Effect of Heat Treatments on Canola Press Oils. I. Non-Triglyceride Components

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Increasing heat treatment given to canola seed prior to pressing resulted in press oils with progressively increasing contents of non-triglyceride components. Phosphorus and chlorophyll contents ranged from 13 ppm and 7 ppm, respectively, in cold press oil to 64 ppm and 68 ppm, respectively, in oil from heated seeds. Refining reduced the amount of these components to 19 ppm and 60 ppm, respectively, in degummed oil and to 4 ppm and 11 ppm, respectively, in bleached oil. Oil with the lowest amount of non-triglyceride material was obtained by cold pressing and/or bleaching.

The major sterols were β-sitosterol (55%), campesterol (35%) and brassicasterol (10%), and the major tocopherols were γ (60%), α (30%) and δ (10%). The content of sterols and tocopherols ranged from 620 to 773 mg/100 g and from 47 to 64 mg/100 g, respectively, in the press oils. The total content of sterols was reduced by 15% and a further 1% on degumming and bleaching, respectively. The total tocopherol content was reduced by 20% and 60% on degumming and on subsequent bleaching. Refining had no effect on the sterol isomer ratio, but there was a significant relative loss of α-tocopherol on bleaching.

KEY WORDS: Canola, heat treatment, non-triglyceride components, press oils, refining.

There has been an increased interest recently in small-scale pressing of oilseeds, especially for edible oil production on the village level in developing countries or for on-farm production of vegetable oil for fuel in both developed and developing countries. The quality of oil and meal produced from the pressing operation is important. There is also increased interest in pressing efficiency in large-scale operations to reduce energy requirements during oil extraction; for example, direct use of a screw-press for pre-pressing is advocated with the intention of avoiding flaking and cooking procedures, and of producing an oil of superior quality (*e.g.*, VPEX press, Krupp Industries, Hamburg, Germany).

Oil quality can be measured by a number of parameters, including non-triglyceride contaminants and indicators of oil damage such as free fatty acids (from hydrolysis) and oxidation products. A "good quality oil" is usually defined as having minimal non-triglyceride contaminants and oxidation products, but antioxidants such as tocopherols are desirable. Non-triglyceride components can have a strong influence on the course of oxidation, and thus identification of the most important non-triglyceride components, and the extraction and refining processes that affect their content, is desirable. The aim of this study was to determine the effect of oil extraction and processing conditions on the content of non-triglyceride components in press oils.

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EXPERIMENTAL PROCEDURES

A commercial sample of *Brassica napus cv.* Westar was obtained from a farm at Blaine Lake, Saskatchewan, Canada, from the 1985 harvest. The sample had a 6% green seed content as measured by the method of Reynolds (1).

Seed preparation. Seed was heated, 1 kg at a time, in a closed metal container placed in an air-oven, and shaken at 5-min intervals. All samples required 40 min to reach the desired temperature. The treatments were none (*i.e.*, cold press), 80°C/30 min, and 100°C/30 min. An additional sample was flaked prior to cooking at 100°C/30 min. This sample was pre-heated to 38–40°C over 10 min to minimize shattering and flaked to 0.3 mm thickness on a pair of smooth rollers (Standard Gas Engine Works, Morden, Manitoba, Canada).

Seed pressing. The oil was expelled using a screw-press (Mini-40 Screw-Press, Simon Rosedowns Ltd., Hull, United Kingdom). It was operated at 120 rpm with choke setting of 8 (0.42 mm). It produced cake in the form of flakes of *ca.* 0.6 mm thickness. Barrel temperature during the run was measured by a thermocouple (115 TC, Omega Engineering, Inc., Stamford, CT) inserted into the barrel wall near the discharge end and recorded on a strip chart recorder.

The press was pre-heated to 45°C with a heating band. Pretreated seed was fed into the covered press feed hopper immediately after heating to minimize heat and moisture loss. Three kg of seed was pressed at a choke opening of 8, 1 kg of which was pressed to warm up the press (start-up), followed by 2 kg for the main run. Oil was collected from the main run only, except for cold and 100°C-heated seed where start-up oil was also collected, so that the effect of increasing barrel temperature could be observed. The expelled oil was centrifuged at 5,000 × *g* for 25 min to remove fines.

Oil refining. Two oil samples were prepared from oil extracted from the 100°C-heated oil. One sample was degummed and the other sample was degummed, refined and bleached. Degumming of 120–170 g of oil was carried out according to Method D-1, 8/84 (POS, Saskatoon, Saskatchewan, Canada, personal communication). The oil was heated in 400-mL tall-form beakers in a water bath at 38°C with vigorous agitation from a stirring shaft and impeller to ensure adequate mixing of the oil. Once the oil temperature had stabilized, 0.2% (v/w of oil) of a 50% citric acid solution was added and the sample was mixed for 15 min. Then 2.0% distilled water was added and the sample was mixed for another 15 min. It was then heated rapidly to 70°C (heating for a maximum of 5 min) and centrifuged at 5,000 × *g* for 25 min, and the clear oil was decanted. The decanted oil was dried on a rotary evaporator at 100°C for 20 min. Both the citric acid solu-

tion and the distilled water were held at 90–100°C before addition to the oil.

Refining was carried out according to Method R-4, 8/84 (POS, Saskatoon, Saskatchewan, Canada, personal communication). The oil was heated and agitated as before and, when the temperature had stabilized, 14 Bé (9.5%) sodium hydroxide solution was added, sufficient to neutralize the free fatty acids present, with 0.08% excess. The sample was mixed for 15 min, then heated rapidly to 70°C and centrifuged, and the clear oil was decanted as before. The clear oil was heated to 75°C and poured into a 250-mL separatory funnel. Deionized water, 10–15%, at 90–100°C was sprayed onto the oil surface and allowed to settle through the oil. The funnel was inverted several times and the aqueous layer withdrawn. The washing procedure was repeated. The washed oil was centrifuged as before.

Bleaching was carried out by a modification of the method of Gunstone and Norris (2). The oil was placed in a Buchner flask attached to a vacuum line and heated to 60–70°C a heating pad with magnetic stirring. After 1.5% Vega Clay bleaching clay (Clay Products Division, Filtrol Corporation, Los Angeles, CA) was added, vacuum was applied, and the mixture was stirred vigorously for 20 min. The mixture was centrifuged, and the clear, bleached oil was decanted.

Commercial canola oil. Crude, non-degummed canola oil was obtained from CSP Foods (Nipawin, Saskatchewan, Canada). It was a blend of pre-press and solvent-extracted oils, predominantly from Westar seed. Seed and oil preparations are summarized in Table 1.

Seed analysis. Moisture and crude fat were determined according to the American Association of Cereal Chemists Official Methods 44-40 and 30-20, respectively (3). Crude fiber and ash contents were determined according to the Association of Official Analytical Chemists Methods (AOAC) 7.070 and 7.009, respectively (4). Crude protein, calcium and phosphorus contents were determined at the same time according to AOAC Method 7.022 (5) by means of an automated Kjeldahl procedure.

Oil analysis. Carotenoids were determined by a modification of the method recommended by De Ritter and Purcell (4). Oil, *ca.* 3.5 g, was weighed into 25-mL volumetric flasks and diluted to volume with hexane. The solution was scanned from 300 nm to 600 nm against hexane. Net absorbance was determined as A446 nm less A600 nm, and ppm carotenoids as lutein equivalents calculated with $\varepsilon max = 2{,}160$ (6).

The chlorophyll determination procedure was based on a modification of the method of Levadoux *et al.* (7). Oil, *ca.* 2.5 g, was weighed into a 25-mL volumetric flask and diluted to volume with petroleum ether. The solution was scanned from 630 nm to 710 nm, and the net absorbance was determined as A660 nm less (A630 nm + A702 nm)/2. A chlorophyll calibration curve was constructed with chlorophyll A (Sigma Chemical Co., St. Louis, MO) in acetone (1 mg/mL). Chlorophyll was calculated as ppm chlorophyll A equivalents.

Color was determined with a Hunter Lab Color Difference Meter (Model D25, Hunter Lab, Fairfax, VA). Standard white plastic containers 6.3 cm in diameter and 0.8 cm deep, filled to within 1 mm from the rim were used, and the instrument was calibrated against a standard white tile. Two readings were taken with the container being rotated 180° between measurements and the results were averaged.

Sulphur compounds within the oil were converted to hydrogen sulphide by nascent hydrogen released from glacial acetic acid by magnesium (Sosulski, F.W., personal communication). The hydrogen sulphide was swept from the oil with a stream of nitrogen and reacted with lead acetate-impregnated paper. The darkness of the resulting lead sulphide deposit corresponded to the sulphur content of the oil. Sulphur content, expressed in ppm, was determined visually by comparison with standards. Standards were prepared with dibenzyl disulphide, 0.03842 g/100 g Mazola oil, over a range of 5–100 ppm sulphur.

Free fatty acids were determined according to Lowry and Tinsley (8). Peroxide values were determined spectrophotometrically at 350 nm according to the micromethod of Swoboda and Lea (9). Phosphorus was determined by a modification of the methods of Raheja *et al.* (10) and Tobani *et al.* (11). Tocopherols and sterols were analyzed by GLC on a 25 m × 0.25 mm cross-linked methyl silicone capillary column [Hewlett-Packard (Canada) Ltd., Edmonton, Alberta] by following the method of Slover *et al.* (12).

Fatty acid composition of the oils was determined by gas chromatography of the free fatty acid methyl esters (FAME). FAMEs were prepared by acid methanolysis according to Hitchcock and Hammond (13) and were chromatographed on a Durabond DBWAX fused silica capillary column, 20 m × 0.25 mm (Chromatographic Specialties, Brockville, Ontario). A Hewlett-Packard 5880A Series Gas Chromatograph with 5880A Series GC Terminal was used. The instrument was equipped with a flame ionization detector (FID) and 3390A Series integrator. This equipment was obtained from Hewlett-Packard (Canada) Ltd., Edmonton, Alberta.

RESULTS

Seed composition. The composition of the Westar seed is given in Table 2.

Fatty acid composition. The seven Westar press oils had similar compositions: *ca.* 59.8% oleic, 19.7% linoleic and 11.1% linolenic acids. The commercial oil had a slightly different composition: 61.3% oleic, 19.8% linoleic and 9.0% linolenic acids. The average coefficient of variation (CV) was 0.7%. Thus the variations in fatty acid composition of the oils would not be expected to cause significant differences in oxidative stability among the oils.

Effect of heat treatments. The amount of non-triglyceride material was lowest in the cold press oil and increased progressively with increasing heat treatment to the seed (Table 3). Oil expelled from 80°C-heated seed (oil 3) contained substantially greater amounts of free fatty acids, phosphorus, chlorophyll, carotenoids and other colored compounds than cold press oil (oils 1 and 2). The amounts of these non-triglyceride components were raised further in oil from the 100°C-heated seed (oils 4 and 5). However, oil from flaked seed (oil 6), despite an additional heat treatment, contained lower amounts of non-triglyceride material than the 100°C-treated seed, except for free fatty acids and peroxide value.

Effect of increasing barrel temperature. Increased barrel temperature during pressing of Westar also resulted in an increase in non-triglyceride components. The effect

TABLE 1

Seed and Oil Treatments

Source	Treatment			Ext.[n] Rate[b] (%)	Oil
	Pre-	BT (°C)[a]	Post-		
Seed					
Westar	none	80–90	none	69.9	1
Westar	none	90–100	none	65.9	2
Westar	80°C	105–110	none	81.2	3
Westar	100°C	<105	none	—	4
Westar	100°C	105–127	none	87.4	5
Flakes					
Westar	100°C	124–127	none	88.1	6
Oil					
Oil 5			degummed	87.4	7
Oil 5			degummed, refined bleached	87.4	8
Commercial	—	—	none	—	9

[a]BT, barrel temperature.
[b]Ext.[n] Rate, extraction rate = (total oil − oil remaining in cake)/total oil × 100.

TABLE 2

Analysis of Westar Seed (%db)[a]

	Moisture (%)	Crude protein	Crude fat	Crude fiber	Ash	Calcium	P[b]
Westar	4.9	23.0	48.4	7.5	4.3	0.6	0.7
CV[c] (%)	4.5	1.3	2.0	13.8	1.2	2.4	1.0

[a]Duplicate.
[b]P, phosphorus.
[c]CV, coefficient of variation.

TABLE 3

Non-Triglyceride Components of the Canola Oils[a,b]

Oil	FFA[c] (%)	P[c] (ppm)	Chl (ppm)	Color			Carot (ppm)	PV (mM/kg)	S (ppm)
				L	a	b			
1	0.08	12.6	6.5	38.1	14.5	25.8	126	1.45	1
2	0.09	16.2	10.2	34.3	10.3	23.0	138	.01	tr
3	0.12	22.1	47.3	16.9	1.0	10.1	203	0.,98	tr
4	0.12	41.7	46.7	16.9	1.5	9.9	178	—	tr
5	0.15	64.2	67.8	8.5	3.4	3.6	216	0.99	tr
6	0.23	59.3	55.9	13.9	2.0	7.8	206	1.40	tr
7	0.13	19.3	60.4	—	—	—	212	0.71	tr
8	ND	4.3	10.8	40.3	9.1	27.2	138	0.77	tr
9	0.36	176.7	25.2	28.4	9.2	18.7	118	0.83	5
CV(%)	6.6	6.4	2.5	<1	<1	<1	0.2	0.6	ca.10

[a]Abbreviations: FFA, free fatty acids; P, phosphorus; Chl, chlorophyll as chlorophyll a; Color, L, a, b, Hunter lab colorimeter readings; Carot, carotenoids as lutein; PV, peroxide value; S, sulphur; CV, coefficient of variation.
[b]Codes explained in Table 1.
[c]Duplicates.

of increasing barrel temperature on non-triglyceride materials is shown (Table 3) by comparing both cold press oils (oils 1 and 2) and both 100°C-cooked seed oils (oils 4 and 5). In each case the content of non-triglyceride components was higher in the oil expelled at the higher temperature (see Table 1 for press conditions). Phosphorus and chlorophyll contents increased from 12.6 ppm and 6.5 ppm, respectively, in oil 1 to 16.2 ppm and 10.2 ppm, respectively, in oil 2. In the heated seeds phosphorus and chlorphyll contents increased from 41.7 ppm and 46.7 ppm, respectively, in oil 4 to 64.2 ppm and 67.8 ppm, respectively, in oil 5. The initial cold press oil, oil 1, had

1 ppm sulphur, but the main run for oil 2 had only a trace amount.

Effect of oil processing. Contents of non-triglyceride components were reduced (initial oil is oil 5) by degumming (oil 7) and refining (oil 8). The content of free fatty acids were reduced slightly by degumming but was below detectable limits in the bleached oil. Degumming resulted in the greatest loss of phosphorus, from 64.2 ppm to 19.3 ppm, while bleached oil contained *ca.* 4 ppm residual phosphorus. Bleaching resulted in the greatest loss of chlorophyll, from 67.8 ppm in crude oil to 60.4 ppm in degummed oil to 10.8 ppm in bleached oil Carotenoid contents and color values followed the same trend as chlorophyll contents.

Tocopherol and sterol contents. γ-Tocopherol was the predominant tocopherol, *ca.* 60%, with a smaller amount of α, *ca.* 30%, and a small amount of δ, 10% (Table 4). However, the bleached and solvent-extracted oils (oils 8 and 9) had different tocopherol patterns, 9%, 75% and 16%, and 24%, 61% and 15%, respectively, of α, γ and δ, respectively. The commercial oil (oil 9) and the 100°C-heated oil (oil 5) had the highest total tocopherol contents, *ca.* 65 mg/100 g. Total tocopherols were reduced during degumming and bleaching by 20% and 60% of the total, respectively.

β-Sitosterol was the predominant sterol, *ca.* 55%, with a smaller amount of campesterol, *ca.* 35%, and a small amount of brassicasterol, *ca.* 10%. Total sterol levels in the oils increased with increasing heat treatment—from 690 mg/100 g in oil 1 to 740 mg/100 g in oil 5; and were reduced by degumming and bleaching by 15% and a further 1% of the total, respectively. The solvent-extracted oil (oil 9) had the lowest, 617 mg/100 g, and oil from the flaked seeds (oil 6) had the highest, 773 mg/100 g, sterol content.

DISCUSSION

Effect of heat treatments. Cold press oils are known to contain lower amounts of non-triglyceride material than oil obtained from conventional pre-press operations (14–16). The cold press oil obtained in this experiment had comparable free fatty acids content, peroxide value, chlorophyll and phosphorus contents to those in the literature. However, sulphur content was lower, trace to 1 ppm as compared to *ca.* 6 ppm for published values.

Residence time, temperature and moisture content of the seed during cooking affect oil quality (17). The disruption of cell structure and solubilization of phospholipids and pigments during heating would account, in part, for the increased level of non-triglyceride material in oil expelled from heated seed as compared to cold press oil. Heating the seed to 100°C, or higher, has been reported to increase this solubilization and would account for the increased level of non-triglyceride components in oil from 100°C-heated seed (oils 4 and 5), as compared to oil from 80°C-heated seed (oil 3). Work by other researchers reported by Hougen *et al.* (18) showed that while cold pressed oils were free of lecithin, heating to 45°C released phospholipids into the oil. However, another factor to be considered is the difference in extraction rates between cold press, *ca.* 69%, and heated seed, *ca* 81% and *ca.* 87% (for 80°C- and 100°C-heated seed, respectively). The amount of phospholipids and other polar compounds passing into the oil increases during the later phases of extraction. This increase was reported to begin after *ca.* 40–70% of the total oil had been extracted (19). Thus, the difference in extraction rates would be expected to influence the content of non-triglyceride components in the oil. However, it is probable that this makes a smaller contribution than heating of the seed.

The lower levels of phosphorus and color bodies in the oil expelled from flaked seed (oil 6) may be due to binding and/or agglomeration of non-triglyceride components during preheating or flaking, which would result in decreased solubilization, or fixing, of phospholipids and pigments in the cake (20). The higher content of free fatty acids and greater peroxide value are indications of oil damage and are probably a result of the increased seed heat treatment.

In general, press oils are of a higher quality, *i.e.*, lower contents of non-triglyceride materials, than extracted oils from the same seed. This was shown by the pre-press solvent-extracted commercial oil (oil 9), which contained considerably higher levels of phosphorus, free fatty acids and sulphur as compared to the press oils. However, levels of color bodies, chlorophyll and carotenoids were within the same range as the press oils. The conclusions drawn by Blake (16) and Knuth and Homann (14) that cold pressing produces an oil of excellent quality, *i.e.*, low content of non-triglyceride components, are confirmed by these experimental results.

Effect of seed quality. The content of non-triglyceride

TABLE 4

Tocopherol and Sterol Contents (mg/100 g)[a,b]

Oil	Tocopherols				Sterols			
	α	γ	δ	Total	Brassica	Campe	β-Sito	Total
1	17.3	34.4	5.7	57.4	69.1	236.0	378.8	689.3
2	17.3	34.6	6.5	58.4	70.1	238.8	386.8	695.7
3	15.5	31.8	4.8	52.1	62.0	213.0	345.6	620.6
4	13.8	29.2	4.2	47.2	61.6	210.4	341.1	684.9
5	21.0	38.5	4.7	64.2	73.8	254.4	412.9	741.1
6	17.7	36.7	4.9	59.3	77.9	265.4	430.0	773.0
7	15.9	31.6	4.1	51.6	62.7	216.7	351.7	631.1
8	2.5	19.9	4.2	30.8	62.1	211.0	348.0	621.1
9	15.6	40.5	10.3	66.4	73.0	198.7	345.5	617.2

[a]CV, 2.0–2.7%.

[b]Codes explained in Table 1.

components in the press oils is affected not only by press conditions but by seed quality. The experimental oils expelled from cooked and/or flaked seeds contained substantially differing amounts of non-triglyceride components as compared to commercial expeller oils. Levels of phosphorus were substantially lower than literature values for expeller oil, *e.g., ca.* 300 ppm (21) as compared to *ca.* 60 ppm for oil from heated flaked seed (oil 6). This can be explained by the fact that the phospholipid content in the oil is reduced by a decrease in seed moisture—seeds with 5% and 9–11% moisture had two times and three times, respectively, as much phospholipid as seed with 2.5% moisture content (19). Commercial seed is usually pressed at *ca.* 8–9% moisture (22), but the experimental seed had a moisture content of *ca.* 4%. This lower moisture content would at least partly account for the low level of phosphorus found in the cooked seed press oils.

Levels of free fatty acids were lower than those found commercially, usually 0.4–1.0% (22). This could also be attributed in part to the low seed moisture content. Lipase and lipoxygenase activities, which lead to hydrolysis and, hence, an increase in free fatty acids content, are reduced at lower moisture contents.

The low sulphur contents of the oils were also probably due to low seed moisture, well below the 8–9% needed for increased myrosinase activity (17). The slightly higher level in cold press oil (oil 1) might be due to inadequate heat treatment as the seed was not cooked and was pressed at 80–90°C. Myrosinase activity is inhibited above *ca.* 90°C at less than *ca.* 6% moisture (23). However, this result is consistent with those reported by Pickard *et al.* (24). They found that press oil from ambient seed had 0.5–0.9 ppm sulphur while oil from 90°C-heated seed had 0.1–0.6 ppm sulphur.

Chlorophyll content was higher than commonly found in commercial oils, 2–25 ppm (22). This is also a reflection of seed quality, the seed had a 6% green seed content, and on this basis would have been graded as Canada Rapeseed No. 2 (25). Dahlèn (26) found that there was a 10-fold decrease in chlorophyll content in solvent-extracted oil from mature seeds as compared to oil from immature seeds.

Carotenoid contents of the press oils were considerably higher than those reported by Hazuka and Drozdowski (6) in lipid extract. However, the range of carotenoid contents expected in canola is not known, and thus these values may not be abnormally high. Differences in the determination procedure may also account, in part, for the higher experimental results.

Effect of increasing barrel temperature. The increase in non-triglyceride components with increase in barrel temperature for a particular seed (cold press and 100°C-heated seed) was probably a consequence of increased pressure and shear exerted on the seeds, which was manifested by an increase in barrel temperature, rather than the increase in temperature *per se.* Temperature and pressure are closely related (27). The increased pressure and shear would increase the solubilization of non-triglyceride components, and thus their content in the oil.

Effect of oil processing. Degumming removes most of the phospholipids by hydration and separation of the resultant gums. Hydratable phospholipids include phosphatidylcholine (PC), phoshatidylethanolamine (PE), phosphatidylinositol (PI) and phosphatidylserine (PS), which have strongly polar groups; non-hydratable phospholipids include phosphatidic acid (PA) (28). Most of the phospholipid in canola oil is present as PC, PE and PI, *ca.* 50, 20, and 20 mole %, respectively (29), and this would be removed during degumming and alkali-refining. These authors also reported *ca.* 10 mole % PA which, together with any more PA formed during processing, would be left in the oil. This would account for the residual phosphorus levels in the bleached oil.

Bleaching is an adsorption process. It is affected by choice of activated earth (*i.e.*, acidity) dosage, temperature, time, mixing and atmospheric vs. vacuum conditions (30). Acid-activated bleaching clays adsorb peroxides and color bodies, such as chlorophyll and carotenoids. The Vega Clay Plus used in this experiment was an effective adsorber of chlorophyll (and free fatty acids), despite the high initial level in the heated seed oil. However, it was less effective at removing carotenoids. The increased peroxide value, compared to degummed oil, is probably an indication of decreased stability of bleached oil during storage.

Tocopherol and sterol contents. Tocopherol contents and isomer distribution (Table 4) were consistent with the literature (31). Pretreatment of the seed did not significantly affect tocopherol content, although the highest levels were found in oils from 100°C-heated seed (oil 5) and from flaked seed (oil 6). There is no literature available on the effect of oil extraction conditions on tocopherol content in the oil, but Rutkowski and Myzk (32) found that in the solvent extraction of rapeseed oil increasing the solvent temperature in the range 14–52°C did not significantly affect the tocopherol content of the oil. In this experiment a small increase in the tocopherol content was observed in oil from a particular seed treatment with an increase in barrel temperature. A possible explanation for the uniform tocopherol content of the press oils is that since the tocopherols are part of the neutral lipids, they are easily extracted with the initial press oil. Increasing the degree of oil extraction, which increases the content of polar components, would not significantly raise the tocopherol content of the oil. The commercial oil (oil 9) contained slightly higher levels of tocopherols than the press oils. The degree of reduction in tocopherols by degumming and by alkali-refining and bleaching was consistent with results previously reported (32,33). However, a major difference was found in the isomer distribution. The previous workers, quoted above, found only a small relative loss of α-tocopherol as compared to γ- and δ-tocopherols during processing. In this experiment there was a significant relative loss of α-tocopherol in the bleached oil: α-tocopherol accounts for 8%, 30% and 33% of the total in bleached, degummed and crude (oils 8, 7 and 5), respectively. One explanation is that there was a selective adsorption of α-tocopherol on the bleaching clay. It is also possible that α-tocopherol is more sensitive to heat and oxidation than the other tocopherols and was preferentially destroyed during processing and storage.

The levels of tocopherols present in the oils, even after bleaching, would have significant antioxidant effectiveness and vitamin E activity (31). The good oxidative stability of canola/rapeseed has been attributed to its relatively high tocopherol content (34).

The total sterol content and isomer distribution (Table

4) were also consistent with the literature (31,35). Sterol content of the press oils closely paralleled tocopherol content, except that oil from the flaked seed (oil 6) contained the highest amount of sterols.

The overall reduction in sterol content after refining was consistent with the literature (36). Unlike tocopherols, there was no change in isomer distribution during processing.

Seed and oil processing conditions exert a considerable effect on the content of non-triglyceride components in press oils. The effect of these differences in non-triglyceride content on oxidative stability of the oils is shown in the second part of this research (37).

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