved through 120-140 mesh, freeze-dried, and set aside.

Ethanol and phenyl alcohol extraction

Put 10 mL sample powder into a round bottom flask, 300 mL of an ethanol solution (W2-1) and a mixed solution of phenyl-alcohol (W2-2) were added, respectively. The W2-1 was placed in a water bath and heated at 81 °C for four hours, and W2-2 was placed in a constant temperature water bath at 56 °C for four hours. After the solution was cooled, it was filtered under vacuum, and the liquid obtained by filtration was concentrated by rotary evaporation to 20 mL [8-10].

The FT-IR analysis

The infrared spectroscopy was carried out by means of a FT-IR to detect a mixture of the sample powder and the potassium bromide which were sufficiently ground and pressed [11, 12].

The GC-MS analysis

The sample was injected into 10 μL of ethanol extract. The specifications of the elastic quartz capillary column are 30 m × 20 μm × 0.25 μm using a high purity helium as the carrier gas and a column flow rate set to 1 mL/min. The split ratio is 2:1 [13]. The temperature program of the GC starts at 50 °C, then heated to 130 °C at 5 °C/min without stopping, subsequently heated to 180 °C at a rate of 2 °C/min without stopping, and finally the rate is increased to 30 °C/min for heating to 300 ºC for 5 minutes [13-15].

The TGA-DTG analysis

The Euonymus powder was analyzed using a thermogravimetric analyzer (TGA Q50 V20.8 Build 34) [16]. The equilibrium gas is nitrogen and the release rate is 20 mL/min [17]. The temperature program of TG was started from 30 °C, and was heated to 850 ° C at a rate of 10 ° C/min, 20 ° C/min and 40 °C/min, respectively, then kept at 850 °C for 5 minutes [18, 19]. Get its TGA and DTG curves.

Results and discussion

The FT-IR spectroscopy analysis

The functional group types of *Euonymus alatus.* extract can be analyzed by the relationship between the infrared spectrum and molecular structure. According to fig. 1, there is a broad and strong absorption peak at 3400 cm^{-1} in the infrared spectrum. So, the extract may contain alcohol or phenolic substances. There is a strong and sharp double absorption peak at 3000-2700 cm^{-1}, it is speculated that the *Euonymus alatus.* extract may contain an aldehyde group. There are multiple absorption peaks between 1740 and 1400 cm^{-1}. That is due to the stretching vibration of the carbon-oxygen double bond, so the *Euonymus alatus.* extract may contain acids, aldehydes, or esters. There are many absorption peaks in the 1400-1000 cm^{-1} region, and the extract may contain hydrocarbons, ethers, lipids, or aromatic heterocycles [20].

Temperament analysis of ethanol extract

According to the analysis of GC-MS in fig. 2, the ethanol extract of *Euonymus alatus.* contains 17 kinds of chemical substances, among which Methyl 3-bromo-1-adamantaneacetate (41.90%), 2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R (3.alpha.,

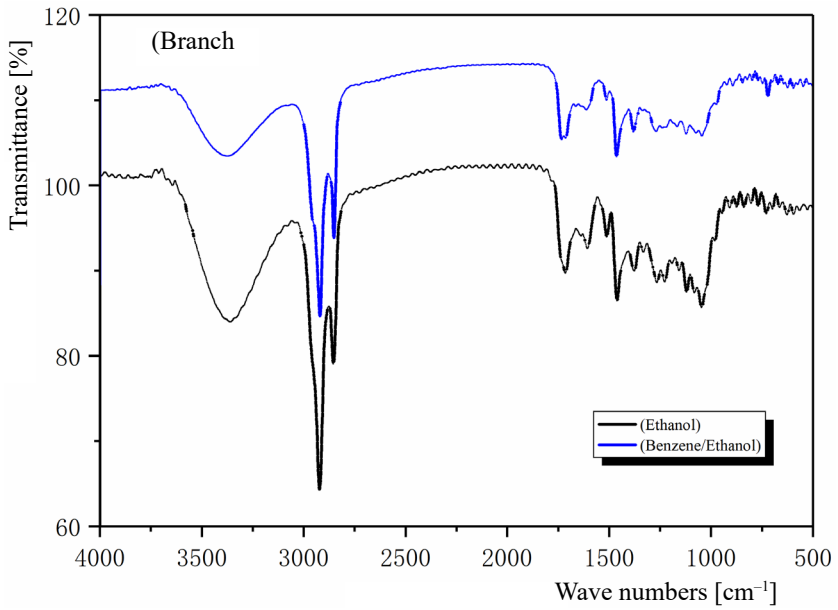

Figure 1. Infrared spectrum of *Euonymus alatus*

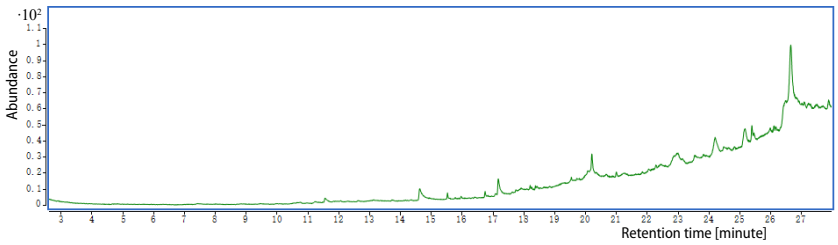

Figure 2. Total ion chromatography of ethanol extract from *Euonymus alatus*

5a.alpha., 9.alpha., 9a.alpha.)] (9.42%), (2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl) octahydronaphthalen-1(2H)-one (8.99%), Cyclopenteno [4.3-b] tetrahydrofuran, and 3-[(4-methyl-5-oxo-3-phenylthio)tetrahydrofuran-2-yloxymethylene]-(6.86%) are most abundant.

As can be seen from tab. 1, the phenyl alcohol extract of *Euonymus alatus*. primarily contains 26 substances, of which .gamma.-Sitosterol (30.94%), ethenyldecahydro-2-hydroxy-. alpha.,2,5,5, 8a-pentamethyl-, [1R-[1.alpha.(R*),2.beta.,4a.beta.,8a.Alpha.]] (11.03%), tetramethyl-6-ethenye-10, and 14-dimethylene-pentadec-4-enyl) cyclohexane (10.73%) are the most widely observed.

The GC-MS analysis of the phenyl alcohol extract of *Euonymus alatus*. shoots obtained a variety of substances, some of which have high utility value. Among them, oleic acid can be used in soaps, lubricants, flotation agents, ointments, and oleates [21]. 9,12-Octadecadienoic acid (Z, Z) can be used as drying oil in paints and varnishes and in the manufacturing of pharmaceuticals. Cedrol is a sesquiterpene alcohol widely used in woody, spicy and oriental flavors 23]. It is also widely used as a flavoring agent for disinfectants and hygiene products [22, Dibutyl phthalate is a commonly used plasticizer to improve the performance of polymers, reduce production costs, and improve production efficiency [24].

Table 1. Results of GC-MS analysis of the components of the phenyl alcohol extract of *Euonymus alatus* bark

No.	Retention time [minute]	Relative content [%]	Compound name
1	3.56	0.36	2-Phenethyl-.beta.-phenylpropionate
2	11.6	0.46	Undec-10-ynoic acid, butyl ester
3	11.9	0.47	Phenol, 3,5-bis(1,1-dimethylethyl)-
4	14.62	3.99	(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol
5	15.52	1.06	2H-Benzocyclohepten-2-one, decahydro-9a-methyl-, trans-
6	15.97	0.49	2-Propen-1-ol, 3-(2,6,6-trimethyl-1-cyclohexen-1-yl)-
7	16.44	0.37	4-(1,3,3-Trimethyl-bicyclo[4.1.0]hept-2-yl)-but-3-en-2-one
8	16.74	0.52	Oleic Acid
9	16.83	3.09	Dibutyl phthalate
10	17.06	0.35	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-
11	17.18	3.26	trans-Sinapyl alcohol
12	17.73	0.38	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-
13	18.2	0.41	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
14	18.26	0.37	Isolongifolol
15	18.37	0.36	9,12-Octadecadienoic acid (Z,Z)-
16	18.41	0.61	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-
17	20.08	0.48	Retinal
18	20.21	3.06	Cedrol
19	20.64	0.78	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
20	20.78	0.57	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
21	21	0.63	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
22	22.05	0.35	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
23	22.29	0.31	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
24	22.41	0.5	2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R-(3.alpha.,5a.alpha.,9.alpha.,9a.alpha.)]-
25	22.72	0.45	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
26	22.95	2.71	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
27	23.15	0.45	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
28	23.54	0.63	2,2-Dimethyl-6-methylene-1-[3,5-dihydroxy-1-pentenyl]cyclohexan-1-perhydrol
29	23.85	0.93	2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R-(3.alpha.,5a.alpha.,9.alpha.,9a.alpha.)]-

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Table 1. (Continuation)

No.	Retention time [minute]	Relative content [%]	Compound name
30	24.96	1.21	2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R-(3.alpha.,5a.alpha.,9.alpha.,9a.alpha.)]-
31	25.18	1.34	2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R-(3.alpha.,5a.alpha.,9.alpha.,9a.alpha.)]-
32	25.4	3.61	trans-Geranylgeraniol
33	25.47	2.07	(2R,3R,4aR,5S,8aS)-2-Hydroxy-4a,5-dimethyl-3-(prop-1-en-2-yl)octahydronaphthalen-1(2H)-one
34	25.99	0.57	Benzoic acid, 4-methyl-2-trimethylsilyloxy-, trimethylsilyl ester
35	26.13	1.08	Cedran-diol, (8S,14)-
36	26.18	1.23	2H-3,9a-Methano-1-benzoxepin, octahydro-2,2,5a,9-tetramethyl-, [3R-(3.alpha.,5a.alpha.,9.alpha.,9a.alpha.)]-
37	26.67	30.94	.gamma.-Sitosterol
38	26.9	11.03	1-Naphthalenepropanol, .alpha.-ethenyldecahydro-2-hydroxy-.alpha.,2,5,5,8a-pentamethyl-, [1R-[1.alpha.(R*),2.beta.,4a.beta.,8a.alpha.]]-
39	27.11	0.6	2,6-Dihydroxyacetophenone, 2TMS derivative
40	27.29	1.6	2-[3-(4-tert-Butyl-phenoxy)-2-hydroxy-propylsulfanyl]-4,6-dimethyl-nicotinonitrile
41	27.47	5.59	Cedran-diol, (8S,14)-
42	27.88	10.73	1,1,6-trimethyl-3-methylene-2-(3,6,9,13-tetramethyl-6-ethenye-10,14-dimethylene-pentadec-4-enyl)cyclohexane

The TGA-DTG analysis

The TGA reflects the thermal stability of the material [25]. It is necessary to understand the thermal stability of the substance, which will be helpful for further development and utilization. It can be analyzed from fig. 3 that *Euonymus alatus (Thunb.)Sieb.* has three stages of weight loss, and the expression patterns of the different testing rates are basically the same. The first stage is between 100-200 ℃, and the weight loss rate is around 16%. The mass loss rate is about 15% in the second stage, and the temperature is between 250-500 °C. The third stage mass loss rate is about 15%, and the temperature is between 660 °C and 740 °C, after three stages of weight loss, the sample quality did not change significantly [26].

As the rate of temperature increased, the maximum weight loss rate of the sample increased. When the heating rate was increased from 10 ℃/min, to 20 ℃/min, and finally

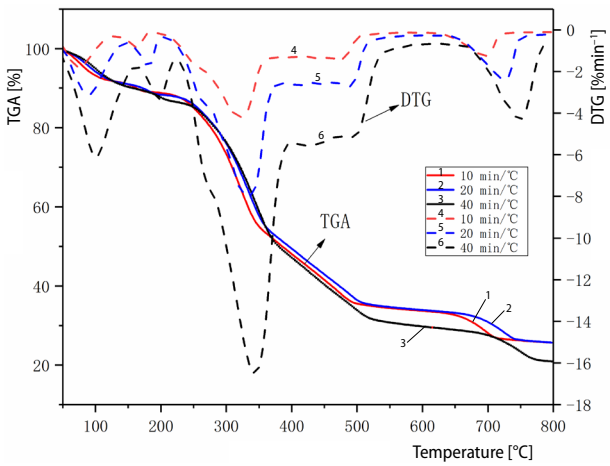

Figure 3. The TGA-DTG curve of *Euonymus alatus* shoot at 10 ℃/min, 20 ℃/min and 40 ℃/min

to 40 °C/min, the maximum weight loss rate of the samples was 4 %/min, 7.5 %/min, and 16.7 %/min, respectively [27].

Conclusions and discussion

According to the FT-IR analysis of the absorption peaks of the extract combined with GC-MS and TGA-DTG analysis, the *Euonymus alatus* shoot contains many active substances. In FT-IR, the absorption peaks were primarily distributed at 3400 cm^{-1}, 3250 cm^{-1}, 3000 cm^{-1}-3750 cm^{-1} and 1800 cm^{-1}-500 cm^{-1}. The GC-MS analysis showed that there were 17 chemical substances in the ethanol extract of *Euonymus alatus* and 26 substances in the phenyl alcohol extract. It can be seen that *Euonymus alatus* has potential for use in the medical, spice, chemical, and other fields. However, there are still some substances that require further scientific research as their value-added functions are still unknown.

In summary, *Euonymus alatus* is a sustainable biological resource. The research in this paper provides a theoretical basis for the highly value-added development and utilization of *Euonymus alatus.*

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