Pungent Principal of *Alpinia galangal* (L.) Swartz and Its Applications

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The pungent principal of galangal [*Alpinia galangal* (L.) Swartz] rhizomes was isolated and identified as 1′-acetoxychavicol acetate (galangal acetate). Galangal acetate exhibits a unique pungent sensation, which is less intense than that of capsaicin and without a lingering effect. Applications of galangal acetate were tested in beverages, sweet goods, dressings, and personal care products. In many applications, galangal acetate is preferred to other pungent ingredients. It can be used as an alcohol enhancer or an alcohol replacer in alcohol and alcohol-free beverages. Galangal acetate is not stable in aqueous solutions and undergoes hydrolysis/isomerization reactions. Therefore, galangal acetate was absent in galangal essential oil obtained by steam distillation. However, galangal acetate was found as one of the major volatile components of the galangal rhizomes by headspace GC analysis. The stability of galangal acetate was studied under various conditions.

Keywords: *Alpinia galangal; spice; pungency; flavor; 1′-acetoxychavicol acetate; galangal acetate*

INTRODUCTION

Galangal, also called galanga, galingale, galangale, and calangall, is a pungent aromatic rhizome produced in eastern Asia. There are two different species of galangal: one is the so-called lesser or smaller galangal (*Alpinia officinarum* Hance Farw.), a perennial herb native to China (Gao liang jiang), with pyramidal racemes of rose-veined white flowers; the other is the so-called greater galangal [*Alpinia galanga* (L.) Swartz. or *Languas galanga* (L.) Stuntz], a stemless perennial herb of southeastern Asia with fragrant short-lived, largely white flowers. In this paper we deal with greater galangal.

The rhizomes of galangal are widely used as spice or ginger substitutes for flavoring foods (e.g., meat and curries) throughout Asian countries. Galangal is also used as a stomach ache medicine in China (Hong dou kou) and in Thailand. The essential oil of galangal root is also used in perfuming. The biological activities of galangal have been intensively studied in recent years, and it is reported as possessing antitumor, pungency, antibacterial, antiulcer, antifungal, and insecticidal properties (Itokawa et al., 1987; Janssen and Scheffer, 1985; Kondo et al., 1993). The essential oil composition of galangal has been reported in several research articles [e.g., Lawrence et al. (1969), Scheffer et al. (1981), DePooter et al. (1985), and Charles et al. (1992)]. The antioxidant activities of galangal were also studied (Jitoe et al., 1992; Zheng et al., 1993).

Galangal has a unique flavor profile and is described as having more woody, minty, and floral aromas than ginger (Mori et al., 1995). The extract of galangal is used for liquor flavoring. Most recently, galangal oleoresin is also commercially available as a food spice. The appearance and taste of the galangal root are very similar to those of ginger. However, the chemical composition of galangal oleoresin is very different from that of ginger as indicated by a preliminary screening using HPLC. It is of great importance for spice processing and utilization to discover the pungent principles in galangal and to explore its potential for use in food, beverage, and other related products.

MATERIALS AND METHODS

Materials. Dry galangal root was imported from Indonesia, and frozen fresh galangal root was obtained in an oriental grocery store in Clifton, NJ (imported from Thailand). Galangal oleoresin was prepared by Soxhlet extraction of galangal roots with ethanol, and then the solvent was removed.

Fractionation for Screening. Galangal oleoresin, dissolved in ethanol (95%), was fractionated by flash chromatography (silica gel, 1 × 10 in., sample load ~0.6 g of oleoresin). The solvent systems were hexane/ethyl acetate (4:1), hexane/ethyl acetate (1:1), ethyl acetate, ethyl acetate/ethanol (4:1), ethyl acetate/ethanol (1:1), ethanol, and water. The eluate was collected in 20-mL test tubes and recombined into fractions according to the TLC results.

Extraction and Fractionation of Galangal Oleoresin. Galangal oleoresin was extracted with pentane. After the solvent was removed, the pentane extract was fractionated by flash chromatography (silica gel, 1 × 10 in.). A solvent system composed of hexane and methyl *tert*-butyl ether (MTBE) was used: hexane; hexane/MTBE (9:1); hexane/MTBE (4:1); hexane/MTBE (1:1); and MTBE. The eluate was collected and recombined into fractions. After the solvent was removed by rotary evaporation and then by a nitrogen stream, a few microliters of the concentrate were added to 0.5 mL of water containing 10% ethanol for sensory screening.

Hydrolysis of Galangal Acetate. Hydrolysis reactions of galangal acetate under various experimental conditions were carried out in a 0.02 M KH_2PO_4 buffer solution, and the concentration of galangal acetate was 100 ppm. The pH value of the buffer was adjusted to a predetermined value using diluted NaOH or HCl solution. After reaction, the mixture was extracted by hexane/MTBE (1:1) and analyzed by GC/MS. The specific experimental conditions are given in the corresponding figures.

Determination of Galangal Acetate and Its Reaction Products. The concentration of galangal acetate in dry galangal roots, frozen galangal roots, and galangal oleoresins was determined by GC analysis with external calibration. The relative concentrations of reaction products of galangal acetate were calculated on the basis of GC peak areas relative to that of galangal acetate.

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Analytical Instruments. GC/MS analysis was carried out on an HP 6890 gas chromatograph/HP 5972A quadrupole mass spectrometer system. Separation was mostly performed using a 30-m × 0.25-mm (i.d.) capillary column coated with a 1-mm film of DB-1 stationary phase (J&W Scientific, Folsom, CA). Helium was used as the carrier gas. The oven temperature program used was from 80 to 270 °C at a rate of 4 °C/min. The injector and transfer line temperatures were held at 250 °C. Injection was set as split with a ratio of 50:1. The mass spectrometer was operated with an ionization voltage of 70 eV and was scanned from *m/z* 35 to 400 at ~1 scan/s. Purification of galangal acetate was performed on a Waters HPLC system with a mobile phase of 75% methanol in water (flow rate = 4 mL/min). A 250-mm, 10-mm i.d. C18 column was used. IR spectra were recorded using the Perkin-Elmer system 2000 FTIR. A Varian Gemini 300 NMR (300 MHz) was used for the NMR analysis.

Sensory Evaluation of Galangal Acetate. Informal sensory screening was conducted during isolation and identification procedures. For evaluating the hotness of galangal acetate, five panelists were recruited and trained with different concentrations of capsaicin using a line scale. Synthesized galangal acetate (racemate) was used for sensory evaluation. All samples were served at room temperature in 1-oz soufflé cups. Unsalted crackers were provided, as well as water for rinsing, between tastings. Specific rinsing procedures were followed according to the ASTM method to reduce effects of desensitization and excitation (*Annual Book of ASTM Standards*, 1995). Synthetic 1′-acetoxychavicol acetate (99%) was used for the testing, and pelargonic acid vanillylamide (synthetic capsaicin, Fluka) was used as the reference.

RESULTS AND DISCUSSION

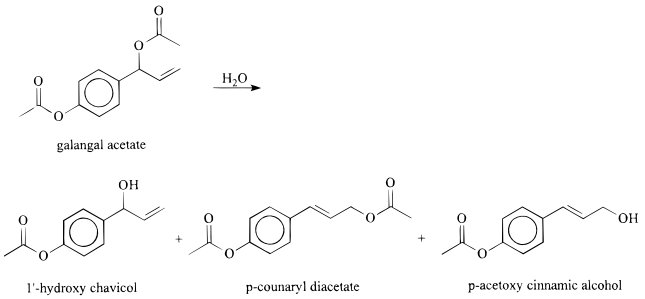
Preliminary Screening. Galangal oleoresin was fractionated by flash chromatography. Sensory testing (taste) was carried out by four panelists. Two fractions were found to be "hot". There were, however, two different hot sensations: One fraction had a "bite" effect and was described as heat similar to that of capsaicin; the other fraction had no "bite" effect and was described as astringent. The fraction described as a "bite" sensation was chosen as the analytical target, which is a relatively nonpolar fraction and also contains essential oil components. The other fraction is a relatively polar fraction.

Fractionation and Isolation. Because the hot principal component was found in a relatively nonpolar fraction in the preliminary experiments, further extraction on a larger scale was carried out using a nonpolar solvent. The galangal oleoresin was dissolved in 95% ethanol and then diluted with water. After extraction with hexane, the organic phase was dried and the solvent removed. For tasting, a small amount of the extract was dissolved in 10% ethanol. The extract was much hotter than the oleoresin. This clearly confirmed that the hot component(s) was (were) indeed in the hexane extract.

The extract was then fractionated into seven fractions (fractions A−G) by flash chromatography. The aqueous solution was tasted by four panelists. Fraction D was clearly identified as the major hot fraction. GC analysis revealed that fraction D contained a major component of 92%.

The major component in fraction D was purified further by semipreparative HPLC (C-18, 10 × 250 mm) with a mobile phase of 75% methanol in water (4 mL/min). The purity of this compound was >99% by GC/FID. The hot taste of this compound did not change after the purification. It is concluded that it is indeed the hot principal of galangal. This compound was analyzed by IR and MS. However, it is unknown in our mass spectra and IR spectra libraries and was subjected to further structural analysis.

Chart 1. Hydrolysis of Galangal Acetate



Identification. The compound isolated from fraction D was found to be a colorless oily liquid, although it can be crystallized by seeding its solution. The structure elucidation was based on IR, MS, and NMR spectra.

The IR spectrum showed strong absorptions at 1742 and 1204 cm^{-1}, which indicated the presence of a carbonyl C=O group and a single C−O bond. C−H valence stretching around 3000 cm^{-1} indicated C−H bonds both on unsaturated (>3000 cm^{-1}) and on aliphatic (2919, 2851 cm^{-1}) C-bonds. The aromatic C=C valence vibration also clearly showed up at 1608 and 1508 cm^{-1}. The IR spectrum suggested an aromatic ester.

In the mass spectrum of the pungent compound, the most abundant mass peaks were 192, 150, 132, and 43. The molecular weight of this compound was estimated as 234. Characteristic fragments included $CH_3-C\equiv O^+$ at *m/z* 43 from methyl ketones, $C_6H_5^+$ at *m/z* 77 from phenyl derivatives, and loss mass 42 (234 − 192, 192 − 150) due to formation of $CH_2=C=O$ by a McLafferty rearrangement.

The proton NMR spectrum showed 14 protons in the molecule. Two symmetrical doublets at 7.3 and 7.6 ppm indicated four protons on a para-substituted benzene ring. Proton resonances at 5.54 (2H, dd), 6.25 (1H, ddd), and 6.52 (1H, d) probably correspond to protons on an allyl group. Two methyl groups at 2.35 and 2.55 ppm suggested two acetyl groups. Carbon-13 APT and DEPT indicated 13 carbons: 2 CH_3, 1 CH_2, 6 CH, and 4 quaternary carbons. Two carbon signals at 169.8 and 169.9 ppm are typically from carboxyl groups. Two pairs of carbon atoms have identical chemical shifts at 121.6 and 128.4 ppm, confirming a para-substituted benzene ring. $^1H-^1H$ and $^1H-^{13}C$ correlation NMR experiments showed cross-peaks in COSY, HETCOR, and long-range HETCOR, clearly suggesting an allyl group and two acetyl groups. The chemical structure of the molecule isolated from fraction D is proposed as 1′-acetoxychavicol acetate (galangal acetate) (Chart 1).

Fraction E, one of the major components in the galangal extract, is a tasteless solid. It has IR, MS, and NMR spectra very similar to those of the hot component 1′-acetoxychavicol acetate. It is also unknown in our mass spectra and IR libraries. Structure elucidation concluded that it has the structure of *p*-coumaryl diacetate (Chart 1).

1′-Acetoxyeugenol acetate (Chart 2) was also found in galangal root and described as pungent. However, its concentration is much lower (2% of galangal acetate) in galangal roots. Therefore, the major contributor to galangal pungency is believed to be galangal acetate.

Chart 2. 1′-Acetoxyeugenol Acetate

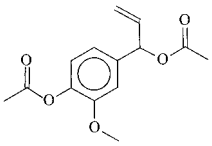


Table 1. Contents of 1′-Acetoxychavicol Acetate in Galangal

sample	% (w/w)	sample	% (w/w)
dry galangal	2.4	oleoresin (lot 1)	3.7
frozen fresh galangal	0.6	oleoresin (lot 2)	4.7

Table 2. Composition of Starting Material and Its Reaction Mixture (Percent)

component	starting material	2 h of reflux	24 h of storage
1′-hydroxychavicol acetate	nd[a]	37.6	22.6
1′-acetoxychavicol acetate	97.4	nd	62.0
p-acetoxycinnamic alcohol	nd	53.9	11.3
p-coumaryl diacetate	0.2	5.9	3.1

[a] nd, not detected.

A literature search revealed that galangal acetate is known as a component in galangal and was described as an antiulcer, antifungal, and antitumor substance, a xanthine oxidase inhibitor, and an inhibitor of Epstein−Barr virus activation and phagocytosis (Watanabe et al., 1995). The synthesis method is also described (Mitsui et al., 1976). *p*-Coumaryl diacetate is also known as an inhibitor of xanthine oxidase (Noro et al., 1988). Synthesis of galangal acetate verified the chemical structure (Bachmann et al., 1997).

Concentration of Galangal Acetate in Galangal. The concentration of galangal acetate was determined in dried galangal roots, frozen fresh galangal roots, and galangal oleoresin (Table 1). The samples were extracted by hexane and analyzed by GC. Although galangal has a high concentration of galangal acetate, it was not reported as a component in galangal essential oils (Lawrence et al., 1969; Scheffer et al., 1981; DePooter et al., 1985; Charles et al., 1992; Rui et al., 1982; Xue et al., 1987). Galangal acetate was found in trace amounts in an extract by simultaneous distillation extraction but was one of the major GC peaks by headspace analysis of galangal roots in our laboratory.

Hotness of Galangal Acetate. Synthetic galangal acetate (racemic) was used for the sensory evaluation. From an informal evaluation of galangal acetate solution, it was described as spicy with a quicker onset of heat sensation as compared to capsaicin. The heat sensation was perceived initially at the tip of tongue, which then spread to the rest of the oral cavity and throat. Compared to the pungent type of heat sensation from capsaicin, galangal acetate was described as being less pungent and less warming. Scoville heat units for four concentrations of galangal acetate were obtained using the ASTM standard method of evaluating red pepper heat (*Annual Book of ASTM Standards*, 1995). A linear correlation was obtained between the strength of heat and the concentration of galangal acetate within the tested range (Table 3).

Stability of Galangal Acetate. During the isolation experiments and sensory evaluation, it was found that 1′-acetoxychavicol acetate was not stable in aqueous solution. After an aqueous solution had stood for a few hours at room temperature, the pungent taste of the aqueous solution (10% ethanol) of galangal acetate disappeared. Because the stability of galangal acetate is one of the determining factors for its applicability in food systems, it is of great interest to study the reaction products and reaction mechanism.

Table 3. Comparison of Hotness of Galangal Acetate and Capsaicin

concn of galangal acetate (ppm)	av Scoville heat units ($N = 5$)	calcd concn of capsaicin (ppm)
5	45543	0.69
10	55593	0.85
15	60317	0.92
20	67854	1.03

Chart 3. Proposed Reaction Intermediate

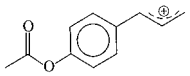
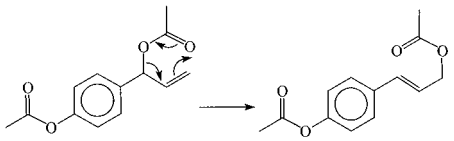


Chart 4. Proposed Sigmatropic Rearrangement of Galangal Acetate



We refluxed a 100 ppm aqueous solution of galangal acetate for 2 h. The aqueous solution was no longer pungent after reflux. The reaction products were extracted with methylene chloride and analyzed by GC/MS. The starting material was not detectable in the reaction mixture. Three major products were identified as 1′-hydroxychavicol acetate, *p*-acetoxycinnamic alcohol, and *p*-coumaryl diacetate (Chart 1) by comparison of their mass spectra with reference mass spectra.

It was reported that 1′-acetoxychavicol acetate undergoes hydrolysis reactions when refluxed with water, and *p*-acetoxy-*trans*-cinnamic alcohol and 1′-hydroxychavicol acetate were the hydrolysis products (Xue et al., 1987). *p*-Coumaryl diacetate was not reported as a reaction product of galangal acetate under hydrolysis conditions in the literature. Mori and co-workers also observed the instability of galangal acetate during steam distillation (Mori et al., 1995).

An aqueous solution of galangal acetate (100 ppm, 1% ethanol) was stored at ambient temperature. The pungency of the solution was reduced after overnight storage. Analysis of the stored solution also found the three hydrolysis products mentioned above. The relative concentrations of the hydrolysis products are shown in Table 2.

The formation of galangal acetate and *p*-acetoxycinnamic alcohol is probably through an acid-catalyzed S_N1 reaction mechanism, and the carbocation shown in Chart 3 is probably involved as the intermiediate.

The isomerization of galangal acetate to *p*-coumaryl diacetate looks like a [3,3] sigmatropic rearrangement, which occurs when 1,5-dienes are heated (Chart 4). *p*-Coumaryl diacetate can also be derived from the intermediate as shown in Chart 3.

Temperature certainly plays an important role in the hydrolysis reactions. If the aqueous solution of 100 ppm galangal acetate is stored in the refrigerator, it remains "hot" for at least several days. All hydrolysis products mentioned above are not pungent or much less pungent than galangal acetate. Therefore, the hydrolysis reactions lead to instability of the pungency of this com-

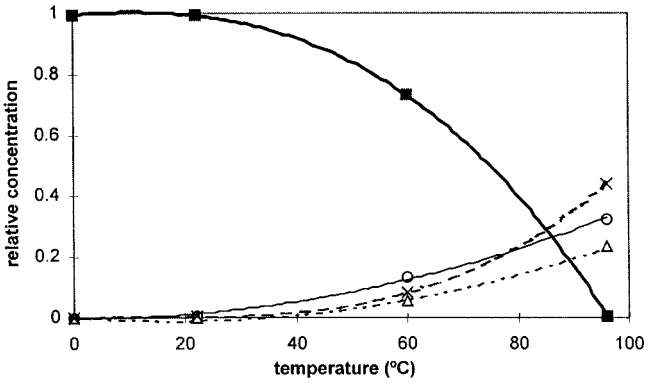


Figure 1. Temperature effect on reactions of galangal acetate in 5% ethanol for 1 h: (○) 1′-hydroxychavicol acetate; (■) galangal acetate; (△) *p*-acetoxycinnamic alcohol; (×) *p*-coumaryl diacetate.

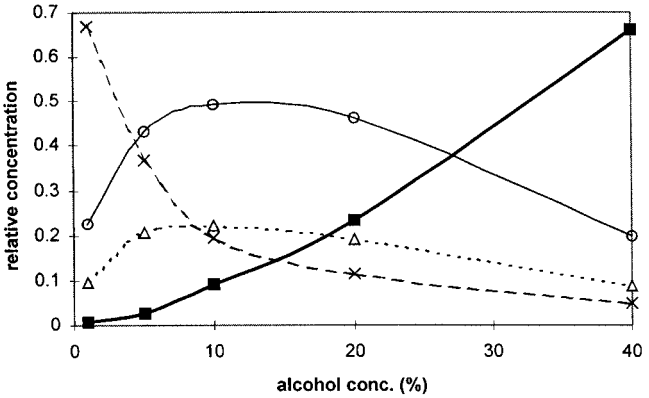


Figure 2. Ethanol concentration effect on reactions of galangal acetate at 60 °C for 5 h: (○) 1′-hydroxychavicol acetate; (■) galangal acetate; (△) *p*-acetoxycinnamic alcohol; (×) *p*-coumaryl diacetate.

pound. The stability of galangal acetate was further studied under various experimental conditions.

Temperature. Under hydrolytic conditions, the reaction rate of galangal acetate increases with increasing temperature. In 5% ethanol solution, the starting material is almost completely converted after 1 h of reflux. At room temperature, the reaction is slow. At higher temperature, the isomerization rate is higher than the hydrolysis reaction rate. Under refrigerated conditions, galangal acetate is stable for several days, even in 1% ethanol solution (Figure 1).

Ethanol Concentration. The reaction rate of both hydrolysis and isomerization of 1′-acetoxychavicol acetate is affected by ethanol concentration. The overall reaction rate of 1′-acetoxychavicol acetate decreases with increasing ethanol concentration. The formation of *p*-coumaryl diacetate is inhibited in higher ethanol concentration, whereas the formation rate of 1′-hydroxychavicol acetate and *p*-acetoxycinnamic alcohol increases with increasing ethanol concentration when c(EtOH) < 10% and then decreases when c(EtOH) > 10% (Figure 2).

pH Effect. Hydrolysis of galangal acetate can be catalyzed by hydrogen ions. Therefore, the pH value of the reaction system affects the stability of this compound. As shown in Figure 3, galangal acetate is more stable in neutral solutions. Its reaction rate increases with decreasing pH value. The influence of solution acidity on the formation of the different reaction products varies. The concentration of galangal acetate and

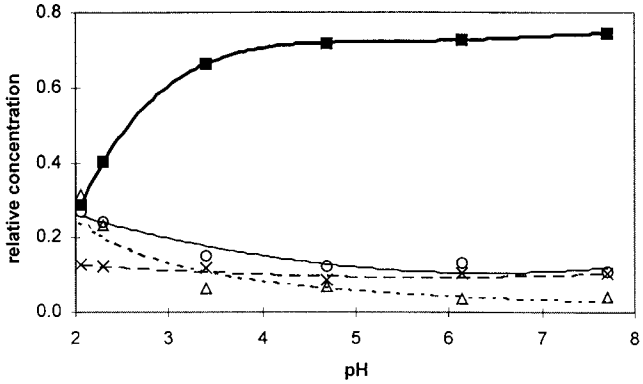


Figure 3. pH effect on reactions of galangal acetate in 5% ethanol at 60 °C for 1 h: (○) 1′-hydroxychavicol acetate; (■) galangal acetate; (△) *p*-acetoxycinnamic alcohol; (×) *p*-coumaryl diacetate.

p-acetoxycinnamic alcohol decreases with increasing pH value, while the concentration of *p*-coumaryl diacetate remains practically constant.

In vegetable oil 1400, galangal acetate was heated at 80 and 120 °C for 1 h. HPLC analysis indicated that galangal acetate remained practically unchanged after heating.

Solutions to the Instability of Galangal Acetate. Galangal acetate is stable in lower temperature, higher alcohol content and in neutral solutions. As estimated, galangal acetate is stable in 30−40% ethanol, pH 6−7, and at room temperature for several months. The instability of galangal acetate limited its applications. Therefore, we tried to find more stable analogues of galangal acetate. The allylic acetate structure plays a very important role in the hydrolysis/isomerization reactions. Modification of this part of the chemical structure could improve the stability. On the other hand, any changes of the chemical structure could affect the pungency of the derived compounds. A series of analogues of galangal acetate has been synthesized, and the relationship among pungency, stability, and chemical structure has been further studied (Bachmann et al., 1997).

Applications. Although galangal acetate was found as one of the major volatile components of galangal roots by headspace GC, the pure compound has a very weak odor. The flavor value of galangal acetate is mainly due to its trigeminal impact.

Pungency is a very important flavor-related sensation for many types of food, beverages, and personal care products. Pungency includes various sensory effects which can be described as biting, stinging, hot, sharp, burning, and warm. Most well-known pungent stimuli originate from spices and vegetables, such as capsaicinoids (chili pepper), piperines (black pepper), gingerols (ginger), and isothiocyanates (mustard, horseradish). These spices and vegetables, which are widely used in savory products, enhance and provide product-specific flavor characters. For beverages, the most common pungent stimuli are carbon dioxide and ethanol. The consumption of alcoholic beverages is an important part of diverse cultures. The excess consumption of alcohol, however, can cause social and health-related problems. Therefore, demands for alcohol-free beverages with the alcohol sensations are increasing on the beverage market. It is a challenging task for the beverage and flavor industry to develop products mimicking the alcohol sensations. So far, an effective alcohol enhancer

or replacement without undesirable aroma/taste and without a lingering effect has not been found. As discovered by sensory evaluation, galangal acetate exhibits a "clean" pungent sensation—it is tasteless and odorless at concentrations in the parts per million range, and the duration of pungency is much shorter than that of capsaicinoids. Therefore, galangal acetate is ideal for applications not only for savory products and sweet goods but also for beverages and personal care products. The applications of galangal acetate were examined.

Beverages. Galangal acetate enhances the alcohol taste (giving the alcohol more "burning" or "warming" effects). It can be used as a partial replacement of alcohol in beverages. For example, the taste of a 40-proof alcoholic beverage base with 50 ppm of galangal acetate was described as excellent, having a good balance of initial burn and aftertaste burn, and the effects on taste from the 40-proof beverage were judged to be greater than those of a 60-proof beverage. Galangal acetate was applied to an alcohol-free base (160 ppm) and resulted in a taste like an alcoholic beverage. Corresponding alcoholic beverages were used as references. Informal sensory evaluation was conducted in the beverage application group.

Sweet Goods. Galangal acetate was applied to hard candy and chewing gum and imparted a peppery pungent taste without an undesired lingering effect.

Dressings (Savory). Without a lingering effect, galangal acetate contributed spicy and pungent characters to mayonnaise, sour cream, and ketchup at a usage level of 500−1000 ppm.

Personal Care Products. By the addition of galangal acetate at a level of 100 ppm, toothpaste or mouthwash bases imparted a warm/hot sensation.

For a more detailed description of the use of galangal acetate in food and beverage applications, the reader is referred to the patent (Bachmann et al., 1997).

Spectroscopic Data. The ^{1}H and ^{13}C NMR and MS data are summarized below for 1′-acetoxychavicol acetate, as are the MS data for 1′-acetoxyeugenol acetate and the hydrolysis reaction products *p*-coumaryl diacetate, 1′-hydroxychavicol acetate, and 1′-acetoxycinnamic alcohol.

The NMR spectra were recorded using a Varian Gemini 300; $CDCl_3$ was used as solvent. The chemical shifts (ppm) are reported relative to TMS.

1′-Acetoxychavicol acetate (galangal acetate): ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.35 (3H, s), 2.55 (3H, s), 5.54 (2H, dd), 6.25 (1H, ddd), 6.52 (1H, d, J = 5.3 Hz), 7.33 (2H, d, J = 7.0 Hz), 7.63 (2H, d, J = 7.0 Hz); ^{13}C NMR δ 21.09 (CH_3), 21.19 (CH_3), 75.47 (CH), 117.04 (CH_2), 121.63 (CH), 128.38 (2CH), 135.98 (2CH), 136.40 (C), 150.40 (C), 169.33 (C), 169.86 (C); IR (neat) 2919 m, 2851 m, 1764 s, 1742 s, 1608 w, 1508 m, 1371 m, 1234 s, 1204 s, 1167 m, 1096 w, 1017 m, 912 m, 689 w cm^{-1}; UV absorption maxima (in methanol/water) 215 nm (intensive), 260 nm (weak); MS (EI), *m*/*z* 43 (100), 55 (12), 77 (21), 103 (16), 104 (12), 105 (17), 121 (25), 131 (52), 132 (83), 133 (41), 149 (21), 150 (72), 192 (40), 234 (0.15).

p-Coumaryl diacetate: MS (EI), *m*/*z* 43 (100), 77 (16), 94 (17), 103 (14), 105 (13), 107 (18), 121 (32), 131 (30), 132 (18), 133 (36), 149 (54), 150 (41), 192 (70), 234 (16), 235 (2).

1′-Acetoxyeugenol acetate: MS (EI), *m*/*z* 43 (100), 55 (17), 65 (15), 77 (14), 91 (21), 103 (29), 119 (18), 131 (54), 147 (24), 151 (14), 162 (85), 163 (17), 179 (14), 180 (93), 181 (11), 222 (46), 264 (7).

1′-Hydroxychavicol acetate: MS (EI), *m*/*z* 39 (16), 43 (56), 51 (10), 55 (35), 65 (16), 77.1 (32), 94 (37), 95 (43), 107 (40), 121 (47), 123 (37), 131 (12), 133 (21), 149 (59), 150 (100), 192 (11).

1′-Acetoxycinnamic alcohol: MS (EI), *m*/*z* 39 (10), 43 (35), 55 (11), 65 (11), 77 (20), 91 (14), 94 (53), 107 (100), 108 (12), 131 (10), 150 (70), 192 (16).

Summary. Galangal acetate was identified as the pungent principal of galangal rhizomes. In comparison with other known pungent components, it imparts a delayed spicy and pungent sensation and a clean taste without a lingering effect. It can be used as an alcohol enhancer or replacement in beverages. Application of galangal acetate in sweet goods, dressings, and personal care products produces a desirable pungent taste. However, galangal acetate easily undergoes hydrolysis/isomerization reactions under typical hydrolytic conditions in water or aqueous ethanol. The reaction can be slowed at a lower temperature, in higher alcohol concentration, and in a medium with a higher pH value. The reaction products are not pungent at all or are much less pungent than the starting material. The hydrolytic instability of galangal acetate limits the applications. Because the allylic acetate structure facilitates the hydrolytic reactions, modification of the chemical structure could improve the stability. Pungent and stable analogues of galangal acetate, which broaden the potential applicability of this class of compounds in beverage, food, and personal care products, are under investigation.

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