

Research Article

Analysis on Nutrients Change of Fresh Ginger after Storage

^{1,2}Xingcui Wang, ²Bili Cao, ¹Qiqin Xue, ¹Yong-guang Liu and ¹Ning Qiao

¹Weifang University of Science and Technology, China

²State Key Laboratory of Crop Biology, Ministry of Agriculture, Key Laboratory of Horticultural Crop Biology, College of Horticulture Science and Engineering, Shandong Agricultural University, China

Abstract: In order to determine the composition of ginger and fresh ginger and efficacy differences, this study uses gas chromatography-mass spectrometry to identify the ginger and fresh ginger supercritical CO₂ extract of the chemical composition and relative content. The results showed that the extraction rate of ginger and fresh ginger oleoresin is respectively 5.15±0.12% and 4.67±0.15%, the chemical composition of both contained basically the same, mainly zingiberene α -, β -half times the water Qinene, β -myrrhene, α -farnesene, α -curcumene, 6-gingerol, 6 zingiberene phenol and decomposition zingerone etc., but significant differences relative content. In the aroma of terpene compounds, ginger relative amount of the compound 1, 8-cineole, β -fragrant small chestnut, citral, geraniol, geranyl acetate and α -zingiberene other significant lower than fresh ginger and γ -Selinene and large myrcene D detected only in fresh ginger, ginger and the relative content of α -curcumene significantly higher than fresh ginger. The relative amounts of the total ginger gingerol compounds than fresh ginger high of 7.86%, in particular 6-and 10-zingiberene relative content of phenol phenol zingiberene high 15.49 and 30.51%, respectively, compared with fresh ginger.

Keywords: Fresh ginger, nutrients change, storage

INTRODUCTION

Ginger is a perennial herb ginger fresh ginger rhizome, high 40~100 cm. Alias ginger root, one hundred hot clouds, hook loaded finger due to Sim, Yan Liang kid, fresh ginger, honey roast ginger. Ginger rhizome (ginger), Cork (ginger skin), leaves (ginger leaves) can be used as medicine. Ginger has a divergence, vomiting, cough and other effects in Chinese medicine inside (Ali *et al.*, 2008).

Ginger is the treatment of hydrochloric acid-ethanol effective ulcer drug, its active ingredient zingiberene, has a role in protecting the gastric mucosa cells. In the aromatic stomachic crude drugs, especially in multi-ginger plants contain zingiberene essential oils, such as terpenes, is one of the active ingredients stomach crude drugs (Jolad *et al.*, 2004). Ginger decoction of canine gastric acid secretion and gastric juice showed a two-way action and excitement suppression, suppression within the first few hours after the excitement to continue longer. Ginger decoction (10%) 1.2 mg/only gavage to rats, significantly inhibited hydrochloric acid and stress-induced gastric mucosal injury, PG synthesis with indomethacin after blocking, the protective effect of ginger disappeared, indicating the protective mechanism may gastric mucosa and promote the synthesis and release of endogenous PG-related reduction.

Ginger make pepsin weakened, lipolytic action of the enzyme is enhanced. Ginger can be severely damaged pancreatic amylase, trypsin digestion of starch to make a significant decline. We can inhibit the β -amylase amylase, starch saccharification hindered. Ginger can act on the sympathetic and vagal system, there is a direct inhibition of gastric function and gastric smooth muscle excitability. The use of rat intestinal absorption spectrometry also stream Sulfaguanidine role in promoting the study results show that: water extract of ginger has a significant role in promoting the absorption and enhance its bioavailability, full effect. Ginger extract can inhibit the dog vomiting caused by copper sulfate. The mixture was separated out from the ginger and ginger zingerone enone also antiemetic effect, the minimum effective dose of 3 mg, Pigeon vomiting dog vomiting and digitalis for central emetic apomorphine-induced causes are invalid, so ginger believes there or peripheral antiemetic effect (Ma and Gang, 2006).

Rabbit digestive tract can give zingerone intestinal relaxation, motility dysfunction. Ginger is a carminative, digestive tract has a mild stimulating effect, can make bowel tension, rhythm and increased motility, sometimes followed by a decrease can be used for gas or colic due to other causes. Experiments show: ginger oil on carbon tetrachloride-induced liver injury in rats have a therapeutic effect, can make to reduce serum SGPT;

Corresponding Author: Xingcui Wang, Weifang University of Science and Technology, China

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carbon tetrachloride-induced liver injury in mice have a preventive effect and can reduce the amount of BSP retention. Ginger honey storage solution 5 mL/kg orally to rats, carbon tetrachloride-induced liver injury is also a therapeutic effect, compared with the control group, the serum SGPT and SGOT significantly reduced lobular damage, hepatic steatosis and necrosis also lighter; 60% for ethanol-induced liver injury in the rat equally effective.

Ginger storage technology:

Ginger harvest: For storage, Ginger usually in the beginning of winter when the frost fell harvest. Early harvest 'organizations soft, high water content, spicy light, intolerance storage, late harvest in the field are easy to cold. Timely harvest of ginger rhizome is fully dilated, more fiber, low water content, spicy heavier, product storability. Ginger harvest should be selected in sunny or cloudy morning were dry, rain and rain harvesting ginger water content is too high, not storability, it is best not to harvest under the sun, in order to avoid excessive sun exposure. Ginger does not generally require, postharvest want a little dry in the field, but not in the field overnight. After the harvest should be stored under the cellar, cellar under the front along with the leaf stems break off together and a rigorous selection, excluding organized tender, mechanical damage, plague and other non-storability of ginger products (Jolad *et al.*, 2005).

Ginger's storage:

Temperature: Ginger is a typical physiological dormancy vegetables. Freshly picked ginger, shedding skin, breathing strong. Initial storage easily accumulated heat, must pay attention to maintaining effective ventilation, avoid heat injury ginger. In the reservoir after about a month, roots aging, no peeling flesh consistency, gradually stripping leaf scar at long flat, round terminal bud growth, this process is to strengthen the process of ginger storability, called T round head V. Round V T during 20x required to maintain the temperature around the cellar, but also well ventilated. After suitable cellar temperature is about 15x, the temperature is below 10x susceptible to cold damage, the temperature is too high and easy to accelerate decay and germination (Onyenekwe and Hashimoto, 1999).

Humidity: Ginger storage, appropriate relative humidity of 90 to 95%. Humidity, first with wet sand bunk, a layer of wet sand layer of ginger, then covered with a layer of wet sand on top of the top cover. Ginger breathing due to strong initial storage, high temperature cavities, not to Jiaokou completely closed, to maintain ventilation. Early harvest ginger crisp, easy peeling, require temperature is kept at 20x more than make ginger callus aging, scars long flat, no peeling. After the temperature was controlled at about 15x. Winter Jiaokou

must Gaiyan prevent cellar temperature is too low, storage process should always check to prevent the occurrence of abnormal changes Ginger pit possession (Smith and Robinson, 1997).

In high water table areas, digging general storage, excavated soil around the pit around and shoot real as walls, Bottom diameter of 2.0 m, the pit diameter 2.3 m, pit depth 2.3 m, about every pit storage 5000 kg. Storage is too small, due to temperatures greater impact difficult insulation. Per 500 kg of ginger should insert a thin bamboo reeds or ventilation bunched beam with a diameter of about 10 cm. Bulk Ginger in the pit to pit, was shaped bread covered ginger leaves and stamped on the soil around the root ginger. Depending on the situation after the temperature dropped several times to add the casing. Top of the casing is made with straw roof rain gutters around the dig. Note that the initial storage ventilation to prevent the cellar temperature is too high, after the application of soil to fill the cracks to prevent cold air penetration. This method will be after winter storage of ginger, once the cellar, transported around the supply market. Also available for secondary storage, storage can be used when pouring sand storage method and storage ginger law.

Sand: Sand is the ginger with the sand in the pit area after the cavities, according to a layer of sand a floor layer 1-2 Ginger laying a width 1.0~1.5 m, height does not exceed 1 m rectangular stack, each stack of about 1 200~2500 kg. Should be inserted in the middle of a pile with bundles of reeds or bamboo grass about 10 cm in diameter ventilation beam and placed a thermometer, you can always measure the stack temperature. Seal around the pile of wet sand, you should pay attention to ventilation and cooling in summer and cold winter cover. When the sand is too dry can be watered to prevent shrinkage of the rhizome (Balladinda *et al.*, 1998).

T pouring ginger act V storage: Choose a slightly sloping site, the settings above can translucent shade, ground put the skids, skids along the slope arrangement. Jiang later transferred by the selection of neatly arranged in an inverted drain empty baskets, baskets code on the skids, usually 2 to 3 layers. Arbours located around the windbreak. Later, as the temperature changes in the basket of ginger a day pouring cold water 1 to 3 times, each time to be drenched, so that to maintain proper low humidity environment, prompting ginger sprout and grow, maintain normal metabolism, so basically not bad roots. Finally, some stems up to 0.5 m tall, light green leaves. After the winter, natural brown stems, then the original basket into the repository should pay attention to frost, so Ginger again after the winter to supply after the Spring Festival. During pouring ginger, red ginger, if found, would indicate imminent rhizome rot, should be promptly treated.

Disease prevention:

Ginger rot: Also known as ginger blast, as *Pseudomonas* spp. Infection caused by pathogenic bacteria, the disease occurs not only in the field, may also occur in the storage period. Initial disease victims as water-soaked roots, brown and then lose their luster, softening rot, finally leaving only the rind. At this point, decayed tissue turns white sticky sap, with foul odor. The optimum temperature for bacteria breeding 28x. Disease prevention and control measures are mainly: improve field management; rigorous selection process before the pit entry, remove contaminated disease block; harvest, avoid mechanical damage during transport; strengthen temperature and humidity during storage management.

Mycosis: Mycosis is the emergence of a layer of dark skin patches or rot in ginger surface, prone to injuries in the tubers, the environment and appropriate circumstances. As the disease progresses, white mold and black mold gradually penetrate into the tubers. Control methods are good storage cellar disinfection. At present, the commonly used method of disinfection is smoked and cellar applicator certain amount of quicklime two methods, simple, obvious effect.

Ginger during storage due Enthusiasm, improper ventilation, cold air suddenly entered the storage environment, so ginger and cold on the physiological deterioration occurs, which is a physiological disease caused by low temperatures. Chilling after by Ginger was water-soaked and soon rot serious. Control methods should note three aspects: First, it should be noted in the production process cannot be harvested too late to avoid the cold field; the second is in the storage process, should pay attention to weather changes, strengthening antifreeze precautionary measures; three storage temperatures drop to 8x or so, the ginger pit cover with straw insulation, start lid 5~7 cm thick and later with the temperature drop gradually thicker straw and finally covered with mud.

Analysis of nutrients ginger and fresh ginger: Ginger is important condiments widely consumed, with a special spicy aroma. Studies have shown that ginger's spicy non-volatile substances containing 3'-methoxy-4'-hydroxyphenyl functional groups ginger ingredients, aromatic substances mainly volatile terpenoids. For a long time, "ginger or the old lady" has become one of the important Chinese idiom, but more analysis of the functional components of ginger and fresh ginger has not been reported. For this reason, the present study, GC-MS technique ginger and fresh ginger supercritical CO₂ extraction product (ginger oleoresin) ingredients were analyzed and compared to further determine the difference between functional components of ginger and fresh ginger for the rational use of different types of

ginger deep processing products research and development to provide a theoretical basis.

MATERIALS AND METHODS

Reagents, materials and equipment: The HPLC grade dichloromethane. "Ambassador Hill ginger 1" newly harvested fresh ginger and ginger planting use. QP2010 Plus GC/MS instrument Shimadzu Corporation; HA221-50-06 supercritical CO₂ extraction device supercritical extraction Ltd. Nantong Hua; on RE52-99 rotary evaporator Haiya Biochemical Instrument.

Ginger extract: The ginger washing, slicing, drying (temperature 40°C, the water content of about 13%), crushed (40 mesh sieve), take ginger 100 g, at a temperature of 38°C, under pressure of 25 MPa conditions, with supercritical CO₂ extraction device extraction 2 h, concentrated by vacuum rotary evaporator (temperature 30°C) was ginger oleoresin, in- at 20°C stored for use.

Component analysis of ginger oleoresin:

Sample preparation: About 20 mg of ginger oleoresin dissolved in 10 mL of dichloromethane and the front of the column with 0.45 µm pore membrane filter. Chromatographic conditions: Column for Rtx-5 msec (0.25 mm×0.25 µm×30 m); helium carrier gas; the flow rate was 1.2 mL/min; injection volume was 1 µL, split ratio of 10: 1; temperature program of 80°C (3 min)→140°C (2 min)→230°C (3 min)→260°C (5 min).

MS conditions: Ionization mode for EI; ionization energy 70eV; scan interval to 1s; scan range: 45~550 amu; interface temperature 250°C, ion source temperature was 230°C, electron multiplier voltage of 800 V.

RESULT ANALYSIS

Ginger oleoresin extraction rate: Experimental results show that the use of supercritical CO₂ extraction method were extracted from the ginger and fresh ginger ginger oleoresin content there is a significant difference, were up 5.15±0.12% and 4.67±0.15%. Visible, ginger ginger oleoresin was significantly higher than fresh ginger.

The chemical composition of ginger oleoresin: Figure 1 is a ginger and fresh ginger supercritical CO₂ extraction of ginger oleoresin were GC/MS analysis of the resulting total ion chromatogram, the computer NIST05 MS library search, relevant literature and artificial solution spectrum, both identified 76 each ingredients, including 49 kinds of volatile oils, 27 kinds of ginger ingredients to area normalization method to determine the relative content of each component.

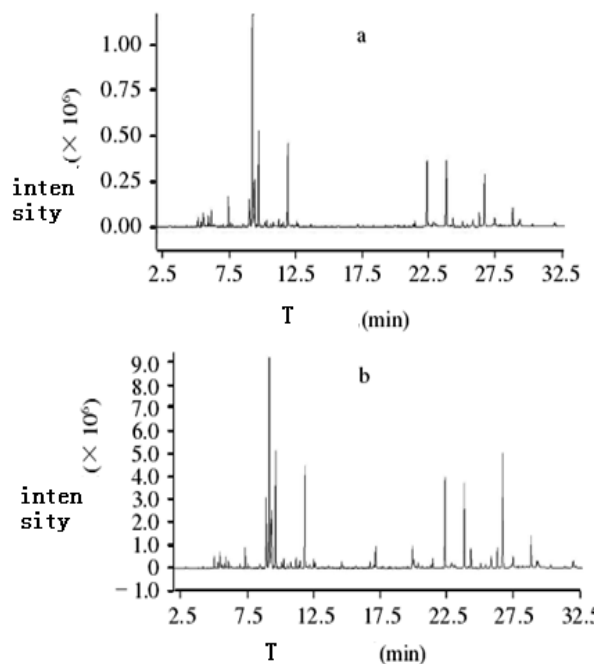


Fig. 1: Total ion current chromatograms of supercritical CO₂ extracts of seed ginger and fresh ginger

According to the sense of smell and taste, can be the chemical composition of ginger oleoresin divided into two categories: one for rendering aroma volatiles-ginger oil, its chemical composition is mainly for single terpenes and sesquiterpenes substances (Table 1); the other is rendered non-volatile pungent odor-gingerol compounds, the chemical composition of 4'-hydroxy-3'-methoxybenzene phenolic compounds containing functional groups (Table 2).

As can be seen from Table 1, ginger extract and fresh ginger extract volatile oil is basically the same chemical composition, mainly zingiberene α -, β -half times phellandrene, β -myrrh ene, α -farnesene, α -curcumene, etc., but the relative amounts of ginger and fresh ginger, there are some major differences in the chemical composition. Ginger and fresh ginger aroma of ingredients-the relative content of volatile oil were 56.11 and 59.31%. Aroma components β -half times phellandrene, β -myrrh ene, α -farnesene in ginger and fresh ginger and other little differences and 1, 8-cineole, β -fragrant small chestnut aldehydes, lemon content, geraniol, geranyl acetate, etc.

In the ginger extract significantly lower than that of fresh ginger, wherein the 1, 8-cineole, β -fragrant aldehyde in small chestnut ginger extract almost undetectable; old Jiangzhong Shun-citral, trans-citral, geraniol, geranyl acetate and the relative content of α -zingiberene were lower than the 62.30% of fresh ginger, 62.0, 8.20, 45.37 and 19.92%, respectively. The relative content of α -ginger curcumene are increased by 137.4%

Table 1: Chemical compositions and their relative contents of volatile oil in supercritical CO₂ extracts from seed-ginger and fresh ginger

Compound type and name	The relative content (%)	
	Fresh ginger	Old ginger
1, 8-cineole	0.08	tr
Linalool β -linalool	0.13	0.12
β -fragrant small chestnut aldehyde	0.03	tr
Borneol	0.61	0.60
4-pine oil alcohol	0.05	0.04
Terpineol	0.32	0.32
Rhodomyrtus womb alcohol	-	0.04
Citronellol	0.11	0.21
Anti-citral	0.61	0.23
Geraniol	0.61	0.56
Cis-citral	1.00	0.38
L- α -bornyl acetate	0.15	0.16
δ -elemene	0.11	0.06
Geranylflavanone acid	0.19	0.27
Geranyl acetate	2.16	1.18
β -elemene	0.36	0.44
Ene ring different alfalfa	0.10	0.07
Anti- α -fragrant orange oil ene	0.21	0.23
α -fragrant orange oil ene	0.11	0.15
(E) - β -farnesene	0.34	0.35
(Z) - β -farnesene	0.14	0.14
Fragrant magnolia ene	0.09	0.13
γ -selinene	0.24	-
α -curcumene	2.62	6.22
Large myrcene D	0.92	-
α -zingiberene	22.29	17.85
γ -cadinene	1.02	1.03
α -farnesene	3.93	3.72
β -myrrh ene	3.87	3.77
(+) -Table-bicyclic sesquiterpene	0.25	0.23
Phellandrene		
β -half times phellandrene	8.58	8.54
α -leafy ene	0.32	0.25
Speaker ene oxide	0.15	0.15
4-vinyl- α , α , 4-trimethyl-3- (1-methyl-vinyl) -	0.66	0.68
Cyclohexanemethanol	0.66	0.68
4, 11, 11-trimethyl-8-methyl -	0.66	0.69
Bicyclo (7.2.0) 4-undecen	0.66	0.69
Coniferin coniferol	-	-
(-) - α -bisabolol	0.64	0.66
(E) -epoxy farnesene	0.14	0.11
(+) - α -myrrh ene	0.70	0.81
Courbevoic alcohol	0.25	0.28
Acid nerolidol	0.63	0.71
β -eudesmol	tr	0.18
Shun-Z- α -epoxy myrrh ene	0.40	0.50
Torreyia alcohol	0.12	0.13
Z- α -anti-bergamot alcohol	0.27	0.24
(Z, E) -farnesol	0.09	0.10
Decanal	1.77	1.94
2-undecanone	0.10	0.15
2, 6, 6-trimethyl-bicyclo (3.1.1) hept-2-ol	-	0.05
Lauric dodecanoic acid	0.10	0.18
2, 6-dimethyl-2, 6-octadiene-1, 8-diol	0.68	0.87
Lauric acid dodecanoic acid	0.10	0.18
2, 6-dimethyl-2, 6-octadiene-1, 8-diol	0.68	0.87

compared with fresh ginger. Be inferred from the relative content and molecular structure of α - and α -zingiberene alkenyl two turmeric compounds, it may be because the growth process continues ginger α -zingiberene off part of the hydrogen converted to α -

Table 2: Chemical compositions and their relative contents of gingerols in supercritical CO₂ extracts of seed ginger and fresh ginger

Compound type and name	The relative content (%)	
	Fresh ginger	Old fresh
4-gingerol	0.14	0.26
Zingerone	9.24	9.78
Methyl ether zingerone	0.45	0.58
Dehydrogenation zingerone	0.10	0.26
4-zingiberene phenol	0.12	0.13
4-gingerol	0.14	0.26
E-6-gingerol	0.23	0.27
6-zingerone phenol	0.63	0.82
5-gingerol	0.06	0.10
Z-6-zingiberene phenol	7.36	8.50
6-ginger dione	1.24	1.10
Two acetoxy-4 ginger dione	0.30	0.10
6-gingerol	9.38	9.91
6-different gingerol	0.16	0.19
Methyl-6-gingerol	0.11	0.12
Gingerol-8	Zingerone phenol	0.04
Acetyl-6-gingerol	0.79	0.54
6-ginger diol	0.43	0.45
8-zingiberene phenol	1.42	1.83
Two-acetoxy-6 ginger glycols	2.20	2.33
8-ginger dione	0.39	0.25
8-gingerol	1.36	1.43
E-10-iso zingiberene phenol	0.06	0.06
Z-10-iso zingiberene phenol	0.09	0.11
10-zingerone phenol	0.03	0.07
10-zingiberene phenol	2.36	3.08
10-ginger dione	1.67	1.22
10-gingerol	0.33	0.33

curcumene, thereby increasing the relative content of α -curcumene ginger, which is also the color of ginger extract slightly darker than the fresh ginger. In addition, detection in fresh ginger extract to γ -Selinene (0.24%) and a large myrcene D (0.92%), but was not detected in the ginger in both chemical composition, may be in ginger continued to grow during the second year, converted to the exigencies of other secondary metabolites. Visible, slightly less ginger fragrance component, relatively low content of its aroma is slightly lighter than the fresh ginger.

As can be seen from Table 2, ginger and fresh ginger extract hot component is basically the same, mainly 6-gingerol, 6-gingerol alkenyl phenol, 10-dione ginger, ginger-diacetoxy-6-diol decomposition products 10-zingiberene phenol and gingerol compounds-zingerone etc., but significant differences relative content. Ginger and fresh ginger relative content of total gingerol compounds were 43.89 and 40.69%, the relative amounts of ginger ginger compounds 7.86% higher than the fresh ginger. Ginger extract the relative content of almost every kind of gingerol compounds than fresh ginger high, especially in 6-and 10-zingiberene relative amounts of phenol phenol zingiberene high 15.49% respectively, compared with fresh ginger and 30.51%. Therefore, there are more intense than fresh ginger in ginger spicy.

CONCLUSION

Vegetable product quality is a more complex and ambiguous nature of the concept. Different researchers have a different understanding and presentation, the quality is generally referring to the comprehensive character and appearance of the product composed of a number of internal factors; but for the processing of a particular specific products, namely processed product quality is also a very specific sense, means a major component of the product to meet the requirements of a deep processing products can be produced specifically correspond to certain processed products, the processing of products yield rate significantly improved or significantly improved quality. This study shows that ginger rhizome dry matter, soluble sugar, starch, crude fiber and ginger oleoresin content were increased with the growth and extension of storage time; and soluble protein and free amino acid content was higher in the early growth of ginger, late growth and storage of low and no significant change. One hundred and fifty seven days ago after sowing ginger rhizome dry matter content is low and ginger oleoresin, spicy taste lighter, less crude fiber, pickled ginger suitable for processing, but the ginger after sowing 91 days, yield only 8541.4 kg/hm² and a single The average quality of fresh rhizome plants only 109.7 g, though fresh roots, but of little value commodity production; and ginger storage 60 days, dry matter, soluble starch and ginger oleoresin content has been basically stable, suitable for dehydration ginger, ginger oil and starch processing.

In this study, supercritical CO₂ extract of ginger and fresh ginger in ginger oleoresin, its extraction rate was 5.15±0.12% and 4.67±0.15%, showed ginger oleoresin contained more abundant than fresh ginger.

The use of GC/MS analysis of ginger oleoresin composition found the same main chemical constituents of ginger and fresh ginger extract contained, but its relative content quite different. In the aroma of terpene compounds, 1, 8-cineole, β -fragrant small chestnut, citral, geraniol, geranyl acetate, α -zingiberene and other content is of less than fresh ginger. The relative amounts of ginger in α -curcumene is higher than fresh ginger. It was spicy ginger compounds, the relative amounts of ginger compounds is higher than fresh ginger. Therefore, g fresh ginger aromatic odor than light, but its spicy flavor is strong.

According to the extraction rate and the chemical composition of ginger and fresh ginger oleoresin, this research found that ginger has the physiological activity of the main ingredient-compound content Gingerols class higher than fresh ginger, therefore, fresh ginger has a higher ratio nutritional value.

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REFERENCES

- Ali, B.H., G. Blunden, M.O. Tanira and A. Nemmar, 2008. Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research [J]. *Food Chem. Toxicol.*, 46(2): 409-420.
- Balladinda, D.A., O. Headleyo, I. Chang-Yen and D.R. McGaw, 1998. High pressure liquid chromatographic analysis of the main pungent principles of solar dried West Indian ginger (*Zingiber officinale* Roscoe). *Renew. Energ.*, 13: 1614-1635.
- Jolad, S.D., R.C. Lantz, A.M. Solyom, G.J. Chen, R.B. Bates and B.N. Timmermann, 2004. Fresh organically grown ginger (*Zingiber officinale*): Composition and effects on LPS-induced PGE2 production [J]. *Phytochemistry*, 65(13): 1937-1954.
- Jolad, S.D., R.C. Lantz, G.J. Chen, R.B. Bates and B.N. Timmermann, 2005. Commercially processed dry ginger (*Zingiber officinale*): Composition and effects on LPS-stimulated PGE2 production [J]. *Phytochemistry*, 66(13): 1614-1635.
- Ma, X.Q. and D.R. Gang, 2006. Metabolic profiling of in vitro micropropagated and conventionally greenhouse grown ginger (*Zingiber officinale*) [J]. *Phytochemistry*, 67: 2239-2255.
- Onyeneke, P.C. and S. Hashimoto, 1999. The composition of the essential oil of dried Nigerian ginger (*Zingiber officinale* Roscoe) [J]. *Eur. Food Res. Technol.*, 209: 407-410.
- Smith, R.M. and J.M. Robinson, 1981. The essential oil of ginger from Fiji [J]. *Phytochemistry*, 20: 203-206.