Characteristics and Composition of Chaenomeles Seed Oil

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SUMMARY

Characteristics and chemical composition of chaenomeles seeds and seed oil were investigated in samples of Japanese quince (*Chaenomeles japonica*) and a hybrid taxon (*C. japonica* x *C. speciosa*). The content of oil in the seeds was 6.1–16.8% based on dry weight, with an average value of 8.2%. The content of moisture in the seeds was 40–46%. The average iodine index of the seed oil was 98, and the acidity index was 2.4. Nine fatty acids were detected: erucic acid, palmitic acid, stearic acid, arachidic acid, behenic acid, oleic acid, cis-11-eicosenoic acid, linoleic acid and linolenic acid. The oil was rich in unsaturated fatty acids (89%), linoleic acid and oleic acid being the main types present. The amount of individual fatty acids varied from traces to 53% for linoleic acid. The ratio saturated/unsaturated fatty acid was very low (0.1). Chaenomeles seed oil could thus be useful in *e.g.* the food industry, if it were competitive from an economic viewpoint.

INTRODUCTION

Japanese quince (*Chaenomeles japonica*) is an East Asian plant with interesting potential as a fruit crop, currently being domesticated in northern Europe (Rumpunen *et al*. 1998, Rumpunen 2002). Its yellow scenting fruits are rich in juice, fibre (Lesinska *et al*. 1988, Thomas *et al*. 2000, Thomas & Thibault 2002) and seeds (Rumpunen *et al*. 2000). In various species within the genus *Chaenomeles*, seeds may constitute up to 10% of the fruit fresh weight, and are thus a large residue at juice extraction. If possible this residue should be further used *e.g.* for extraction of seed oils. Only few authors report some data on chaenomeles fruit composition (*e.g.* Lesinska 1987, Lesinska *et al*. 1988, Golubev *et al*. 1991, Rumpunen 1995). No reliable reference has so far been found reporting the content and composition of chaenomeles seed oil.

Oils with a suitable composition of essential fatty acids are currently being sought (*c.f.* Melgarejo & Artés 2000, Melo *et al*. 2000). The lipid composition has a particular importance because of the potentially healthy polyunsaturated fatty acids (PUFA). PUFA are important since they play a preventive role in cardiovascular diseases, contributing to the reduction of blood cholesterol (de Hoya & Mata 1989). Oils from various plants may also have industrial applications, *e.g.* in cosmetics and in health care products.

Therefore, the characteristics and chemical composition of chaenomeles seed oil were investigated.

MATERIALS AND METHODS

Fruits

Mature chaenomeles fruits were obtained from plant breeding institutes in Sweden, Finland and Latvia. Several genotypes of different *Chaenomeles* species and hybrids were sampled: *C. japonica* (sites C, D, F, NV and RG), and *C. japonica* x *C. speciosa* (site RG). The letters (C, D, F, NV and RG) represent different test plots in the orchards where the plants were cultivated. The soil differed between test plots, in that the NV soil was sandier than the D and RG soils, which contained considerably more clay. The plants from which the fruits were sampled were grown from seed, and planted in the field over a period of four years. Thus, the plants sampled were of different ages. However, all fruits of Japanese quince were sampled at the same developmental stage, when the fruit skin had turned yellow and the seeds had turned brown, indicating maturity. For the other taxa, which usually do not develop a completely yellow skin, fruits were picked when the seed coat had turned brown. The fruits were then sent by surface transport to Spain for analysis. Background data on sampling site of fruits and the genetic origin of plants are given in Table 1.

Separation of the fruit seeds

Seeds were separated from the fruits prior to juice extraction and adhering non-seed tissue was removed if necessary. Only fresh chaenomeles seeds were analysed and used for extraction of oil.

Chemical analysis of seeds

The moisture of the seeds was determined as weight loss by dehydration (100 °C x 24 h). The content of oil was determined using a Soxhlet extractor apparatus with petroleum ether (40–60 ºC) as the solvent. Moisture and content of oil were then expressed as percentages, based on fresh weight (f.w.) and dry weight (d.w.), respectively. The samples were always analysed in duplicate.

Chemical properties of oil

Acid and iodine indices were determined following the standard AOAC (1990) method. The acid index value of the oil was then expressed as the percentage of oleic acid.

Composition of seed oil

Oil was cold extracted with chloroform:methanol (2:1 v/v) (Folch *et al*. 1957). Pure seed oil was obtained after evaporation of the solvent under reduced pressure in a rotational evaporator. The fatty acids were transesterified with methanol according to Hellín *et al*. (1998) using sodium methylate (0.2 N).

Table 1. Site for sampling of fruits, and origin of the *Chaenomeles* taxa studied.

Site[a]	Country	Taxon	Seed origin
NV	Sweden	*C. japonica*	orchard, crossing, Babtai, Lithuania
RG	Sweden	*C. japonica*	orchard, open pollination, Dobele, Latvia
RG	Sweden	*C. japonica*	orchard, open pollination, Babtai, Lithuania
D	Sweden	*C. japonica*	orchard, open pollination, Babtai, Lithuania
F	Finland	*C. japonica*	orchard, open pollination, Dobele, Latvia
C	Latvia	*C. japonica*	orchard, open pollination, Dobele, Latvia
RG	Sweden	*C. japonica* x *C. speciosa*	orchard, open pollination, Dobele, Latvia

[a]Letters NV, RG and D represent different test plots at the Department of Horticultural Plant Breeding, Swedish University of Agricultural Sciences, Kristianstad (Sweden), F represents a test plot at the Department of Plant Biology, University of Helsinki, Helsinki (Finland) and C represents a test plot at Dobele State Horticulture Plant Breeding Experimental Station, Dobele (Latvia).

Pentadecanoic acid-methyl ester (Sigma Chem. Co., St. Louis, MO, USA) was added as an internal standard. The fatty acids-methyl esters were then analysed by gas chromatography in a Hewlett Packard gas chromatograph with a flame ionisation detector (FID) and a BPX70 column (70% cyanopropyl polysilphenylene-siloxane). Helium was used as the carrier gas at a flow of 1 ml/min. The injector and detector temperature was 250 and 280 ºC, respectively. The oven temperature programme was set at an initial temperature of 80 °C, which was increased to 155 °C at 3 °C/min, then increased to 205 °C at 5 °C/min and finally increased to 206 °C at 0.1 °C/min. For injection, 1 ml of the sample was used. Peaks from the chromatograms of the samples were identified by comparison with mass spectra of authentic compounds. Quantification was based on external standards.

Statistics

All results were expressed as an average value with standard deviation (SD) for the samples analysed.

RESULTS AND DISCUSSION

Separation of seeds

The main fractions of the chaenomeles fruit were juice and pulp constituting in total 88–92% of the fresh weight, whereas the seed fraction was 5–9% (Table 2). For comparison, the quantity of seeds in chaenomeles fruits was similar to that in raspberries (Johansson *et al*., 1997), but higher than in *e.g.* apples.

Characteristics of seeds

The content of moisture in *C. japonica* seeds was 40.4–45.9% (Table 3) and 40.5% in the sample of *C. japonica* x *C. speciosa*. The average content of moisture in seeds was 41.9%.

The content of oil in the seeds of *C. japonica* was 6.1–10.1% d.w., with an average value of 8.2% in the samples analysed (Table 3). The content of oil was considerably higher in seeds of the single hybrid taxon studied, *C. japonica* x *C. speciosa* (16.8% d.w). The content of oil in chaenomeles seeds was similar to that in pomegranate seed oil (Melgarejo & Artés 2000), but low compared to that in the seed oil of many other fruits, *e.g.* grape seeds, 16–21% (Bernardini 1986), and raspberry seeds, 10–23% (Johansson *et al*. 1997, Oomah *et al*. 2000).

Characteristics of seed oil

The iodine index of *C. japonica* seed oil was on average 98.1, ranging from 94.1 to 105.6, and slightly higher for *C. japonica* x *C. speciosa* (Table 4). This variation is practically the same as for the colza oil iodine index (Bernardini 1986) but lower than *e.g.* the values reported by Mello *et al*. (2001) for melon

Table 2. Seed and pulp + juice fractions obtained at processing of chaenomeles fruits.

Site	Samples[a] (*n*)	Seed (*x* % ± SD)	Pulp + Juice (*x* % ± SD)
C. japonica			
NV	19	7 ± 1	90 ± 10
RG	24	8 ± 2	89 ± 50
D	14	5 ± 2	92 ± 8
F	21	9 ± 3	88 ± 17
C	11	6 ± 1	92 ± 10
C. japonica x *C. speciosa*			
RG	2	7 ± 1	89 ± 2

[a]Number of genotypes analysed

Table 3. Content of moisture and oil in chaenomeles seeds.

Site	Samples[a] (*n*)	Moisture (*x* % ± SD)	Oil (*x* % d.w. ± SD)	Oil (*x* % f.w. ± SD)
C. japonica				
NV	1	41.8	10.1	5.9
RG	9	41.8 ± 1.3	8.8 ± 1.0	5.1 ± 0.6
D	5	40.4 ± 1.0	9.3 ± 2.4	5.6 ± 1.6
F	11	45.9 ± 4.3	6.1 ± 2.4	3.3 ± 1.6
C	9	41.0 ± 2.6	6.5 ± 1.8	3.8 ± 1.1
C. japonica x *C. speciosa*				
RG	1	40.5	16.8	9.8

[a]Number of genotypes analysed

seed oil. The genotypes sampled at site F (*C. japonica*) and site RG (*C. japonica* x *C. speciosa*) had iodine index values similar to pumpkin seed oil, 107 (Tsaknis *et al*. 1997).

The acid index of the crude seed oil was similar in all genotypes of *C. japonica* (2.2–2.5), whereas the *C. japonica* x *C. speciosa* seed oil had a lower value (1.6). These acid indices are close to the acid index reported for melon seed oil (Ramakrishna *et al*. 1970, Mello *et al*. 2001).

Composition of seed oil

Nine components of fatty acids were detected and identified in chaenomeles seed oil: erucic acid, palmitic acid, stearic acid, arachidic acid, behenic acid, oleic acid, cis-11-eicosenoic acid, linoleic acid and linolenic acid. Erucic acid was only detected in trace levels and was therefore not included in Table 5. Saturated and unsaturated fatty acids constituted about 10% and 89%, respectively, of the total content of fatty acids of the chaenomeles seed oil. The most abundant fatty acids in chaenomeles seed oil were linoleic acid (44–53%) and oleic acid (36–44%). Belitz & Grosch (1987) classified seed oils into four groups: oils high in lauric and myristic acids; oils high in palmitic and stearic acids; oils high in palmitic acid; and oils low in palmitic acid and high in oleic and linolenic acids. According to its composition of fatty acids, chaenomeles seed oil belongs to the last group. In this group the oils are all of vegetable origin and in addition to large amounts of oleic and linoleic acids, they contain less than 20% saturated fatty acids (Nawar 1996). The most important members of this group are cotton seed, corn, peanut, sunflower,

Table 4. Iodine index (± SD) and acid index (± SD) of crude chaenomeles seed oil.

Site	Samples[a] (*n*)	Iodine index	Acid index
C. japonica			
RG	6	94.1 ± 8.7	2.2 ± 0.7
D	3	94.5 ± 5.2	2.5 ± 0.3
F	3	105.6 ± 7.8	2.5 ± 0.7
C. japonica x *C. speciosa*			
RG	1	108.4	1.6

[a]Number of genotypes analysed

Table 5 Composition of fatty acids in chaenomeles seed oil (% ± SD).

Taxon	*C. japonica*				*C. japonica* x *C. speciosa*
Site	RG[a]	NV[b]	D[c]	F[c]	RG[b]
Palmitic ($C_{16:0}$)	9.20 ± 1.44	8.27	7.22 ± 1.30	8.13 ± 1.68	8.96
Stearic ($C_{18:0}$)	1.02 ± 0.14	1.52	1.01 ± 0.08	1.18 ± 0.13	0.94
Arachidic ($C_{20:0}$)	0.62 ± 0.05	0.74	0.60 ± 0.05	0.71 ± 0.08	0.72
Behenic ($C_{22:0}$)	0.25 ± 0.03	0.32	0.23 ± 0.02	0.27 ± 0.03	0.28
Total saturated	11.09	10.85	9.06	10.29	10.90
Oleic ($C_{18:1}$)	36.82 ± 2.51	38.07	42.58 ± 5.29	35.53 ± 0.70	44.16
Cis-11-Eicosenoic ($C_{20:1}$)	0.52 ± 0.04	0.52	0.58 ± 0.06	0.58 ± 0.06	0.61
Total monounsaturated	37.34	38.59	43.16	36.11	44.77
Linoleic ($C_{18:2}$)	50.98 ± 1.72	49.98	47.37 ± 5.25	53.09 ± 0.95	43.94
Linolenic ($C_{18:3}$)	0.65 ± 0.36	0.58	0.51 ± 0.06	0.62 ± 0.06	0.39
Total polyunsaturated	51.63	50.56	47.88	53.71	44.33
Saturated/unsaturated	0.13	0.12	0.10	0.12	0.12

[a]8 genotypes analysed, [b]1 genotype analysed, [c]3 genotypes analysed

safflower, olive, palm, and sesame oils (Nawar 1996), as well as soya, rapeseed and linseed oil (Belitz & Grosch 1987). The seed oils of apple, melon, raspberry and walnut also belong to this group (Ruggeri *et al*. 1998, Yinrong & Yeap 1998, Oomah *et al*. 2000, Mello *et al*. 2001).

The main saturated fatty acid of chaenomeles seed oil was palmitic acid (7.22–9.20%), followed by stearic acid (1% of total fatty acids). These two fatty acids are also the principal saturated fatty acids in melon seed oil. The amount of palmitic acid is similar to amounts in melon seed oil, whereas the amount of stearic acid in melon seeds is higher (4.89%) (Mello *et al*. 2001). The amount of stearic acid is also higher in apple seed oil (4.3%) (Yinrong & Yeap 1998).

Among the unsaturated fatty acids of chaenomeles seed oil, linoleic acid was the principal (up to 53%), followed by oleic acid (up to 44%). For comparison, in seed oil of apple the content of oleic acid has been reported to be rather low (4.1%) (Yinrong & Yeap 1998). Linoleic acid concentration was similar in the samples of *C. japonica* and *C. japonica* x *C. speciosa*.

The saturated/unsaturated fatty acid ratio was in general very low in chaenomeles seed oil (on average 0.12) and it was very similar in all genotypes studied, ranging from 0.10 to 0.13. These results confirm that unsaturated acids predominate, thus chaenomeles seed oil could be an interesting product. However, the chaenomeles seed oil had a strong odour of bitter almond. The compound responsible for this was benzaldehyde, which was determined by GLC and confirmed by mass spectrometry. This may negatively influence the quality and usefulness of the oil, and may require a deodorization step during processing.

Future research on chaenomeles seed oil should include a deeper characterisation and a study of the resistance to oxidation and storage stability. Characteristics of interest such as pH, density, viscosity, colour, refractive index, turbidity, melting point, moisture, saponification index, diene value, *p*-anisidine value, peroxide value, carotenoid content, tocopherol content, neutral lipids, phospholipids and free fatty acids were not determined in our study due to the limited amount of oil available for analysis. In addition, extraction procedures should be developed and improved by the use of enzymes (Coll *et al.* 1995, 1996, Ros *et al*. 1996a, Winkler *et al*. 1997) and membrane technologies (Ros *et al*. 1996b, Moliner *et al.* 1998).

CONCLUSION

Plants of Japanese quince produced fruits rich in seeds, on average 5–9% based on fresh weight. The seeds contained some seed oil, on average 8.2% based on dry weight. This seed oil was characterised by a high iodine index (98 on average) and low acid index (2.3% on average). The main fatty acid components of the seed oil were linoleic acid, oleic acid and palmitic acid. The ratio between saturated and unsaturated fatty acids was very low, on average 0.12. Chaenomeles seed and its oil may therefore be of interest for the food industry, and a source of valuable compounds for food and non-food uses.

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