CHAPTER II

LITERATURE REVIEW

1. Botanical Aspects

1.1 Zingiberaceae Lindley

Herbs perennial, terrestrial, rarely epiphytic, aromatic, with fleshy, tuberous or non-tuberous rhizomes, often with tuber-bearing roots. Stems usually short, replaced by pseudostems formed by leaf sheaths. Leaves distichous, simple, those toward base of plant usually bladeless and reduced to sheaths; leaf sheath open; ligule usually present; petiole present or not, located between leaf blade and sheath, cushion-like in *Zingiber*; leaf blade suborbicular or lanceolate to narrowly strap-shaped, rolled longitudinally in bud, glabrous or hairy, midvein prominent, lateral veins usually numerous, pinnate, parallel, margin entire. Inflorescence terminal on pseudostems or on separate, short, sheath-covered shoots arising from rhizomes, cylindric or fusiform, sometimes globose, lax to dense, few to many flowered, sometimes with bracteolate cincinni in bract axils and then a thyrse, sometimes a raceme or spike; bracts and bracteoles present, often conspicuous, color. Flowers bisexual, epigynous, zygomorphic. Calyx usually tubular, thin, split on one side, sometimes spathelike, apex 3-toothed or -lobed. Corolla proximally tubular, distally 3-lobed; lobes varying in size and shape. Stamens or staminodes 6, in 2 whorls. Lateral 2 staminodes of outer whorl petaloid, or forming small teeth at base of labellum, or adnate to labellum, or absent. Median staminode of outer whorl always reduced. Labellum formed from lateral 2 staminodes of inner whorl. Fertile stamen median, of inner whorl; filament long or short; anther locules 2, introrse, dehiscing by slits or occasionally pores; connective often extended basally into spurs and/or apically into a crest. Ovary inferior, 3-loculed initially, 1- or 3-loculed when mature; ovules ± numerous per locule; placentation parietal, basal or axile. Developed style 1, very thin, placed in a furrow in filament and between anther locules; stigma appearing above anther, funnelform, papillose, ± wet, margin often ciliate. Stylodes 2, reduced to nectaries at apex of ovary. Fruit a capsule, fleshy or dry, dehiscent or indehiscent, sometimes berrylike. Seeds few to many, arillate; aril often lobed or lacerate (Zhengyi and Raven, 2004).

The family contains about 50 genera and 1300 species: pantropical with center of diversity in South and South East Asia, some species in America and subtropical and warm-temperate Asia (Zhengyi and Raven, 2004).

1.2 Amomum Roxburgh, Pl. Coromandel. 3: 75. 1820. nom. cons.

Rhizomes widely creeping. Pseudostems elongate. Leaf sheath long; ligule entire or 2-lobed; leaf blade usually oblong-lanceolate, oblong, or linear. Inflorescence arising from rhizomes, a densely flowered spike or spikelike raceme or panicle; peduncle short or rather long, clothed with imbricate, scalelike sheaths; involucre absent; bracts imbricate, persistent, sometimes soon disintegrating; bracteoles usually tubular. Calyx usually tubular, apex 3-toothed. Corolla tube cylindric; lobes oblong or linear-oblong, central one erect, usually wider and more convex than lateral ones. Lateral staminodes subulate, small, or absent. Labellum conspicuous, usually yellow or orange at center, with some red veins or marks, often white at margin, usually obovate, broadly concave. Filament well developed; anther locules parallel or diverging; connective appendage extending beyond apex of anther, entire or 3-lobed. Ovary 3-loculed; ovules many per locule, superposed. Style filiform; stigma usually funnelform, small, ciliate. Capsule irregularly dehiscent or indehiscent, smooth, prickly, or winged. Seeds oblong or many angled; aril fleshy or membranous, apex laciniate.

About 150 species: tropical Asia and Australia. (Dahlgren, 1985, Hooker, 1954 and Zhengyi and Raven, 2004).

In Thailand, 14 species of *Amomum* are enumerated for a preliminary checklist of the Zingiberaceae of Thailand, Thai Forest Bullentin No. 24 (The Forest Herbarium, 1996), 6 species printed in Thai plant names (เต็ม สมิตินันทน์, 2544), 8 species were studied at Tak Province about morphology and isozyme patterns by Malee Panunumpa (มาลี ภาณุนำภา, 2536) and not less than 11 species are collected at Forest Herbarium (BKF), National park, wildlife and plant conservation department, Bangkok. All species are shown in Table 1.

Table 1. *Amomum* species in Thailand

Thai Forest Bullentin No. 24 (The Forest Herbarium, 1996)	**Thai plant names (เต็ม สมิตินันทน์, 2544)**	**Malee Panunumpa's study (มาลี ภาณุนำภา, 2536)**	**Specimens are collected at Forest Herbarium (BKF)**
Amomum aculeatum Roxb.		/	/
A. dealbatum Roxb.	/		/
A. hastilabrum Ridl.			/
A. lappaceum Ridl.		/	/
A. ovoideum Pierre ex Gagnep.	/		/
A. siamensis Craib			/
A. testaceum Ridl.	/	/	/
A. uliginosum Koenig	/	/	/
A. biflorum Jack	*A. villosum* Lour. var. *villosum*	*A. dictyocoleum* K. Schum.	*A. spiceum* Ridl.
A. globba C. F.	*A.villosum* Lour. var.	*A. fulviceps* Thw.	*A. squarrosum* Ridl.
A. hirticalyx K. Schum.	*xanthioides* (Wall. ex Baker)	*A. littorale* Koenig	*A.villosum* Lour. var.
A. koenigii Gmelin	T. L. Wu & S. Chen	*A. vespertilio* Gagnep.	*xanthioides* (Wall. ex Baker)
A. pierreanum Gagnep.			T. L. Wu & S. Chen
A. rivale Ridl.			

Lacal name of *Amomum* spicies in Thai plant names (เต็ม สมิตินันทน์, 2544).

1. *Amomum dealbatum* Roxb.

   [Ka (ก๊า) (Northern)].

2. *A. ovoideum* Pierre ex Gagnep.

   [Reo daeng (เร่วแดง) (Trat)].

3. *A. testaceum* Ridl.

   Synonym : *A. krervanh* Pierre ex Gagnep.

   [Krawan (กระวาน) (Chanthaburi, Pattani); Krawan khao (กระวานขาว), Krawan phothisat (กระวานโพธิสัตว์) (Central); Pla ko (ปลาก้อ) (Pattani); Camphor seed, Siam cardamon].

4. *A. uliginosum* K. D. Koenig

   [Krawan pa (กระวานป่า) (Pattani); Reo (เร่ว) (Southeastern)].

5. *A. villosum* Lour. var. *villosum*

   [Reo dong (เร่วดง) (Trat)].

6. *A. villosum* Lour. var. *xanthioides* (Wall. ex Baker) T. L. Wu & S. Chen

   Synonym : *A. xanthioides* Wall. ex Baker

   [Pha-la (ผาลา) (Shan-Chiang Mai); Mamak i (มะหมากอี้), Ma i (มะอี้), Mak i (หมากอี้) (Chiang Mai); Reo (เร่ว) (Central); Mak neng (หมากเน็ง) (Northeastern); Mak naeng (หมากแหน่ง) (Saraburi); Bastard cardamom, Tavoy cardamom].

Amomum uliginosum K. D. Koenig

Observ. Bot. 3: 56 (1783).

Thai name: Krawaan paa (Pattani, Thailand) (เต็ม สมิตินันทน์, 2544 and Padua *et al*, 1999); Reo (Southeastern, Thailand) (เต็ม สมิตินันทน์, 2544).

Other name: Bastard cardamom (Vallisuta and Vongratanastit, 1976); puar hijau, puar gajah, tepus merah (Peninsular, Malaysia) (Padua *et al*, 1999);

Distribution: Thailand and Peninsular Malaysia.

Ecology: In lowland forest and on river banks, up to 1000 m altitude.

A large herb up to 300 cm tall, with subterranean, long and much branched rhizome, leafy shoots widely apart; leaves narrowly lanceolate, up to 50 cm x 7 cm, with caudate apex; inflorescence small and globose, up to 5 cm long, on peduncle up to 10 cm long, bracts 2.5- 3 cm long, bracteoles about 2 cm long, tubular at the base; flowers with corolla tube as long as or slightly longer than calyx, labellum ovate and strongly concave, white, sometimes with 2 dark red spots at base and with a dark crimson stripe on each side, anther with a 3-lobed appendage having spreading side lobes; fruit up to 2 cm long, covered by slender and soft spines (Padua *et al*, 1999).

Amomum xanthioides Wallich ex Baker

Hook.f., Fl. Brit. India 6: 239 (1892).

Synonymes: *Amomum villosum* Lour. var. *xanthioides* (Wall. ex Baker) T.L.Wu & S.Chen (1978); *A. villosum* var. *nanum* H. T. Tsai&S. W. Zhao. (Zhengyi and Raven, 2004).

Thai name: Pha-la (Shan-Chiang Mai); Mamak I,Ma i, Mak i (Chiang Mai); Reo (Central); Mak neng (Northeastern); Mak naeng (Saraburi) (เต็ม สมิตินันทน์, 2544).

Other name: Bastard cardamom, tavoy cardamom (English) (เต็ม สมิตินันทน์, 2544; Bown, 1995; Grieve, 1994; Norman and Bunyapraphatsara, 1992 and Trease and Evans, 1996); sa nh[aa]n, s[us]c sa m[aaj]t (Vietnam) (Padua *et al*, 1999); suo sha ren (China) (Zhengyi and Raven, 2004).

Distribution: India, Laos, Cambodia, Vietnam, southern China and Thailand (Padua et al, 1999 and Zhengyi and Raven, 2004).

Ecology: In forest, often in mountainous areas, and usually on wet soils (Padua et al, 1999). In China, cultivated in wet and shady places in sparse forests, 100--800 m. (Zhengyi and Raven, 2004).

A large herb up to 300 cm tall, with thick rhizome; leaves narrowly ovate-lanceolate, up to 40 cm x 9 cm; inflorescence ascending, on peduncle up to 8 cm long, with few flowers, bracts membranous, bracteoles tubular at the base; flowers with corolla tube slightly longer than calyx, labellum spoon-shaped to almost circular and concave with emarginate apex, white with prominent middle vein, anther with a 3-lobed appendage having ear-shaped side lobes; fruit 1.5-2 cm long, yellowish-green and covered by small spines, difficult to break into 3 fragments (Padua *et al*, 1999).

2. Chemical Compositions of Genus *Amomum*

Different parts of *Amomum* plants have been studied for their chemical compositions. The list of chemical compositions of *Amomum* plants are shown in Table 2.

Table 2 Chemical compositions of *Amomum* plants

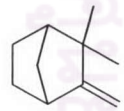
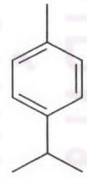
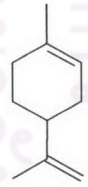
Compound	Structure	Sources	Plant part	Reference
Monoterpene hydrocarbons				
Camphene		*Amomum globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
p-Cymene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978 and
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
Limonene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Hazarika and Nath, 1995 and Lawrence *et al.*, 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

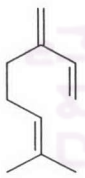
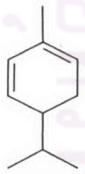
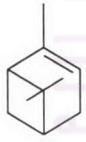
Compound	Structure	Sources	Plant part	Reference
Myrcene		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
α-Phellandrene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. medium Loureiro	Seed	Takido *et al.*, 1978
α-Pinene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

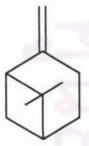
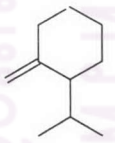
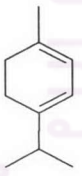
Compound	Structure	Sources	Plant part	Reference
β-Pinene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
Sabinene		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
α-Terpinene		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. subulatum Roxb.	Fruit	Lawrence, 1970
γ-Terpinene		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. subulatum Roxb.	Fruit	Lawrence, 1970

Table 2 Chemical compositions of *Amomum* plants (continued)

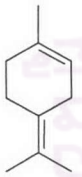
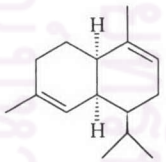
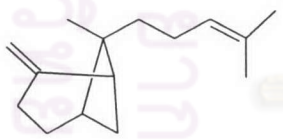
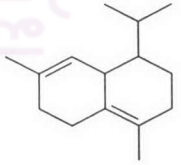
Compound	Structure	Sources	Plant part	Reference
Terpinolene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
Sesquiterpene hydrocarbons				
α-Amorphene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
trans-α-Bergamotene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
δ-cadinene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

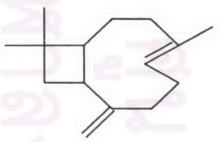
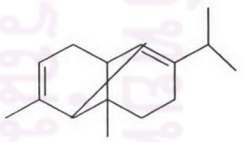
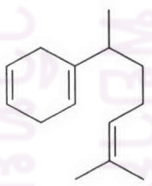
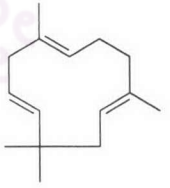
Compound	Structure	Sources	Plant part	Reference
Caryophyllene		*A. testaceum* Rild.	Fruit	Lawrence *et al.*, 1972
Copaene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
Curcumene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1972
Humulene		*A. testaceum* Rild.	Fruit	Lawrence *et al.*, 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

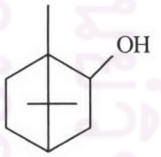
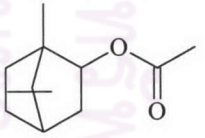
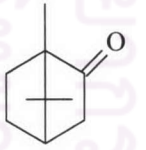
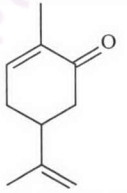
Compound	Structure	Sources	Plant part	Reference
Oxygenated momoterpenes				
Borneol		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. testaceum Rild.	Seed	ทรงโปรด และ ธวัชชัย, 2529
		A. villosum Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988
Bornyl acetate		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. villosum Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988
Camphor		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. villosum Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988
Carvone		*A. testaceum* Rild.	Fruit	Lawrence *et al.*, 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

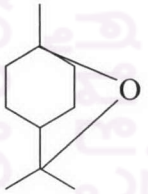
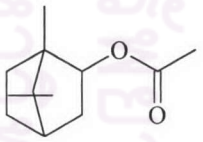
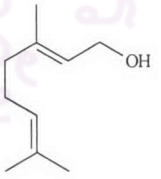
Compound	Structure	Sources	Plant part	Reference
1,8-Cineole		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. linguiforme Benth.	Fresh rhizome	Hazarika and Nath, 1995
		A. medium Loureiro	Seed	Takido *et al.*, 1978
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Seed	ทรงโปรด และ ธวัชชัย, 2529
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
Fenchyl acetate		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
Geraniol		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
		A. korarima Pereira	Fruit	Lawrence, 1970
		A. villosum Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988

Table 2 Chemical compositions of *Amomum* plants (continued)

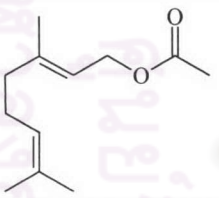
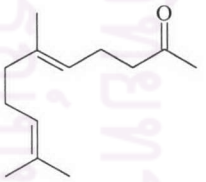
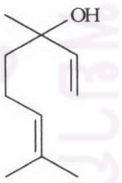
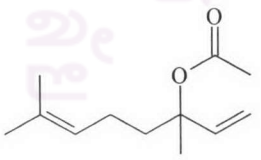
Compound	Structure	Sources	Plant part	Reference
Geranyl acetate		A. *globosum* Lour. A. *villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Fresh fruit Seed	Lawrence *et al.*, 1971 and 1972 Vibuljan, 1988
Geranyl acetone		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
Linalool		*A. globosum* Lour. *A. linguiforme* Benth.	Fresh fruit Fresh rhizome	Lawrence *et al.*, 1971 and 1972 Hazarika and Nath, 1995
Linalyl acetate		*A. testaceum* Rild.	Seed	ทรงโปรด และ ธวัชชัย, 2529

Table 2 Chemical compositions of *Amomum* plants (continued)

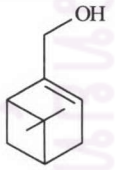
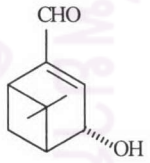
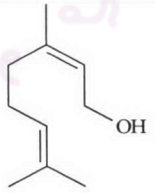
Compound	Structure	Sources	Plant part	Reference
Myrtenal		*A. testaceum* Rild.	Fruit	Kamchonwongpaisan *et al.*, 1995 and Lawrence *et al.*, 1972
Myrtenol		*A. testaceum* Rild.	Fruit	Kamchonwongpaisan *et al.*, 1995
4-Hydroxymyrtenal		*A. testaceum* Rild.	Fruit	Kamchonwongpaisan *et al.*, 1995
Nerol		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972

Table 2 Chemical compositions of *Amomum* plants (continued)

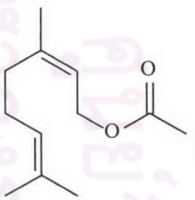
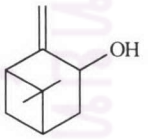
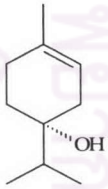
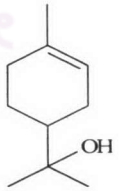
Compound	Structure	Sources	Plant part	Reference
Neryl acetate		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
trans-Pinocarveol		*A. testaceum* Rild.	Fruit	Kamchonwongpaisan *et al.*, 1995
Terpinen-4-ol		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. subulatum Roxb.	Fruit	Lawrence, 1970
		A. testaceum Rild.	Fruit	Lawrence *et al.*, 1972
α-Terpineol		*A. korarima* Pereira	Fruit	Lawrence, 1970
		A. subulatum Roxb.	Fruit	Lawrence, 1970

Table 2 Chemical compositions of *Amomum* plants (continued)

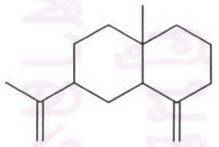
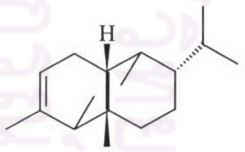
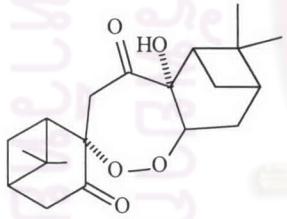
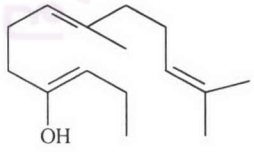
Compound	Structure	Sources	Plant part	Reference
δ-Selinene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
α-Ylangene		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971 and 1972
Oxygenated diterpenes				
(1*S*,5*R*)-2-pinen-10-ol		*A. testaceum* Rild.	Fruit	Kamchonwongpaisan *et al.*, 1995
Oxygenated sesquiterpenes				
Farnesol		*A. globosum* Lour.	Fresh fruit	Lawrence *et al.*, 1971

Table 2 Chemical compositions of *Amomum* plants (continued)

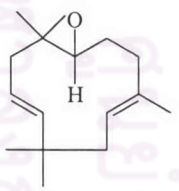
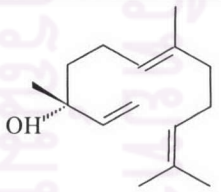
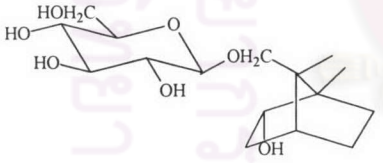
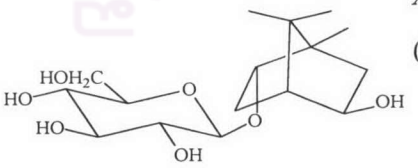
Compound	Structure	Sources	Plant part	Reference
Humulene epoxide		*A. testaceum* Rild.	Fruit	Lawrence *et al.*, 1972
Nerolidol		*A. globosum* Lour. *A. subulatum* Roxb.	Fresh fruit Fruit	Lawrence *et al.*, 1971 Lawrence, 1970
Monoterpene glucosides				
(1*R*,2*S*,4*R*,7*S*)-vicodiol 9-*O*-β-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
(1*R*,2*S*,4*S*,5*R*)-angelicoidenol 2-*O*-β-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003

Table 2 Chemical compositions of *Amomum* plants (continued)

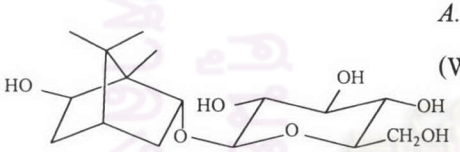
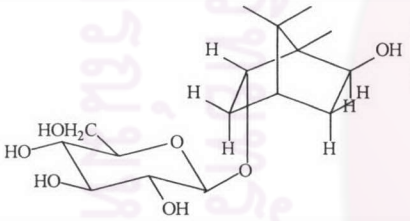
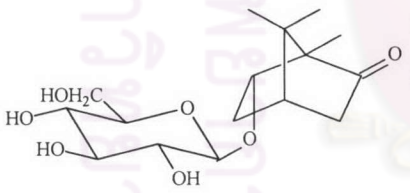
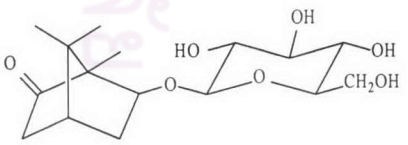
Compound	Structure	Sources	Plant part	Reference
(1*R*,2*R*,4*S*,6*R*)-bornane-2,6-diol 2-*O*-*β*-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
(1*S*,2*S*,4*R*,6*S*)-bornane-2,6-diol 2-*O*-*β*-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
(1*R*,4*S*,6*S*)-6-hydroxycamphor *β*-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
(1*S*,4*R*,6*S*)-6-hydroxycamphor *β*-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003

Table 2 Chemical compositions of *Amomum* plants (continued)

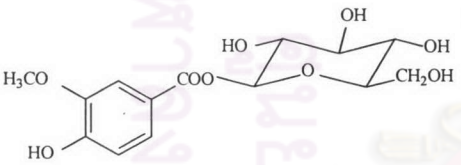
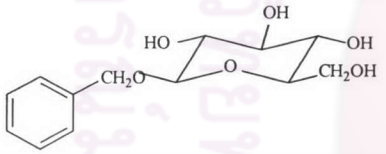
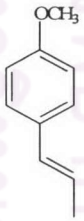
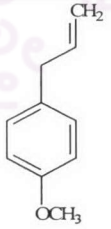
Compound	Structure	Sources	Plant part	Reference
Vanillic acid β-D-glucopyranosyl ester		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
Benzyl β-D-glucopyranoside		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
Miscellaneous				
trans-Anethol		*A. linguiforme* Benth.	Fresh rhizome	Hazarika and Nath, 1995
Methyl chavicol		*A. linguiforme* Benth.	Fresh rhizome	Hazarika and Nath, 1995

Table 2 Chemical compositions of *Amomum* plants (continued)

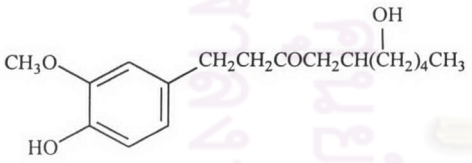
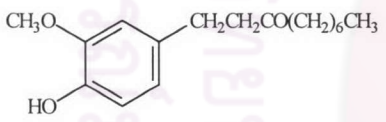
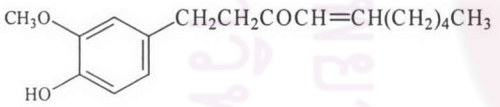
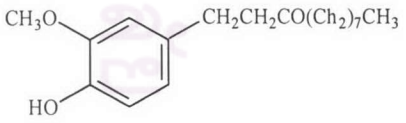
Compound	Structure	Sources	Plant part	Reference
(6)-Gingerol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
(6)-Paradol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
(6)-Shogaol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
(7)-Paradol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975

Table 2 Chemical compositions of *Amomum* plants (continued)

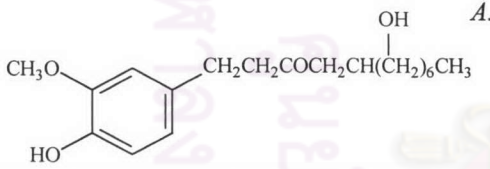
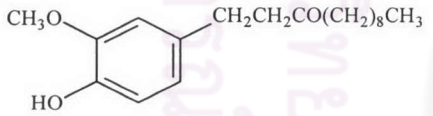
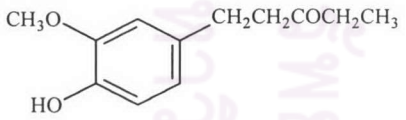
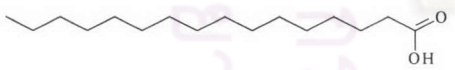
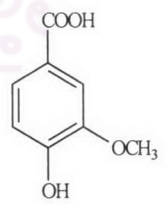
Compound	Structure	Sources	Plant part	Reference
(8)-Gingerol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
(8)-Paradol		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
Zingerone		*A. melegueta* Roscoe	Seed	Tackie *et al.*, 1975
Palmitic acid		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988
Vanillic acid		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Vibuljan, 1988

Table 2 Chemical compositions of *Amomum* plants (continued)

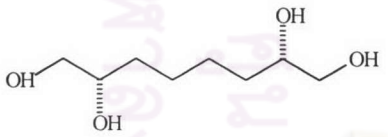
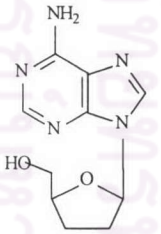
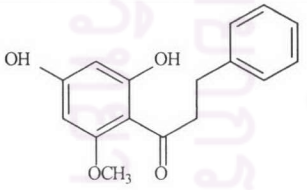
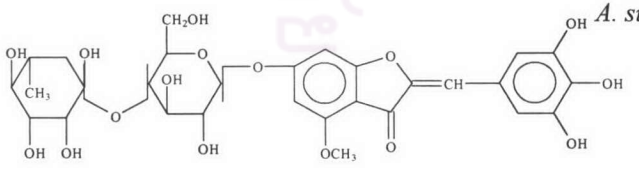
Compound	Structure	Sources	Plant part	Reference
(2*S**,7*S**)-(-)-octane-1,2,7,8-tetrol		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
Adenosine		*A. villosum* Lour. var. *xanthioides* (Wall. ex Bak.) T.L. Wu&Senjen	Seed	Kitajima and Ishikawa, 2003
Cardamonin (2′,4′-dihydroxy-6′-methoxy chalcone)		*A. subulatum* Roxb.	Seed	Rao *et al.*, 1976
Subulin		*A. subulatum* Roxb.	Seed	Lakshmi and Chauhan, 1977

Table 2 Chemical compositions of *Amomum* plants (continued)

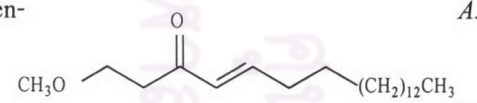
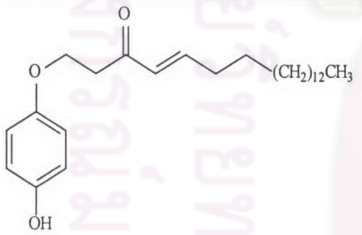
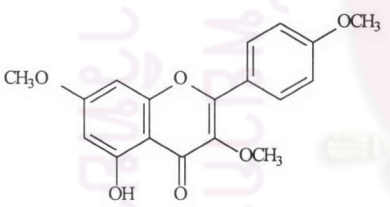
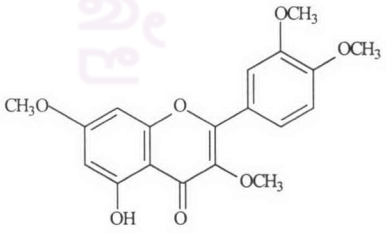
Compound	Structure	Sources	Plant part	Reference
l-methoxy-*E*-4-eicosen-3-one		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
l-(4′-hydroxy-phenoxy)-*E*-4-eicosen-3-one		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
5-hydroxy-3,7,4′-trimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
5-hydroxy-3,7,3′,4′-tetramethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999

Table 2 Chemical compositions of *Amomum* plants (continued)

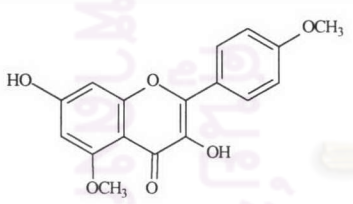
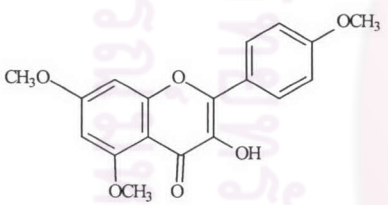
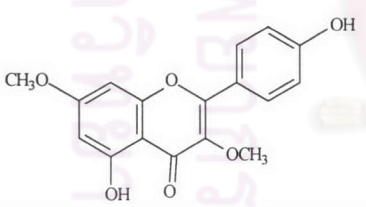
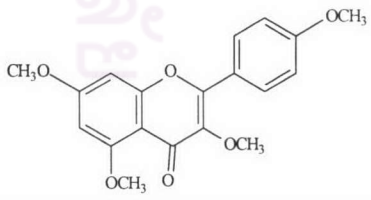
Compound	Structure	Sources	Plant part	Reference
3,7-dihydroxy-5,4′-dimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
3-hydroxy-5,7,4′-trimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
5,4′-dihydroxy-3,7-dimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
3,5,7,4′-tetramethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999

Table 2 Chemical compositions of *Amomum* plants (continued)

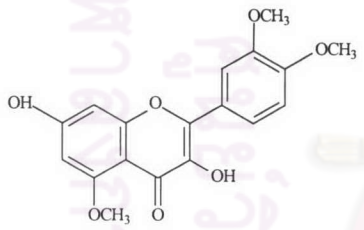
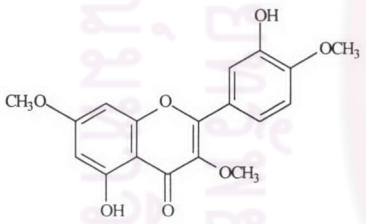
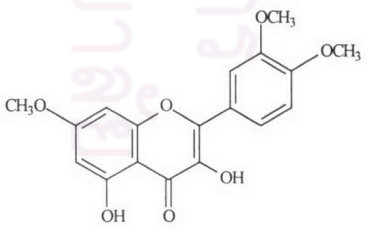
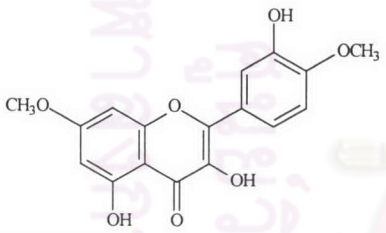
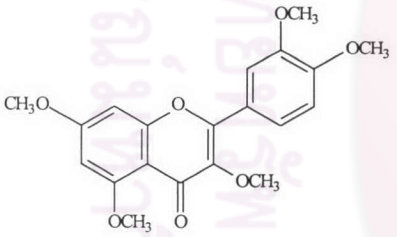
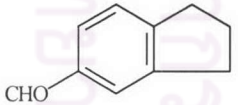
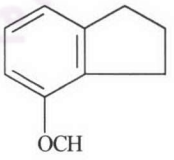
Compound	Structure	Sources	Plant part	Reference
3,7-dihydroxy-5,3′,4′-trimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
5,3′-dihydroxy-3,7,4′-trimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
3,5-dihydroxy-7,3′,4′-trimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999

Table 2 Chemical compositions of *Amomum* plants (continued)

Compound	Structure	Sources	Plant part	Reference
3,5,3′-trihydroxy-7,4′-dimethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
3,5,7,3′,4′-pentamethoxyflavone		*A. koenigii* J. F. Gmelin	Fruit	Dong *et al.*, 1999
lH-indene-2,3-dihydro-5-carboxaldehyde		*A. medium* Loureiro	Seed	Takido *et al.*, 1978
lH-indene-2,3-dihydro-4-carboxaldehyde		*A. medium* Loureiro	Seed	Takido *et al.*, 1978

3. Biological Activities

Biological activities of *Amomum* are shown in Table 3.

Table 3 Bioactivity of *Amomum*

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
Amomum aculeatum Roxb.	Dried rhizome	Petroleum ether extract - Aculeatin D	1. Cytotoxicity: KB cells (IC_{50} 0.38 g/ml) and L-6 cells (IC_{50} 1.00 g/ml). 2. Antiprotozoal activity: *Plasmodium falciparum* strain NF54 (IC_{50} 0.42 g/ml) and strain K1 (IC_{50} 0.47 g/ml); *Trypanosoma cruzi* (IC_{50} 0.49 g/ml) and *T.b.rhodesiense* (IC_{50} 0.20 g/ml). 3. Antibacterial activity: *Bacillus cereus* and *Escherichia coli* (MIC 16 g/ml) and *Staphylococcus epidermidis* (MIC 8 g/ml).	Heilmann *et al.*, 2001
		- 5-Hydroxy-hexacos-1-en- 3-one	Antibacterial activity: *Bacillus cereus* (MIC 32 g/ml); *Escherichia coli* (MIC 64 g/ml) and *Staphylococcus epidermidis* (MIC 16 g/ml).	

Table 3 Bioactivity from *Amomum* (continued)

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
A. cannicarpum (Wight.) Bentham ex Baker	Rhizomes	- Petroleum ether extract	Antibacterial activity: 100 µg/disc (disc diffusion): *Bacillus subtilis* (8 mm); *Staphylococcus aureus* No.740 (5 mm); *Staphylococcus aureus* No. 2940 (12 mm); *Pseudomonas fluorescens* (20 mm); *Ps. aeruginosa* (6 mm); *Klebsiella pneumoniae* (8.5 mm); *Escherichia coli* (5 mm); *Salmonella typhi* (13.5 mm) and *Arthrobacter protophormiae* (7.5 mm).	Mathew *et al.*, 2003
		- Methanol extract	*B. subtilis* (4 mm); *Ps. aeruginosa* (6.5 mm); *K. pneumoniae* (6 mm) and *A. protophormiae* (7.5 mm).	
A. kepulaga Sprague & Burkill	Rhizomes	- Acetone, n-hexane and ethyl acetate extracts	Antioxidant activity: thiocyanate and TBA methods (moderate antioxidant activity).	Jitoe, A. *et al.*, 1992

Table 3 Bioactivity from *Amomum* (continued)

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
A. subulatum Roxb.	Dried fruit		Anti-ulcerogenic effect: % inhibit the gastric lesions induced by ethanol 96% in Albino rats.	Jafri *et al.*, 2001
		- Total MeOH extract	Dose 1720 mg/kg, % inhibit 81.9 (dose dependent).	
		- Petroleum ether fraction	Dose 262 mg/kg, inhibition by 77.34% and increase the wall mucus.	
		- Ethyl acetate fraction	Dose 196 mg/kg, inhibition by 84.53 % and increase the wall mucus.	
		- Residue	Dose 790 mg/kg, inhibition by 71.82%.	
		- Petroleum ether fraction	Constituents other than essential oil are also involved in gastroprotective action.	
		- Essential oil (steam distillation)	Dose 200 mg/kg, inhibition by 88.63%.	
			Dose 200 mg/kg, inhibition by 73.86%.	
		- Total MeOH extract	Toxicity study not found (albino mice).	

Table 3 Bioactivity from *Amomum* (continued)

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
A. subulatum Roxb.	Fresh leaves	- Essential oil (Hydrodistillation)	100% Inhibit of fungus: *Alternaria alternate*; *A. tenuis*; *Aspergillus flavus; A. fumigatus*; *A. sulphureus*; *Cladosporium herbarum*; *Colletotrichum sp.*; *Curvularia lini*; *C. lunata*; *C. pallescens*; *Fusarium oxysporum*; *F. poae*; *F.solani*; *Helminthosporium oryzae* and *Penicillium citrinum* (MIC 3000-4000 ppm).	Mishra and Dubey, 1990
	Fruits	- Essential oil (steam distillation)	Antifungal activity: *Aspergillus flavus* (200 µg/ml; linear growth of culture; % Inhibit 18.2).	Rahman *et al.*, 1999
	Seeds	- Methanol extract	Antibacterial activity: 20 mg/ml (agar well-diffusion): *Klebsiella pneumoniae* (10 mm); *Staphylococcus aureus* (15 mm); *Bacillus bronchiseptica* (14 mm); *B. cereus* (15 mm) and *B. pumilis* (12 mm).	Bonjar, 2004

Table 3 Bioactivity from *Amomum* (continued)

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
A. testaceum Rild. (syn. *A. krervanh* Pierre)	Fruit	- Hexane extract	Antimalarial activity: *Plasmodium falciparum* (EC_{50} ranging from 5 to 50 μM).	Kamchonwongpaisan *et al.*, 1995
		- Myrtenal, myrtenol and *trans*-pinocarveol	Antimalarial activity: *P. falciparum* (EC_{50} ranging from 5 to 50 μM).	
		- 4-Hydroxymyrtenal	Antimalarial activity: *P. falciparum* (EC_{50} 192 μM).	
		- (1*S*,5*R*)-2-pinen-10-ol	Antimalarial activity: *P. falciparum* (EC_{50} 0.17 μM).	
		- Volatile oil (steam distillation)	Acute toxicity: rats (LD_{50} 2.52 g/kg in male and 2.65 g/kg in female).	
	Seed	- Alcohol extract	Inhibited intestinal smooth muscle contraction of a guinea pigs that stimulated by acetylcholine (dose dependent).	ทรงโปรด และ ธวัชชัย, 2529

Table 3 Bioactivity from *Amomum* (continued)

Plant	Part used	Extraction/ Chemical compound	Activity	Reference
A. villosum Lour. var. *xanthioides* (Wall. ex Bak.) T. L. Wu & Senjen (Syn. *A. xanthioides* Wall. ex Bak.)	Seed	Ethanol and methanol extract	Inhibitory effect on gastric acid secretion: (rats and mices)	Yamazaki, 2000
	Fruit	Water extract	Inhibition of NFkB activation and protective effect against alloxan-induced diabetics: pancreatic tissue of female ICR mice	Park, B. H. and Park, J. W., 2001
	Fruit	Methanol extract	Inhibitory activity of COX-2 and iNOS: cultures mouse macrophages RAW264.7 cells (6.1 and 58.7% inhibition at the test concentration of 10 μg/ml, respectively).	Hong *et al.*, 2002
	Fruit	Water extract	Inhibition of nitric oxide formation and prevents cytokine-induced cell death: insulinoma cell line cultured (RINm5F).	Kwona *et al.*, 2003

4. Volatile oil extraction

Naik, Lentz and Maheshwari studied on different plant materials including cardamom, clove, cumin, fennel, ginger, parsley and sandalwood. Those materials were extracted with liquid carbon dioxide and compared to the conventional steam distillation. The results were shown that the yields of the CO_2 extractions were 10% to 360% larger than the yields of the steam distillation, while the extraction time is only 1/2 to 1/10 of the time needs for steam distillation (Naik *et al.*, 1989).