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Polyacetylenic compounds from *Atractylodes* rhizomes

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ABSTRACT

Objectives : *Atractylodes* rhizomes, which have been widely used to treat gastrointestinal disorders, consist of numerous chemical compounds. Polyacetylenes are the parts of characteristic compounds of importance required to understand the therapeutic properties of *Atractylodes* rhizomes. It is necessary to understand the physicochemical and pharmacological properties of polyacetylenes in the Atractylodes rhizomes.

Methods : The literatures from 1970 to January 2016 were searched using Korean and international electronic databases. The chemical structures of polyacetylenes were drawn by structure-drawing software.

Results : The reported polyacetylenes were classified by their chemical skeletons and original resources, and their physicochemical and pharmacological features were discussed. Polyacetylenes with skeletal moieties were reported, such as diene-diyne types (two double and two triple carbon-bonds), triene-diyne types (three double carbon bonds and two triple carbon bonds), and monoene-diyne types (one double carbon bonds and two double carbon bonds), with various functional groups. Atractylodin was most frequently reported from many *Atractylodes* species. Atractylodin-related polyacetylenes showed chemical instability in both high and freezing temperatures. Processing of the Atractylodes rhizomes by stir-frying with bran could affect the contents of polyacetylenes and their bioavailability *in vivo*. Several polyacetylenes showed structure-related anti-inflammatory activities and gastrointestinal activities.

Conclusion : Polyacetylene compounds in Atractylodes rhizomes were based on three chemical backbones and showed diverse physicochemical and pharmacological features. The present study provides structural, physicochemical, and pharmacological information of polyacetylene from *Atractylodes* rhizomes. This information provides fundamental data for further research.

Key words : *Atractylodes* rhizome, polyacetylene, chemical structure, physicochemical properties, pharmacological properties

Ⅰ. Introduction

The dried rhizomes of genus Atractylodes (family: Asteraceae) plants, which have been classified into "Baekchul" and "Changchul", have been used to treat wind-phlegm-caused headache, diarrhea, and phlegm-induced digestive disorders[1]. In the Korean pharmacopeia, four species of *Atractylodes* rhizomes are used as Changchul or Baekchul: the rhizomes of *A. lancea* DC. (AL) and *A. chinensis* Koidz. (AC) are registered as Changchul; and those of *A. macrocephala* Koidz. (AM) and *A. japonica* Koidz.(AJ) are registered as Baekchul[2].

Atractylodes rhizomes contain diverse chemical compounds such as polyacetylenes, sesquiterpenes, and essential oils, and those compounds are thought to exert the pharmacological effect of the rhizomes[3-5]. Of those compounds, polyacetylenes and sesquiterpenes most occurred in Atractylodes rhizomes; however, the occurrences of compounds and the presentation of chemical structures were insufficiently arranged by each *Atractylodes* species[6].

Polyacetylene (or polyethyne by the IUPAC name) consists of polymerization of acetylene, a alkyne-type

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hydrocarbon, with a chain of olefin groups repeated, and possesses long carbon chains with alternating single and double bonds of either *cis* or *trans* geometry[7]. Hydrogen atoms can be attached at conjugated carbon atoms and they can also be replaced by a functional group[8].

Therefore, in this study, the chemical structures of polyacetylenes were classified by their chemical backbones and the species of genus *Atractylodes* where the compounds were contained was presented. Additionally, phytochemical characteristics of those compounds were also discussed through extraction or processing. Thereafter, their pharmacological activities could be understood.

Ⅱ. Materials and methods

1. Paper search

The literatures from 1970 to January 2016 were searched using a variety of electronic bibliographic databases: Korean databases, including the Korea Education and Research Information Service, National Discovery for Science Leaders, the Korean Studies Information Service System, and Korea Institute of Science and Technology Information, Korean Traditional Knowledge Portal, Oriental Medicine Advanced Searching Integrated System, KoreaMed, eArticle, and DBpia; Chinese databases including the China National Knowledge Infrastructure; Japanese databases including Citation Information from the National Institute of Informatics and Japan Science and Technology Information Aggregator, Electronic; and electronic global databases including PubMed, Web of Science, ScienceDirect, and Google Scholar.

2. Search terms and inclusion criteria

The search terms used in the present study were "창출", "백출", "蒼朮", "白朮", "苍术", "白术", "Changchul", "Baekchul", "Changzhu", "Baizhu", "Sojutsu", "Byakujutsu", "Atractylodes rhizome", "Atractylodes macrocephala", "Atractylodes japonica", "Atractylodes lancea", "Atractylodes chinensis", "Atractylodes ovata", and "Atractylodes koreana"

Studies in accordance with the following criteria were included: 1) original articles (not review articles; 2) medicinal part is the rhizome of *Atractylodes* plant; 3) polyacetylenes were isolated or analyzed using analytical tools from *Atractylodes* rhizomes; 4) chemical names including International Union of Pure and Applied Chemistry (IUPAC) names or chemical structures of polyacetylenes were presented; and 5) no language limitation.

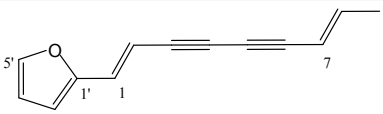
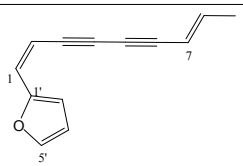
Chemical structures were manually drawn using ChemDraw software (v. Ultra 10.0; Cambridge Soft, Cambridge, MA, USA). If necessary, author amended incorrect chemical structures or names in the studies.

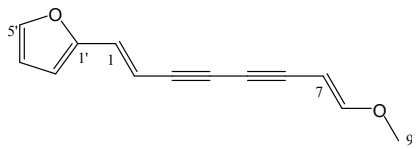
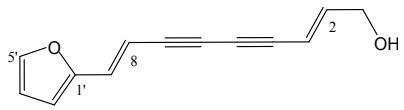
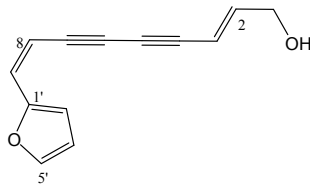
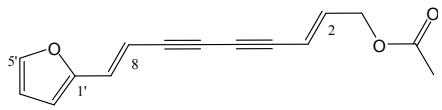
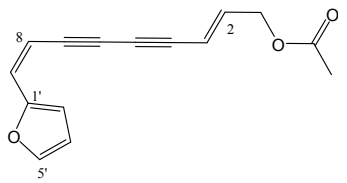
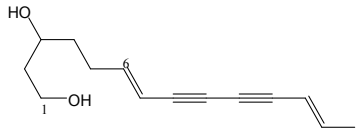
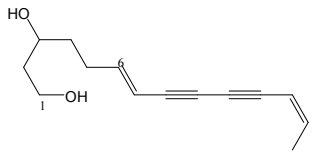
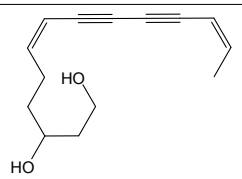
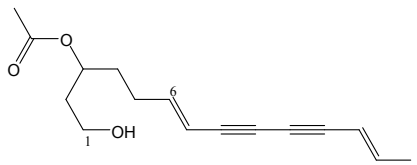
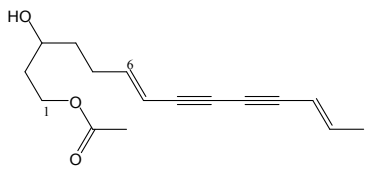
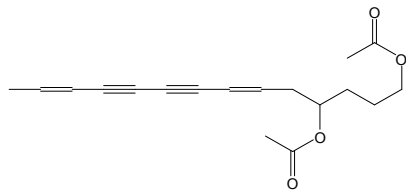
Ⅲ. Results and discussion

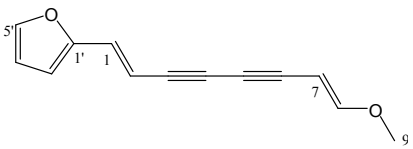
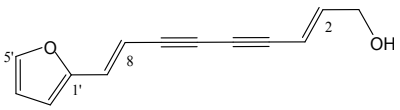
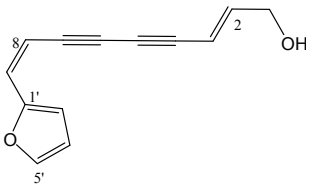
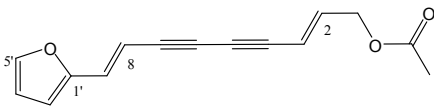
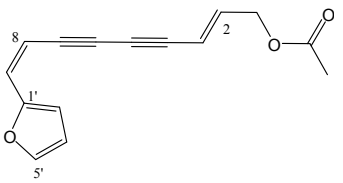
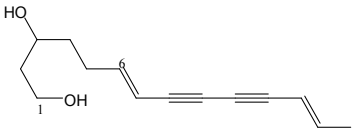
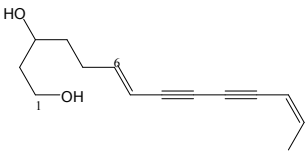
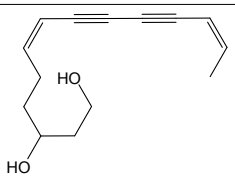
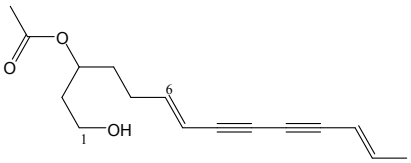
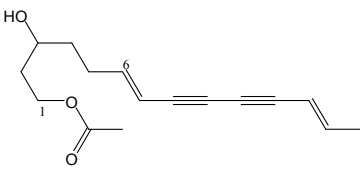
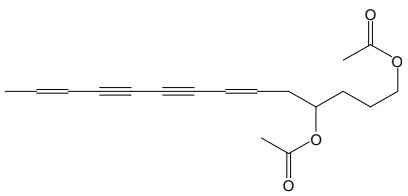
1. Diene-diyne types of Atractylodes polyacetylenes

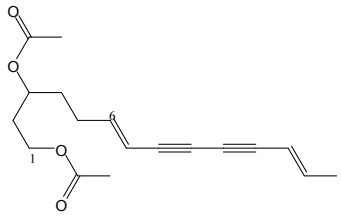
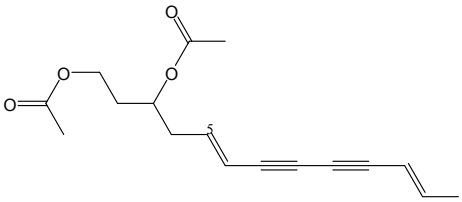
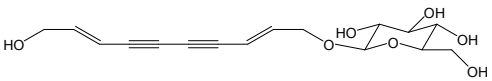
Polyacetylenes of diene-diyne types were classified into furan-ring-attached, alcohol-attached, acetyl-attached, and two more functional groups-attached compounds. Seven atractylodin-related acetylenes, which contained a furan-ring at the terminal carbon, consisted of nine carbons. Another seven polyacetylenes comprised 14 carbons with double bonds at C-6 and C-12, and triple bonds at C-8 and C-10. Diacetyl atractylodiol was acetylene with thirteen carbons and (2E,8E)-decadiene-4,6-diyne-1,10-diol-1-O-β-D-glucopyranoside was the only polyacetylene which consisted of 10 carbons and glucopyranose. Of those compounds, atractylodin was most reported in previous reports and was contained in AL, AC, AJ, and AK (*A. koreana*). However, no diene-diyne types were reported to be contained in AM (Table 1).

Table 1: Polyacetylenes of diene-diyne types.

Name	Structure	Origin
Atractylodin 2-[(1E,7E)-nona-1,7-dien-3,5-diynyl]furan		AL[9-36] AC[19,20,27,28,31-33,36-49] AJ[28,36] AK[28,34,36,38]
(1Z)-Atractylodin 2-[(1Z,7E)-nona-1,7-dien-3,5-diynyl]furan		AL[49,50]

Name	Structure	Origin
9-Nor-atractylodin		AL[13]
Atractylodinol (2E,8E)-9-(furan-2-yl)nona-2,8-dien-4,6-diyn-1-ol		AL[9,17,18,30,31,33] AC[31,33,37,41]
(1Z)-Atractylodinol (2E,8Z)-9-(furan-2-yl)nona-2,8-dien-4,6-diyn-1-ol		AL[50,51]
Acetylatractylodinol [(2E,8E)-9-(furan-2-yl)nona-2,8-dien-4,6-diynyl] acetate		AL[12,17,18,30,31,33] AC[31,33, 41, 47]
(1Z)-Acetylatractylodinol [(2E,8Z)-9-(furan-2-yl)nona-2,8-dien-4,6-diynyl] acetate		AL[49]
(6E,12E)-Tetradecadiene-8,10-diyne-1,3-diol		AC[51]) AJ[52,53] Atractylodes rhizomes[54]
(6E,12Z)-Tetradecadiene-8,10-diyne-1,3-diol		AC[55]
(6Z,12Z)-Tetradecadiene-8,10-diyne-1,3-diol		AC[55]
(6E,12E)-3-Acetoxytetradeca-6,12-dien-8,10-diyn-1-ol		AC[51])
(6E,12E)-1-Acetoxytetradeca-6,12-dien-8,10-diyn-3-ol		AC[51]
1,4-Acetoxytetradeca-6,12-diene-8,10-diyne		AJ[56]

Name	Structure	Origin
9-Nor-atractylodin		AL[13]
Atractylodinol (2E,8E)-9-(furan-2-yl)nona-2,8-dien-4,6-diyn-1-ol		AL[9,17,18,30,31,33] AC[31,33,37,41]
(1Z)-Atractylodinol (2E,8Z)-9-(furan-2-yl)nona-2,8-dien-4,6-diyn-1-ol		AL[50,51]
Acetylatractylodinol [(2E,8E)-9-(furan-2-yl)nona-2,8-dien-4,6-diynyl] acetate		AL[12,17,18,30,31,33] AC[31,33, 41, 47]
(1Z)-Acetylatractylodinol [(2E,8Z)-9-(furan-2-yl)nona-2,8-dien-4,6-diynyl] acetate		AL[49]
(6E,12E)-Tetradecadiene-8,10-diyne-1,3-diol		AC[51]) AJ[52,53] Atractylodes rhizomes[54]
(6E,12Z)-Tetradecadiene-8,10-diyne-1,3-diol		AC[55]
(6Z,12Z)-Tetradecadiene-8,10-diyne-1,3-diol		AC[55]
(6E,12E)-3-Acetoxytetradeca-6,12-dien-8,10-diyn-1-ol		AC[51])
(6E,12E)-1-Acetoxytetradeca-6,12-dien-8,10-diyn-3-ol		AC[51]
1,4-Acetoxytetradeca-6,12-diene-8,10-diyne		AJ[56]

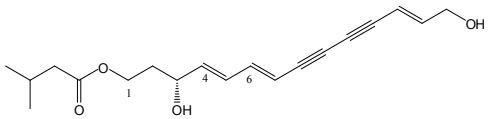
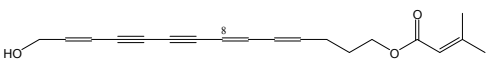
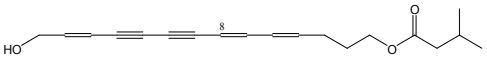
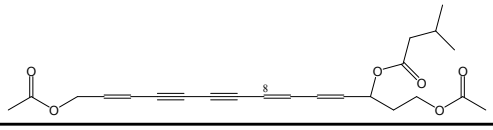
Name	Structure	Origin
(6E,12E)-Tetradecadiene-8,10-diyne-1,3-diol diacetate		AC[51] AJ[35,52-54,57,58]
Diacetyl atractylodiol [(5E,11E)-3-acetyloxytrideca-5,11-dien-7,9-diynyl]acetate		AJ[59,60]
(2E,8E)-Decadiene-4,6-diyne-1,10-diol 1-O-β -D-glucopyranoside		AL[61]

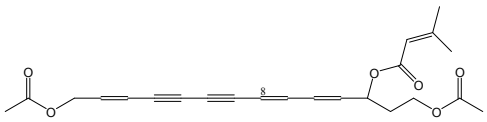
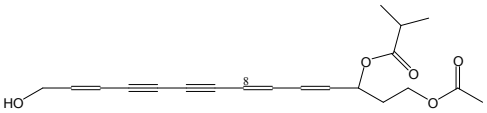
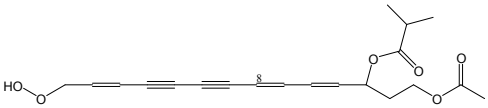
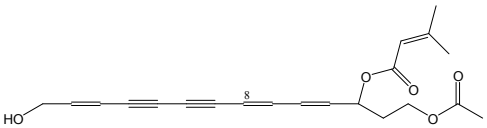
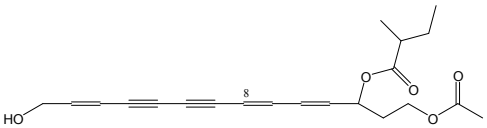
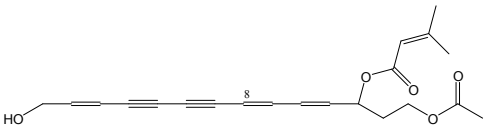
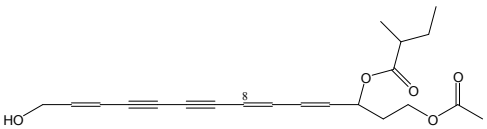
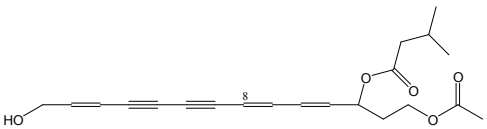
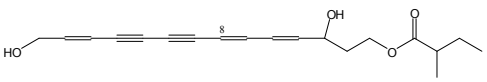
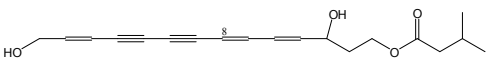
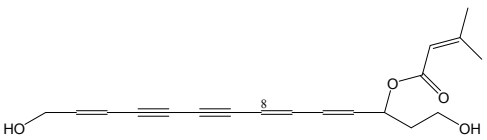
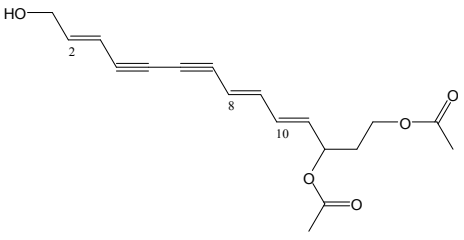
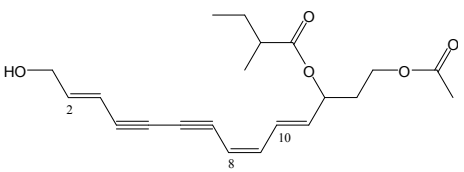
AL, *A. lancea*; AC, *A. chinensis*; AM, *A. macrocephala*; AJ, *A. japonica*; AK, *A. koreana*.

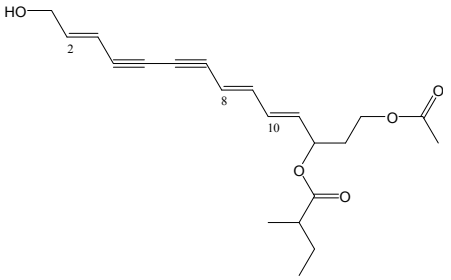
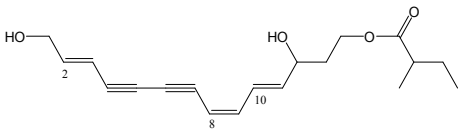
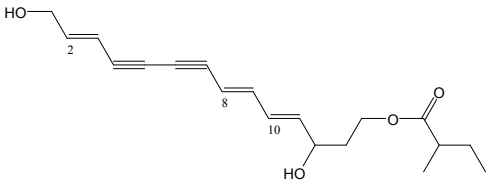
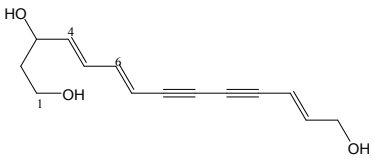
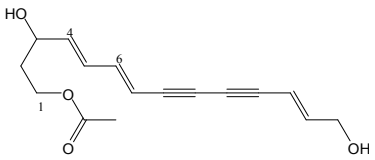
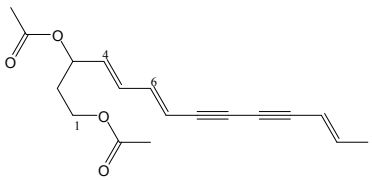
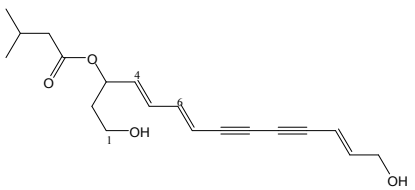
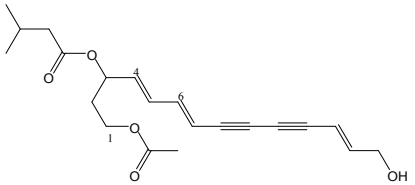
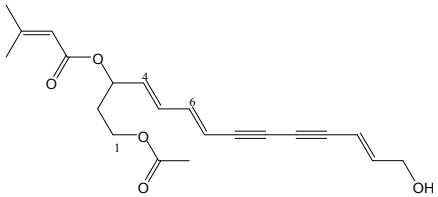
2. Triene-diyne types of Atractylodes polyacetylenes

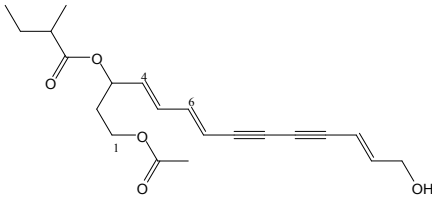
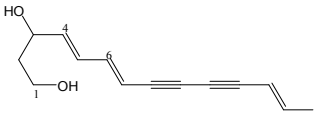
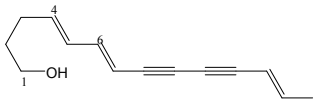
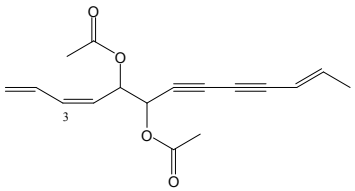
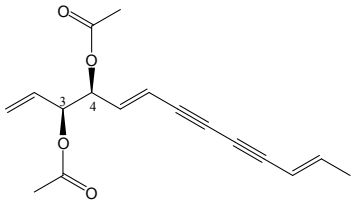
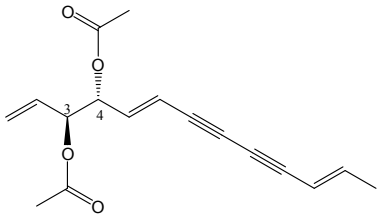
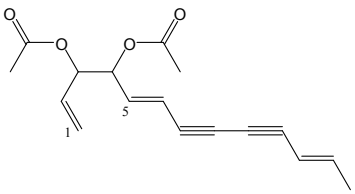
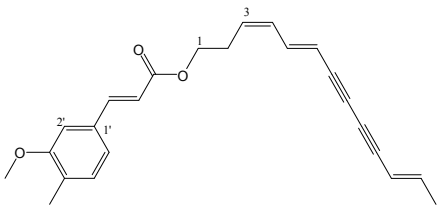
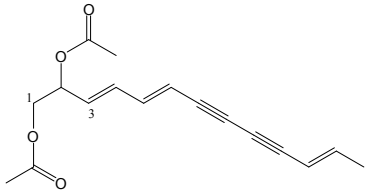
As shown in Table 2, 21 compounds of triene-diyne type polyacetylenes possessed 14 carbons with double bonds at C-2, C-8, and C-12, and triple bonds at C-4 and C-6. Functional groups of these compounds were isovaleryloxy, senecioyloxy, methylbutyryl, methylpropionyl, and acetoxy, most of which were positioned at C-12 or C-14. Another 14 carbon polyacetylenes showed different positions of double and triple bonds: double bonds at C-4, C-6, and C-12, and triple bonds at C-8 and C-10, also with the functional groups such as acetoxy, isovaleryloxy, senecioyloxy, or methylbutyryloxy attachments. Of the nine polyacetylenes with 13 carbons, eight polyacetylenes contained two triple bonds at C-7 and C-9, but double bonds were at different locations: three double bonds at C-1, C-5, and C-11, while at C-3, C-5, and C-11, which were attached by di-acetate, except for one compound with a ferulate. There were three double bonds at C-2, C-4, and C-10, and two triple bonds at C-6 and C-8 with the acetate group attached remaining. Most compounds originated from AM, followed by AL and AO (*A. ovata*), and those from AC or AJ were much less common.

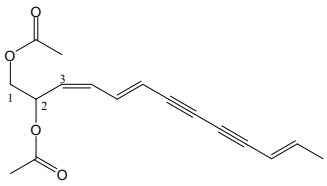
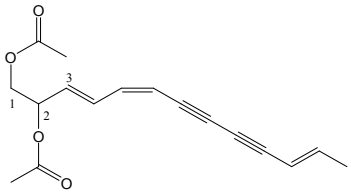
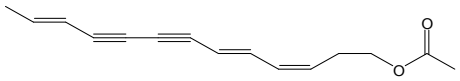
Table 2: Polyacetylenes of triene-diyne types.

Name	Structure	Origin
Atractyloyne (3S,4E,6E,12E)-1-Isovaleryloxy-tetradeca-4,6,12-triene-8,10-diyne-3,14-diol		AL[33] AC[33,62]
Atractylodemayne A 14-Senecioyloxytetradeca-2E,8Z,10E-trien-4,6-diyne-1-ol		AM[63]
Atractylodemayne B 14--Methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63]
Atractylodemayne C 12-Senecioyloxytetradeca-2E,8Z,10E-trien-4,6-diyne-1,14-diacetate		AM[63]
Atractylodemayne D 12--Methylbutyryltetradeca-2E,8Z,10E-trien-4,6-diyne-1,14-diacetate		AM[63]

Name	Structure	Origin
Atractylodemayne E 12-Senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyne-1,14-diacetate		AM[63]
Atractylodemayne F 14-Acetoxy-12-methylpropionyltetradeca-2E,8Z,10E-trien-4,6-diyn-1-ol		AM[63]
Atractylodemayne G 14-Acetoxy-12-methylpropionyltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol		AM[63]
14-Acetoxy-12-senecioyloxytetradeca-2E,8Z,10E-trien-4,6-diyne-1-ol		AM[63-65]
14-Acetoxy-12--methylbutyryltetradeca-2E,8Z,10E-trien-4,6-diyne-1-ol 9		AM[63]
14-Acetoxy-12-senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyn-1-ol		AM[63,65-67]
14-Acetoxy-12--methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63,66,67]
14-Acetoxy-12--methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63,66,67]
14--Methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63]
14--Methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63]
12-Senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyne-1-ol		AM[63]
12,14-Diacetate-2E,8E,10E-trien-4, 6-diyn-1-ol		Atractylodes rhizomes[68]
12-Methylbutyryl-14-acetyl-2E,8Z,10E-atractylentriol		AM[69]

Name	Structure	Origin
12−Methylbutyryl−14−acetyl−2E,8E,10E −atractylentriol		AM[69]
14−Methylbutyryl−2E,8Z,10E−atractylentriol		AM[69]
14−Methylbutyryl−2E,8E,10E−atractylentriol		AM[69]
(4E,6E,12E)−Tetradeca−4,6,12−trien−8,10−diyne−1,3,14−triol		AL[17] AM[70−73]
(4E,6E,12E)−3,14−Dihydroxytetradeca−4,6,12−trien−8,10−diyn−1−yl acetate		AM[70−73]
(4E,6E,12E)−Tetradecatriene−8,10−diyne−1,3−diyl diacetate		AL[49,50] AJ[54,58] Atractylodes rhizomes[68,74,75]
(4E,6E,12E)−3−Isovaleryloxy−tetradeca−4,6,12−triene−8,10−diyne−1,14−diol		AL[33] AC[33,62]
(4E,6E,12E)−1−Acetoxy−3−senecioyloxytetradeca−4,6,12−triene−8,10−diyne−14−ol		AO[54,76−78]
(4E,6E,12E)−1−Acetoxy−3−isovaleryloxytetradeca−4,6,12−trien−8,10−diyne−14−ol		AO[76−78]

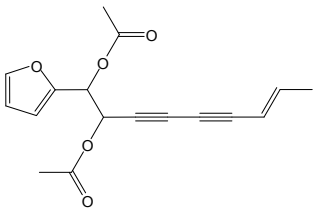
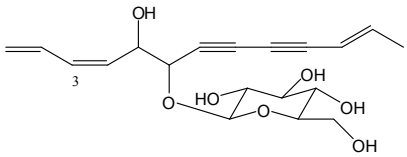
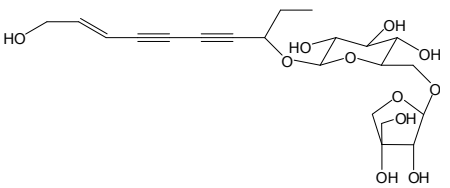
Name	Structure	Origin
(4E,6E,12E)−1−Acetoxy−3−(2−methylbutyryloxy) tetradeca−4,6,12−trien−8,10−diyne−14−ol		AO[76−78]
(4E,6E,12E)−Tetradecatriene−8,10−diyne−1,3−diol		Atractylodes rhizomes[54]
(4E,6E,12E)−Tetradecatrien−8,10−diyn−1−ol		AC[51]
erythro−(1,3Z,11E)−Tridecatriene−7,9−diyne−5,6− diyl diacetate		AL[14,49]
erythro−(1,5E,11E)−Tridecatriene−7,9−diyne−3,4− diacetate		AL[79]
threo−(1,5E,11E)−Tridecatriene−7,9−diyne−3,4− diacetate		AL[79]
(1,5E,11E)−Trideca−1,5,11−trien−7,9− diyne−3,4−diacetate		Atractylodes rhizomes[68]
(3Z,5E,11E)−Tridecatriene−7,9−diynyl−1−O−(E)− ferulate		AL[49]
(3E,5E,11E)−Tridecatriene−7,9−diyne−l,2−diacetate		AL[79]

Name	Structure	Origin
(3Z,5E,11E)−Tridecatriene−7,9−diyne−1,2−diacetate		AL[79]
(3E,5Z,11E)−Tridecatriene−7,9−diyne−1,2−diacetate		AL[79]
(2Z,4E,10E)−Trideca−2,4,10−trien−6,8−diynyl acetate		Atractylodes rhizomes[68]

AL, *A. lancea*; AC, *A. chinensis*; AM, *A. macrocephala*; AJ, *A. japonica*; AO, *A. ovata*.

3. Monoene−diyne types of Atractylodes polyacetylenes

Four monoene−diyne type polyacetylenes were reported to be a single double bond and two triple bonds, consisting of nine, ten, twelve, and thirteen carbons, with furan ring or sugars attached (Table 3).

Name	Structure	Origin
1−(2−Furyl)−(7E)−nonene−3,5−diyne−1,2−diacetate		AL[79] Atractylodes rhizomes[68]
Ethyl−10−methyl−8−dodecene−3,5−diynoate		AM[80]
(1,3Z,11E)−Tridecatriene−7,9−diyne−5−hydroxyl−6−O−β −D−glucopyranoside		AL[81]
(2E)−2−Decene−4,6−diyne−1,8−diol 8−O−β −D−apiofuranosyl−(1→6)−β −D−glucopyranoside		AO[82]

AL, *A. lancea*; AM, *A. macrocephala*; AO, *A. ovata*.

4. Influence of processing on physicochemical and biological properties of Atractylodes polyacetylenes

1) Physicochemical properties

Polyacetylenes experience diverse chemical changes in the process of extraction, especially during boiling with water. Atractylodin ($C_{18}H_{10}O$), which is the most reported polyacetylene from the essential oil in

Atractylodes rhizomes, is an alkyne-polyacetylene containing a 2-nonyltetrahydrofuran skeleton and it has properties such as instability in the air and light due to an unsaturation structure, which leads it to produce brown insoluble resin rapidly in air at room temperature[83]. Atractylodin is highly unstable and becomes brown colored when in contact with air, which makes an oil cavity in primitive oil ducts or lysigenous secretory tissues where atractylodin as well as other polyacetylenes are accumulated. This leads to a brown color on a cut surface of the rhizome[25]. When oxidized at a high temperature (120℃), atractylodin turns to the *cis*-form of atractylodinol, i.e. a H attached to a terminal methyl carbon substituted with OH [13]. Atractyloyne and (4E,6E,12E)-3-isovaleryloxy-tetradeca-4,6,12-triene-8,10-diyne-1,14-diol were converted to (4E,6E,12E)-tetradeca-4,6,12-triene-8,10-diyne-1,3,14-triol, and 14--methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol was deacylated when the rhizomes were extracted by boiling in water[62].

2) Biological properties

Processing of *Atractylodes* rhizomes also influenced the physicochemical properties and absorption of polyacetylenes. The extraction efficiencies of atractylodin and (4E,6E,12E)-tetradecatriene-8,10-diyne-1,3-diyl diacetate from Atractylodes rhizomes were decreased when the rhizomes were stir-fried with bran compared to crude rhizomes[84-86]. However, processing by stir-frying with bran affected these *in vivo* in different ways. The plasma concentration of atractylodin was increased after *Atractylodes* rhizomes were processed by stir-frying with bran rather than crude rhizomes, which indicated that processing of Atractylodes rhizomes can increase the absorption of atractylodin[87]. Stir-frying of Atractylodes rhizomes with wheat bran could promote and accelerate the absorption of (4E,6E,12E)-tetradecatrinen-8,10-diyne-1,3-diyl diacetate and its concentration was highest in the spleen, possibly increasing the spleen-tonifying effect according to the traditional theory[74].

5. Chemical stabilities of Atractylodes polyacetylenes

Stability is another concerning issue as the occurrences of bioactive polyacetylenes can be changed under certain circumstances, like drying of the rhizomes under the sun. Atractylodin, atractylodinol, and acetylatractylodinol were reported to have 1-*cis* isomers, (1Z)-atractylodin, (1Z)-atractylodinol, and (1Z)-acetylatractylodinol. The proportions of those 1-*cis* isomers were less than 1-tran isomers as the 1-*cis* isomers could be formed during drying process of the Atractylodis rhizomes under the sun: i.e. (1E)-acetylatractylodinol is rapidly isomerized to (1Z)-acetylatractylodinol[49]. On the one hand, the stabilities of 1-*cis* isomers were weaker than those of 1-trans isomers: (1Z)-acetylatractylodinol more expeditiously disappeared in n-hexane solution compared to (1E)-acetylatractylodinol dissolved in same solvent in the freezer. On the other hand, 1-*cis* isomer of atractylodin was relatively increased up to a similar ratio with its parent compound, atractylodin, in freezer storage, indicating that atractylodin was considerably instable than its isomer and different from those two polyacetylenes, (1E)-atractylodinol and (1Z)-atractylodinol, which showed the same degree of instability[49].

6. Pharmacological activities of Atractylodes polyacetylenes

In terms of pharmacological activity, polyacetylenes exhibited structure-activity relationships: the introduction of an acyl group into a compound increased the inhibitory effect against NO production; i.e., 14-acetoxy-12-senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyn-1-ol, 14-acetoxy-12-β-methylbutyryltetra-deca-2E,8E,10E-trien-4,6-diyn-1-ol, and 14-acetoxy-12-β-methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol showed lower IC_{50} level than 12-senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyn-1-ol, 14-β-methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol, and 14-β-methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol[64]. Moreover, the compounds with negative specific rotation, 14-acetoxy-12-senecioyloxytetradeca-2E,8E,10E-trien-4,6-diyn-1-ol and 14-acetoxy-12-β-methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol, showed stronger inhibitory effects against NO production than those with positive rotation, 14-acetoxy-12-senecioyloxytetradeca-2E,8Z,10E-trien-4,6-diyn-1-ol and 14-acetoxy-12--methylbutyryltetradeca-2E,8Z,10E-trien-4,6-diyn-1-ol[63]. Deacylated product of 14-β-methylbutyryltetradeca-2E,8E,10E-trien-4,6-diyn-1-ol, due to boiling extraction with water, results in diminished anti-inflammatory activity[63].

Other studies also provide us with pharmacologically explainable clues that could be employed to interpret the traditional therapeutic properties of the Atractylodes rhizomes. Atractylodiol and diacetyl-atractylodiol from *A. japonica* can stimulate the contractility of the distal colon in rats by inhibiting the

mechanism of nitrergic-purinergic relaxation[52]. Atractylodin, atractylodinol, acetylatractylodinol, and 4,6,12-tetradecatriene-8,10-diyne-1,3,14-triol from *A. lancea* can promote delayed gastric emptying[17]. These acetylenes, even though the traditional therapeutic properties cannot be entirely explained, are considered key elements for pharmacological accounts of the effects of *Atractylodes* rhizomes that have been used to treat gastrointestinal disorders.

Ⅳ. Conclusions

Through bibliographical research, polyacetylenes from the Atractylodes rhizomes were divided into three categories; diene-diyne types, triene-diyne types, and monoene-diyne types. Those compounds showed a variety of moieties according to diverse functional groups, with following characteristics:

1. Certain polyacetylenes, including atractylodin or atractylodinol, were chemically unstable at a high temperature and even in freezer storage

2. Processing of the Atractylodes rhizomes by stir-frying with bran could lower the contents of polyacetylenes in the rhizomes, but improve bioavailability in vivo

3. Structure-related activities of polyacetylenes were shown in pharmacological studies and gastrointestinal activities were also reported.

The present study will help to understand the physicochemical and pharmacological properties of polyacetylene from *Atractylodes* rhizomes.

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