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Quantitative Determination of Allergenic 5-Alk(en)yl-resorcinols in Mango (*Mangifera indica* L.) Peel, Pulp, and Fruit Products by High-Performance Liquid Chromatography

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Despite a number of serious case reports of mango dermatitis, no attempts at the identification and quantification of allergenic 5-alk(en)ylresorcinols in mango fruits have so far been made. Therefore, total alk(en)ylresorcinol content and relative homologue composition in 13 mango peel samples and 7 samples of mango pulp were determined by HPLC and LC-MS/MS analyses. Furthermore, mango puree and nectar prepared on pilot plant scale were also analyzed and compared with commercially available thermally preserved products. Depending on cultivar, alk(en)ylresorcinol contents ranged from 79.3 to 1850.5 mg/kg of dry matter (DM) in mango peels and from 4.9 to 187.3 mg/kg of DM in samples of mango pulp. The profile of alk(en)ylresorcinols was found to be highly characteristic, with an average homologue composition of C15:0 (6.1%), C15:1 (1.7%), C17:0 (1.1%), C17:1 (52.5%), C17:2 (33.4%), C17:3 (2.4%), C19:1 (2.1%), and C19:2 (0.8%). Mango puree samples prepared from peeled and unpeeled fruits revealed contents of 3.8 and 12.3 mg/kg of fresh weight, respectively. Content and homologue composition were not significantly affected during puree processing and thermal preservation. In nectar samples prepared from peeled and unpeeled fruits, contents of 1.4 and 4.6 mg/L, respectively, were found.

KEYWORDS: Mango; *Mangifera indica* L.; alk(en)ylresorcinols; peels; pulp; puree; nectar; pickles; HPLC

INTRODUCTION

Mango (*Mangifera indica* L., Anacardiaceae) is one of the most important tropical fruits. Mango and mango products such as puree, nectar, chutneys, and pickles experience worldwide popularity, with increasing importance also in the European market (*1*). From a phytochemical point of view, representatives of the Anacardiaceae family are notorious for the dermal irritation evoked by its members, such as poison ivies and oaks (*Toxicodendron* spp.). The compounds responsible for these contact allergies are lipophilic phenolics composed of a catechol or a resorcinol moiety linked to an alk(en)yl chain (*2*, *3*). Although most of the dermatological problems are related to alk(en)ylcatechols (*2*), alk(en)ylresorcinol-induced dermatitis is frequent among cashew nut workers (*4*−*6*) and can be evidenced after contact with *Philodendron* species (*7*, *8*) and by cutaneous tests with isolates from triticale, wheat, and rye (*9*). It is generally accepted that the phenolic ring, after being oxidized to a reactive quinone, will bind to cellular proteins, whereas the long aliphatic side chain will help the hapten to be inserted on the cytoplasmatic membrane of epidermal cells for activation (*2*, *3*). In contrast to alkylcatechols, the less allergenic alk(en)ylresorcinols are not readily oxidized to *o*-quinones because both hydroxyl groups and chain are in the meta position. However, through oxidation of the dihydroxybenzene nucleus a 1,2,3-trihydroxybenzene is formed (*10*), and further oxidation of this molecule may result in the formation of an *o*-quinonic form, active for allergy induction (*2*, *3*). The alk(en)ylresorcinols can therefore be considered as the haptenic species rather than the real antigens formed by a hapten−protein complex (*3*). In the case of *M. indica*, allergenic reactions are mainly observed during harvest of the fruit caused by the resinous sap (*11*). 5-(2-*Z*-Heptadecenyl)resorcinol isolated thereof is regarded as the responsible dermatitis allergen (*12*). Although the mango fruit is sometimes considered to be non-allergenic even by plant taxonomists, there are many records of dermatological problems (*13*). Such incidences appear to be less frequent in tropical areas where the fruit is grown, and it has been suggested that eating mango in infancy and steadily thereafter may result in oral desensitization (*14*). The fruit peel seems to be the chief source of mango dermatitis, and circumoral dermatitis is frequent if the fruit is eaten without removal of the skin (*13*, *14*). Epicutaneous tests on human subjects with fruit peel (*15*) and isolated pentadecyl-, heptadecenyl-, and heptadecadienylresorcinols elicited strong positive reactions and pointed out that allergenicity of these compounds, which was found to be IgE mediated, depends on the degree of unsaturation in the alkyl

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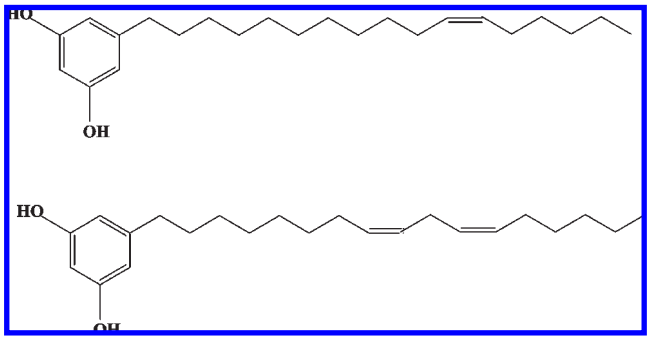

Figure 1. Structures of 5-(11′*Z*-heptadecenyl)- and 5-(8′*Z*,11′*Z*-heptadecadienyl)resorcinol.

chain (*16*). Furthermore, cross reactions between mango contact allergens and urushiols were observed (*17*). Our recent LC-MS studies revealed that mango peels may contain up to 15 resorcinol derivatives, with chain lengths from C15 to C19 and several degrees of unsaturation, the 5-(11′*Z*-heptadecenyl)- and 5-(8′*Z*,11′*Z*-heptadecadienyl)resorcinol being the predominant compounds (**Figure 1**) (*18*, *19*). In another study, patch testing of mango flesh, which was so far believed to be devoid of sensitizers, was strongly positive, suggesting that alk(en)ylresorcinols in mango pulp were present in concentrations high enough to produce mango dermatitis (*20*).

Therefore, the objective of the present study was to provide an overview about alk(en)ylresorcinol contents and homologue composition in mango peel and pulp of several cultivars. Depending on cultivar, peeling of the fruits is sometimes omitted in industrial puree and nectar production (*21*). Furthermore, products such as mango pickles are usually prepared from unpeeled fruits. Therefore, mango purees and nectars produced from both peeled and unpeeled fruits on a pilot plant scale were also analyzed and compared with commercial samples of mango puree, nectar, and pickles. Taking together the growing popularity of mango products and the considerable number of patients suffering from mango dermatitis, such data are needed and have to our knowledge not been reported elsewhere. Characterization and quantification of individual compounds were carried out by HPLC-MS/MS and HPLC-DAD, respectively (*18*).

MATERIALS AND METHODS

Solvents and Reagents. All reagents and solvents used were of analytical or HPLC grade (VWR, Darmstadt, Germany). Synthetic alkylresorcinols (C15:0, C17:0, and C19:0) were used for external calibration and were purchased from ReseaChem GmbH (Burgdorf, Switzerland).

Mango Samples. Ten to 12 mature mango fruits of the cultivars Tommy Atkins (Brazil), Kent and Keitt (Kenia), and Maya (Israel) were purchased from the local market. The cultivars Phet Ban Lad, Kiew Sawoi, Nam Dok Mai, and Kaew were obtained directly from the Department of Horticulture, Chiang Mai University, Thailand. Freeze-dried peels of the cultivars Guire 3, Guire 82, Guire 10, Tianyang Chuan Mang, and Tianyang Xiang Mang were obtained from China. The peels were removed from the flesh with a stainless steel knife, immediately lyophilized, and vacuum-sealed in polyethylene bags. Samples were stored at −20 °C until analysis. Commercial mango purees, nectar, and pickles were obtained from a local supermarket.

Mango Puree and Nectar Production at Pilot Plant Scale. Approximately 30 kg of mature mango fruits (cv. Tommy Atkins) was manually washed and divided into two batches for the preparation of mango puree prepared from both peeled and unpeeled fruits. After manual pitting, the fruit mesocarp was successively cut into pieces, mashed, and finished in a PAP 0533 pulper (Bertuzzi, Brugherio, Italy) with sieves of 10, 1.5, and 0.4 mm mesh size, respectively.

To inactivate endogenous enzymes, the purees were continuously heated at a flow rate of 95 L/h, using a tubular heater (Ruland Engineering & Consulting, Neustadt, Germany). A product temperature of approximately 70 °C was achieved by heat exchange against hot water, followed by final heating to 93 °C for 25 s using the integrated tubular Actijoule unit and subsequent cooling to approximately 30 °C. Mango nectar prepared from both peeled and unpeeled fruits of 12 °Brix and 35% pulp was produced by diluting the mango purees with a sugar syrup of 66.7 °Brix and drinking water. The nectar was then homogenized in a LAB 60-10 TBSK high-pressure homogenizer (APV Gaulin, Lübeck, Germany) at 300 bar. Finally, the nectar was continuously pasteurized at 95 L/h and 95 °C for 25 s, as previously described for the pulp. The pasteurized nectar was hot filled into 0.5 L glass bottles, sealed under steam injection, and cooled to room temperature in a water bath.

Sample Preparation. The extraction and purification of alk(en)ylresorcinols was performed as described previously (*18*). Mango peels were removed from the flesh with a stainless steel knife. The pulp and the peels were immediately lyophilized, powdered using liquid nitrogen and a stainless steel Warring blender, and stored in vacuum-sealed polyethylene bags at −20 °C until analysis. Aliquots of 2.5 g of lyophilized peels and 5 g of the lyophilized pulp, respectively, were extracted with 50 mL of dichloromethane in a round-bottom flask under continuous stirring for 1 h under nitrogen atmosphere. The extract was centrifuged (10 min, 3480*g*), and the residue was extracted with 50 mL of dichloromethane for 30 min. The combined supernatants were subjected to solid-phase extraction on 2 g of polyamide CC6 0.05−0.16 mm (Macherey-Nagel, Dueren, Germany). The adsorbant was filled into Econo-Pac columns (Bio-Rad, Munich, Germany) and successively conditioned with 10 mL of methanol and 25 mL of dichloromethane prior to application of the mango peel extract to the column. After washing with dichloromethane (25 mL), alk(en)ylresorcinols were recovered by elution with methanol (50 mL). The eluate was evaporated to dryness in vacuo at 30 °C, and the residue was dissolved in 0.5 mL of methanol. The solution was filtered through a 0.45 μm membrane filter (Whatman, Clifton, NJ) and used for HPLC and LC-MS analysis, respectively.

For the determination of alk(en)ylresorcinols from puree, nectar, and pickles the extraction procedure was modified as follows: Aliquots of 50 g of puree, 100 mL of nectar, and 15 g of pickles, respectively, were homogenized with ethanol (96%, v/v) using an Ultraturrax and stirred for 1 h after being flushed with nitrogen. Ethanol pretreatment was required because of its better wettability compared to dichloromethane in order to achieve maceration of the viscous material. The homogenate was centrifuged (10 min, 3480*g*) and the residue extracted with 50 mL of dichloromethane for 1 h. After the addition of 20 mL of water (except for nectar samples) to the ethanolic supernatant, the ethanol was removed in vacuo and the remaining aqueous fraction was partitioned twice with 30 mL of dichloromethane. The dichloromethane fractions were pooled, and any water present was removed by the addition of excess Na_2SO_4. Subsequently, the solution was subjected to solid-phase extraction on polyamide as described above.

Recovery Studies. Recovery studies were performed by adding suitable amounts of 5-pentadecylresorcinol stock solution to puree, nectar, and pickle samples prior to extraction. Determinations for recovery studies were performed in duplicate.

HPLC and LC-MS Analyses. The separation of alk(en)ylresorcinols was performed using an Agilent HPLC series 1100 (Agilent, Waldbronn, Germany) equipped with ChemStation software, a model G1322A degasser, a model G1312A binary pump, a model G1313A autosampler, a model G1316A column oven, and a model G1315A diode array detection system. The column used was a 150 × 3.0 mm i.d., 3 μm particle size, analytical scale Phenomenex C18 Aqua (Torrance, CA), with a C18 ODS guard column (4.0 × 2.0 mm, i.d.), operated at 25 °C. The mobile phase consisted of 100% methanol (eluent A) and 100% water (eluent B), and the following gradient program was used: 17% B to 9% B (20 min), 9% B isocratic (10 min), 9% B to 0% B (5 min), 0% B isocratic (5 min), 0% B to 17% B (0.1 min), 17% B (4.9 min). Total run time was 45 min. The injection volume was 10−50 μL. All alk(en)ylresorcinols were monitored at 275 nm at a flow rate of 0.6 mL/min. Additionally, UV spectra were recorded in the range of 200−600 nm at a spectral acquisition rate of 1.25 scans/s (peak width = 0.2 min).

LC-MS analyses were performed with a HPLC system similar to that described above connected in series with a model Esquire 3000+ ion trap mass spectrometer fitted with an APcI source (Bruker, Bremen, Germany). Data acquisition and processing were performed using Esquire Control software. Positive ion mass spectra of the column eluate were recorded in the range of m/z 100−500 at a scan speed of 13000 Th/s (peak width = 0.6 Th, fwhm). Nitrogen was used both as the drying gas at a flow rate of 10 L/min and as the nebulizing gas at a pressure of 60 psi. The nebulizer temperature was set at 350 °C, and a potential of +4000 V was used on the capillary. Corona needle current was set at 4000 nA, and the vaporizer temperature was set at 400 °C. Helium was used as the collision gas for selective collision-induced dissociation (CID) at a pressure of 4.9×10^{-6} mbar. CID spectra were obtained with an isolation width of 1.0 Th for precursor ions and a fragmentation amplitude of 1.75 V.

Individual compounds were identified by their retention times and UV and mass spectra (*18*) and quantified using a calibration curve of the corresponding standard compound. When reference compounds were not available, which was the case for the unsaturated constituents, the calibration of the corresponding saturated substances was used including a molecular weight correction factor (*22*). All data presented are mean values ± standard deviation of two independent experiments ($n = 2$).

RESULTS AND DISCUSSION

Recovery Studies. Recovery studies were performed to validate sample preparation for quantitative recovery. Stock solutions of 5-pentadecylresorcinol were added to puree, nectar, and pickles prior to extraction. Recovery rates were 76 ± 1.6% for puree samples, 96 ± 0.4% for nectar samples, and 89 ± 0.4% for mango pickles.

Alk(en)ylresorcinol Levels and Homologue Composition in Mango Peels and Pulp. Alk(en)ylresorcinol content and relative homologue composition of 13 different samples of mango peels and 7 different samples of mango pulp, selected from several sources, were analyzed (**Tables 1** and **2**). Because of the limited availability of reference compounds, peak identity was confirmed by LC-MS/MS. The characterization of individual compounds has recently been reported in detail (*18*), so UV and mass spectrometric data are not given here. The separation of alk(en)ylresorcinols in a peel extract of the cultivar 'Kaew' is shown in **Figure 2**. Except for the Chinese cultivars 'Tianyang Xiang-Mang', 'Guire 82', and 'Guire 3', all samples analyzed showed an almost identical alk(en)ylresorcinol profile with the monounsaturated C17 homologue being the major compound (C17:1) followed by its diunsaturated congener (C17:2). Oka et al. (*17*) reported contact allergic properties to these homologues isolated from mango peels, and the corresponding structures assigned to 5-(12′*Z*-heptadecenyl)resorcinol and 5-(9′*Z*,12′*Z*-heptadecadienyl)resorcinol. However, to our knowledge, no data referring to their structures have been reported so far. Therefore, the detailed structures of these homologues were recently elucidated in our laboratory and were unambiguously established to be 5-(11′*Z*-heptadecenyl)resorcinol and 5-(8′*Z*,11′*Z*-heptadecadienyl)resorcinol, respectively (*19*). The third major homologue was assigned to 5-pentadecylresorcinol (C15:0), which was also identified by Cojocaru et al. (*23*), besides a monounsaturated C17 homologue that these authors have assigned to 5-(12′*Z*-heptadecenyl)resorcinol. Minor homologues, which we have recently reported to be present in mango peels, were detected in almost all cultivars analyzed (**Table 1**) and were identified as 5-heptadecatrienylresorcinol (C17:3), 5-pentadecenylresorcinol (C15:1), 5-nonadecadienylresorcinol (C19:2), 5-heptadecylresorcinol (C17:0), and 5-nonadecenylresorcinol (C19:1). Therefore, the HPLC profile given in **Figure 2** consisting of the three major [C17:1 > C17:2 (vice versa for the Chinese cultivars 'Tianyang Xiang-Mang', 'Guire 82', and 'Guire 3′) > C15:0] and several minor compounds appears to be highly characteristic of mango. Astonishingly, only the C15:0 and C17:1 homologues were identified in peel samples of several mango varieties in previous studies (*23*−*25*), thus demonstrating the necessity of additional mass spectrometric detection, which was used in the present work.

Depending on cultivar, total alk(en)ylresorcinol contents in peel samples ranged from as low as 79.33 mg/kg of DM in 'Nam Doc Mai' to as high as 1850.51 mg/kg of DM in 'Maya' (**Table 1**). A clear relationship between total alk(en)ylresorcinol content and geographical origin of these cultivars could not be deduced. The large differences in alk(en)ylresorcinol content might be due to challenging environmental conditions resulting in higher contents compared to mango fruits possibly treated with fungicides. The average relative homologue composition was relatively consistent among samples and was found to be C15:0 (6.1%), C15:1 (1.7%), C17:0 (1.1%), C17:1 (52.5%), C17:2 (33.4%), C17:3 (2.4%), C19:1 (2.1%), and C19:2 (0.8%). Standard deviations of individual homologues in peel, pulp, and fruit product samples were always below 10%. Most striking differences in the homologue composition were observed for the Chinese cultivars 'Tianyang Xiang-Mang', 'Guire 82', and 'Guire 3′ mentioned above, showing inverse proportions of the major homologues C17:1 and C17:2 (**Table 1**). Apart from the chemotaxonomic relevance of this observation, these differences in homologue composition might also be useful in authenticity control of mangoes and mango products. There are only a very few reports on varietal differences in alk(en)ylresorcinols in mango peel (*24*, *25*). Droby et al. (*24*) studied several mango varieties in Israel and reported a mixture of 5-heptadecenylresorcinol and 5-pentadecylresorcinol in mango peel of unripe fruits ranging from 154 to 232 μg/g of FW, which decreased as the fruit had ripened. This observed decrease coincides with the breaking of latency of *Alternaria alternata*, a fungus causing black spot disease in mango fruits. Recently, Hassan et al. (*25*) studied varietal resistance to postharvest anthracnose in relation to the concentration of identified 5-heptadecenylresorcinol and 5-pentadecylresorcinol in mango peel. The more resistant varieties had higher levels of both resorcinolic compounds in their peel, suggesting an important role of alk(en)ylresorcinols in plant disease resistance. Cultivars very susceptible to anthracnose, for example, 'Nam Dok Mai' and 'Kent' grown in Australia, contained much lower alk(en)ylresorcinol contents (*25*). These cultivars were also found to possess the lowest resorcinol contents in the present study (**Table 1**), making varietal differences in alk(en)ylresorcinol concentration most likely, irrespective of growing conditions and cultivation site.

Total alk(en)ylresorcinol content and relative homologue composition in the pulp of seven different mango cultivars are given in **Table 2**. Generally, high alk(en)ylresorcinol contents in the peel of the fruit (**Table 1**) resulted in high contents of these compounds in the flesh, which ranged from 4.96 mg/kg of DM in 'Nam Dok Mai' to 187.3 mg/kg of DM in 'Kaew'. However, a clear correlation between total alkylresorcinol content in mango peel and pulp was not found ($R^2 = 0.475$). Relative homologue composition was largely consistent compared to corresponding peel samples. The proportions of alk(en)ylresorcinol content compared to the corresponding peel samples ranged from about 6% ('Phet Ban Lad', 'Nam Dok Mai', 'Tommy Atkins', and 'Maya') to ∼26% in the cultivar 'Kent'. Although the content of alk(en)ylresorcinols in the fruit pulp was determined to be much lower compared to the peel samples, dermatitis-producing concentrations might still be present after the fruit is peeled as evidenced by Weinstein et al. (*20*).

Table 1. Total Alk(en)ylresorcinol Content and Relative Homologue Composition in Peels of Different Mango Cultivars

		homologue composition (%)							
cultivar[a]	total AR (mg/kg of DM)	C15:0	C15:1	C17:0	C17:1	C17:2	C17:3	C19:1	C19:2
Kaew[P]	1412.02 ± 10.94	7.1	0.8	0.7	52.3	35.2	2.3	0.6	0.8
Phet Ban Lad[P]	1767.21 ± 94.61	8.9	0.9	0.91	47.75	37.1	2.46	1.0	0.8
Nam Dok Mai[P]	79.33 ± 2.29	8.9	3.6	1.8	52.2	25.4	3.6	3.2	1.1
Kiew Sawoi[P]	888.83 ± 35.53	8.03	0.7	0.6	55.9	30.4	2.5	0.9	0.6
Kent[M]	395.58 ± 12.34	4.3	2.2	0.8	65.7	23.9	1.6	1.0	0.2
Keit[M]	1112.39 ± 55.95	4.3	1.4	0.9	58.1	29.9	2.2	2.2	0.6
Tommy Atkins[M]	419.30 ± 1.52	3.8	2.9	1.4	57.9	28.3	1.8	3.5	nd[b]
Maya[M]	1850.81 ± 94.57	5.9	1.6	0.8	58.0	28.2	1.7	2.8	0.6
Tianyang Chaun-Mang	612.86 ± 20.41	7.5	2.1	nd	60.0	26.3	2.2	0.95	0.7
Tianyang Xiang-Mang	600.20 ± 21.86	4.5	1.0	0.8	42.4	46.8	2.3	0.8	1.0
Guire 82	361.21 ± 2.98	5.8	1.0	3.6	29.5	46.7	3.9	8.0	1.2
Guire 10	444.51 ± 36.30	4.5	0.8	0.6	43.6	46.7	1.7	0.5	1.2
Guire 3	358.25 ± 9.70	5.6	2.1	0.5	58.8	28.3	2.6	0.9	0.7
mol wt correction factor			0.994		0.994	0.989	0.983	0.995	0.989

[a] P, polyembryonic; M, monoembryonic. [b] nd, not detected.

Table 2. Total Alk(en)ylresorcinol Content and Relative Homologue Composition in the Pulp of Different Mango Cultivars

		homologue composition (%)							
cultivar	total AR (mg/kg of DM)	C15:0	C15:1	C17:0	C17:1	C17:2	C17:3	C19:1	C19:2
Kaew	187.30 ± 7.09	7.1	0.8	0.7	52.3	35.2	2.3	0.7	0.8
Phet Ban Lad	108.43 ± 4.05	7.5	2.1	nd[a]	60.0	26.3	2.3	0.9	0.8
Nam Dok Mai	4.96 ± 0.31	4.5	1.0	0.8	42.5	46.9	2.3	0.8	1.0
Kiew Sawoi	79.05 ± 4.20	8.9	0.9	0.9	47.6	37.1	2.5	1.0	0.8
Kent	103.60 ± 2.65	4.3	2.2	0.8	65.7	23.9	1.6	1.0	0.3
Keitt	105.65 ± 2.31	5.7	2.1	0.6	58.9	28.4	2.6	0.9	0.7
Tommy Atkins	26.33 ± 0.98	6.6	5.3	1.0	66.3	16.5	1.8	2.9	nd
Maya	106.52 ± 13.88	5.8	1.0	3.6	29.5	46.7	3.91	8.0	1.2
mol wt correction factor			0.994		0.994	0.989	0.983	0.995	0.989

[a] nd, not detected.

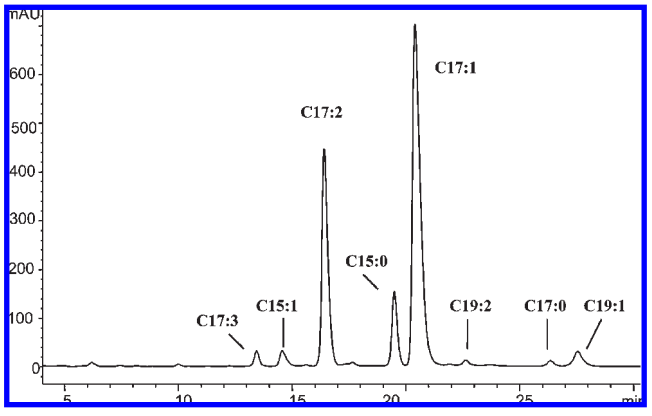

Figure 2. HPLC fingerprint (275 nm) of alk(en)ylresorcinols in mango peels (cv. Kaew). Peak assignments: 5-heptadecatrienylresorcinol (C17:3); 5-pentadecenylresorcinol (C15:1); 5-(8′*Z*,11′*Z*-heptadecadienyl)resorcinol (C17:2); 5-pentadecylresorcinol (C15:0); 5-(11′*Z*-heptadecenyl)resorcinol (C17:1); 5-nonadecadienylresorcinol (C19:2); 5-heptadecylresorcinol (C17:0); 5-nonadecenylresorcinol (19:1).

Table 3 shows alk(en)ylresorcinol content and relative homologue composition in mango fruit products. Mango puree prepared from unpeeled fruits (cv. 'Tommy Atkins') on a pilot plant scale displayed alk(en)ylresorcinol contents of 12.3 mg/kg on a fresh weight (FW) basis, which is about 3 times higher than in puree from peeled fruits (3.8 mg/kg of FW). When the latter value was referred to a dry matter basis (24.90 mg/kg of DM), insignificant differences were observed compared to alk(en)ylresorcinol contents of the pulp samples used for puree production (26.33 mg/kg of DM), indicating stability of alk(en)ylresorcinols during thermal processing, which was also observed in previous studies on bread (*26*) and pasta samples (*27*). Relative homologue composition was also found to be unaffected during puree production. Alk(en)ylresorcinol contents of commercial puree samples were considerably higher and ranged from 33.5 to 56.6 mg/kg of FW. However, because mango varieties used for manufacturing these products are unknown, no conclusions could be drawn as to whether peeled or unpeeled fruits were used. Nectar samples (35% pulp) prepared from peeled and unpeeled fruits revealed alk(en)ylresorcinol contents of 1.4 and 4.6 mg/L, respectively. Their contents in commercial nectar samples amounted to 14.3 and 8.2 mg/L, respectively. However, because varietal information could not be obtained, no conclusion could be drawn as to whether peeling of the fruits was omitted during manufacturing, which was also the case for the commercial puree samples. The commercial pickle samples, which both were prepared from unpeeled fruits, revealed contents of 33.5 and 56.3 mg/kg of FW, respectively, with exceptionally high proportions of the C17:1 homologue (**Table 3**).

In conclusion, the profile of alk(en)ylresorcinols detected in all samples analyzed was found to be highly characteristic for mango, whereas considerable cultivar-dependent differences in alk(en)ylresorcinol content were observed for both peel and

Table 3. Alk(en)ylresorcinol Content and Relative Homologue Composition of Different Mango Products

			homologue composition (%)							
	fruit product	total AR (mg/kg of FW) (mg/L)	C15:0	C15:1	C17:0	C17:1	C17:2	C17:3	C19:1	C19:2
puree	peeled fruits	3.8 ± 0.09	6.0	5.5	1.3	66.5	17.3	1.9	1.8	nd[a]
	unpeled fruits	12.3 ± 0.22	4.4	3.1	0.7	69.0	20.8	2.3	1.7	0.2
	commercial sample 1	16.9 ± 0.11	3.9	1.2	1.1	78.9	13.7	1.2	3.2	0.4
	commercial sample 2	16.2 ± 0.56	6.1	3.2	0.9	58.4	29.1	2.1	1.6	nd
nectar	peeled fruits	1.4 ± 0.1[b]	6.4	6.4	1.8	65. 1	17.5	2.5	0.7	0.2
	unpeeled fruits	4.6 ± 0.06[b]	4.2	3.3	0.7	67.3	20.1	2.1	1.2	0.3
	commercial sample 1	14.3 ± 0.33[b]	5.0	1.8	1.0	51.3	36.6	3.1	1.3	1.4
	commercial sample 1	8.2 ± 0.32[b]	4.6	5.1	0.9	56.0	28.2	3.9	1.2	1.9
pickles	commercial sample 1	33.5 ± 1.23	5.3	2.6	0.8	77.1	10.4	3.7	2.3	nd
	commercial sample 2	56.3 ± 2.91	4.1	1.5	0.7	81.9	9.7	1.9	3.3	nd
mol wt correction factor				0.994		0.994	0.989	0.983	0.995	0.989

[a] nd, not detected. [b] Expressed in mg/L.

pulp samples. In a study by Hassan et al. (*25*) an important role of alk(en)ylresorcinols in plant disease resistance was suggested. These authors found that the higher the concentration of constitutive alk(en)ylresorcinol compounds, the lower the susceptibility to anthracnose. From a phytopathological point of view, the results given here could therefore have important implications for the mango industry, because growers attempting to reduce chemical use on their crops could utilize the natural resistance capacity of particular varieties. From a dermatological point of view, alk(en)ylresorcinols are present in considerable amounts also in the edible part of the fruit and are still present in thermally treated products such as puree and nectar. Only negligible changes were observed in alk(en)ylresorcinol content and composition upon puree processing. Contrary to topical contact, allergenic reactions after oral ingestion of mango and mango products have not been reported so far. Considering that alk(en)ylresorcinols are also present in high amounts in wheat and rye (*2*), it appears that consumption of alk(en)ylresorcinols with food can be considered to be safe.

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