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Chemical characterization and antioxidant activities comparison in fresh, dried, stir-frying and carbonized ginger

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ABSTRACT

Ginger (*Zingiber officinale* Rosc.) is a common dietary adjunct that contributes to the taste and flavor of foods, and is also an important Traditional Chinese medicine (TCM). Different processing methods can produce different processed gingers with dissimilar chemical constituents and pharmacological activities. In this study, an ultra-performance liquid chromatography/quadrupole-time-of-flight mass spectrometry (UPLC/QTOF-MS) was applied to identify the complicated components from fresh, dried, stir-frying and carbonized ginger extracts. All of the 27 compounds were identified from four kinds of ginger samples (fresh, dried, stir-frying and carbonized ginger). Five main constituents (zingerone, 6-gingerol, 8-gingerol, 6-shogaol and 10-gingerol) in these four kinds of ginger sample extracts were simultaneously determined by UPLC-PDA. Meanwhile, the antioxidant effect of fresh, dried, stir-frying and carbonized gingers were evaluated by three assays (2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azinobis(3-ethylbenzthiazolinesulfonic acid) diammonium salt (ABTS), and ferric reducing antioxidant power (FRAP)). The results demonstrated that antioxidant activity of dried ginger was the highest, for its phenolic contents are 5.2-, 1.1- and 2.4-fold higher than that of fresh, stir-frying and carbonized ginger, respectively, the antioxidant activities' results indicated a similar tendency with phenolic contents: dried ginger > stir-frying ginger > fresh ginger > carbonized ginger. The processing contributed to the decreased concentration of gingerols and the increased levels of shogaols, which reducing the antioxidant effects in pace with processing. This study elucidated the relationship of the heating process with the constituents and antioxidant activity, and provided a guide for choosing different kinds of ginger samples on clinical application.

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1. Introduction

Ginger (*Zingiber officinale* Rosc.) is a monocotyledon belonging to the family Zingiberacea. Today ginger is cultivated in many tropical and subtropical areas. The main producers are in India, China, Indonesia, and Nigeria [1]. It is not only an important dietary adjunct that contributes to the taste and flavor of foods, but also a Traditional Chinese medicine (TCM). In recent years, gingers have increasingly attracted the attention of food and pharmaceutical industries due to therapeutic benefits to ameliorate symptoms, such as nausea, vomiting, gastrointestinal discomforts, headache and common cold. Ginger also possesses numerous significant pharmacological properties such as immunomodulatory, anti-inflammatory, anti-microbial, anti-carcinogenic, analgesic, anti-hyperglycemic, anti-apoptotic, and antioxidant activities, which have been reported in numerous studies [2–11]. In addition, ginger is known for containing a num-

Abbreviations: UPLC/QTOF-MS, ultra-performance liquid chromatography/quadrupole-time-of-flight mass spectrometry; TCM, Traditional Chinese medicine; UV, ultraviolet; DPPH, 2,2-Diphenyl-1-picrylhydrazyl; ABTS, 2,2′-Azinobis(3-ethylbenzthiazolinesulfonic acid) diammonium salt; FRAP, ferric reducing antioxidant power; TPTZ, ferric tripyridyltriazine; TPC, total phenolic contents; PDA, Photo-diode array; ESI, electrospray ionization; GAE, gallic acid equivalents; SD, standard deviation; BPI, base peak ion; LOD, the limit of detection; LOQ, limit of quantification.

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Table 1
Characterization of constituents in four kinds of ginger extracts by UPLC QTOF-MS.

No.	t (min)	$(-)m/z$	ppm	Formula	Compounds name	Fresh ginger	Dried ginger	Stir-frying ginger	Carbonized ginger	Reference
1	4.61	389.1597	0.8	$C_{21}H_{26}O_7$	5-Hydroxy-1-(3,4-dihydroxy-5-methoxyphenyl)-7-(4-hydroxy-3-methoxyphenyl)-3-heptanone	+	+	+	+	[18]
2	4.75	405.1907	−0.6	$C_{22}H_{30}O_7$	3,5-Dihydroxy-1-(4-hydroxy-3,5-dimethoxyphenyl)-7-(4-hydroxy-3-methoxyphenyl)heptane	+	+	+	+	[18]
3	4.78	403.1753	−0.4	$C_{22}H_{28}O_7$	3-Acetoxy-5-hydroxy-1-(4-hydroxy-3-methoxyphenyl)-7-(3,4-dihydroxyphenyl)heptanes	+	+	+	+	[18]
4	4.8	375.1805	−0.3	$C_{21}H_{28}O_6$	3,5-Dihydroxy-1,7-bis(4-hydroxy3-methoxyphenyl)heptane	+	+	+	+	[18]
5	4.82	373.1651	0	$C_{21}H_{26}O_6$	5-Hydroxy-l,7-bis(4-hydroxy-3-methoxyphenyl)-3-heptanone	+	+	+	+	[28]
6	5.38	375.1472	2.8	$C_{20}H_{24}O_7$	5-Hydroxy-1-(4-dihydroxy-3-methoxyphenyl)-7-(3,4-dihydroxyphenyl)-3-heptanone	–	+	+	+	[18]
7	5.43	475.1964	−0.4	$C_{25}H_{32}O_9$	3,5-Diacetoxy-7-(4-dihydroxy-3-methoxyphenyl)-1-(3,4-dihydroxy-5-methoxyphenyl)heptane	+	+	+	+	[28]
8	5.67	295.1912	0.3	$C_{17}H_{28}O_4$	6-Gingerdiol	–	+	+	+	[20]
9	5.69	193.0865	0	$C_{11}H_{14}O_3$	Zingerone	+	+	+	+	[a]
10	5.7	293.1757	0.4	$C_{17}H_{26}O_4$	6-Gingerol	+	+	+	+	[a]
11	5.81	291.1599	0.3	$C_{17}H_{24}O_4$	Gingerdione	+	+	+	+	[20]
12	6.08	307.1907	0.7	$C_{18}H_{28}O_4$	Methyl-6-gingerol	–	+	+	–	[20]
13	6.2	321.2067	0.1	$C_{19}H_{30}O_4$	8-Gingerol	+	+	+	+	[a]
14	6.21	317.1757	−0.1	$C_{19}H_{26}O_4$	1-Dehydro-8-gingerdione	+	+	+	+	[29]
15	6.22	275.1651	0.4	$C_{17}H_{24}O_3$	6-Shogaol	+	+	+	+	[a]
16	6.41	347.2216	−0.6	$C_{21}H_{32}O_4$	10-Gingerdione	+	+	+	+	[20]
17	6.42	337.2008	−0.7	$C_{19}H_{30}O_5$	3- or 5-Acetoxy-6-gingerdiol	–	+	+	+	[20]
18	6.52	289.144	0	$C_{17}H_{22}O_4$	1-Dehydro-6-Gingerdione	+	+	+	+	[20]
19	6.56	277.1775	−2.9	$C_{17}H_{26}O_3$	6-Paradol	–	+	+	+	[20]
20	6.61	349.2376	−0.3	$C_{21}H_{34}O_4$	10-Gingerol	+	+	+	+	[a]
21	6.66	303.1953	−0.7	$C_{19}H_{28}O_3$	8-Shogaol	–	+	+	+	[20]
22	6.82	319.1911	0.2	$C_{19}H_{28}O_4$	8-gingerdione	+	–	–	+	[20]
23	6.88	305.2109	−0.8	$C_{19}H_{30}O_3$	8-Paradol	–	+	+	+	[29]
24	6.93	377.2693	0.1	$C_{23}H_{38}O_4$	12-Gingerol	+	+	+	+	[20]
25	7.00	331.2271	−0.2	$C_{21}H_{32}O_3$	10-Shogaol	–	+	+	+	[20]
26	7.16	345.2067	0.1	$C_{21}H_{30}O_4$	Dehydro-10-gingerdione	+	+	+	+	[30]
27	7.41	373.2375	−0.4	$C_{23}H_{34}O_4$	Dehydro-12-gingerdione	+	+	+	+	[29]

[a] Confirmation with reference compounds.

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