Quality of Yellow and Dark Seeds in *Brassica Campestris* Canola Varieties Candle and Tobin

J.K. Daun and **D.R. DeClercq**
Canadian Grain Commission, Grain Research Laboratory Division, 1404-303 Main St., Winnipeg, Manitoba R3C 3G8

Yellow-coated seeds from the *Brassica campestris* cultivars Tobin and Candle were heavier and contained more oil and protein than the dark-coated seeds from the same sample. In addition, the yellow-coated seeds had lower levels of erucic acid, glucosinolates, chlorophyll and crude fiber. These differences were detected in both pedigreed and commercial (producer) samples, but to a larger extent in commercial samples. Reasons for the greater quality differences between yellow- and dark-coated seed could be admixtures of cultivars other than the declared ones of Tobin or Candle or changes in the seed itself as it went from the breeder's stage to the producer stage.

The development of canola varieties with yellow seed coats has been a breeding objective for almost 20 years. Seeds with yellow seed coats were found to have thinner hulls and consequently less fiber and more oil and protein than dark-coated seeds (1). The yellow characteristic itself has been associated with reduced levels of polyphenols (2).

In *Brassica campestris*, the yellow-seeded characteristic was achieved partially in 1977 when the first *Brassica campestris* canola strain, Candle, was licensed in Canada. This variety had "partially yellow" seed coats, that is, a fraction of the seeds were either yellow, or partly yellow colored (Fig. 1). Unfortunately, although being of canola quality, Candle was significantly lower in yield than the then predominant black-seeded rapeseed variety, Torch, and full conversion to canola did not take place until Tobin, a higher yielding "partially yellow" seed coated *B. campestris* line was licensed in 1981 (3).

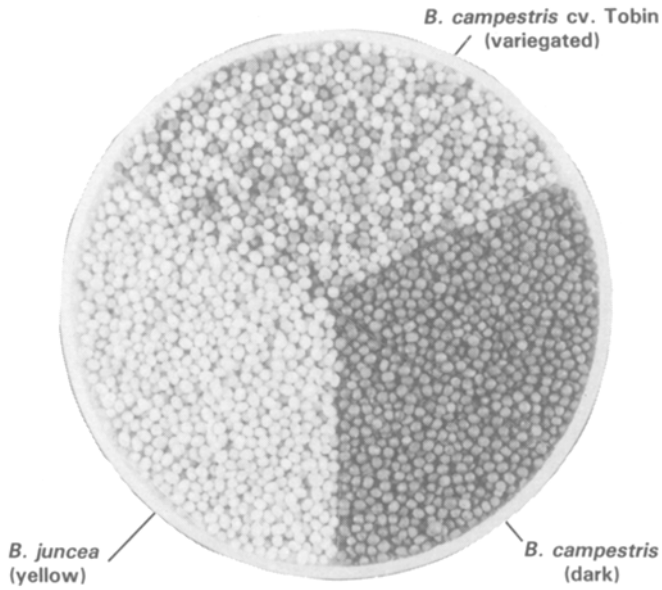

FIG. 1. *Brassica campestris* cv. Tobin (variegated) shown with its *B. juncea* (yellow) and *B. campestris* (black) parents.

Although all the *B. campestris* canola seed grown in Canada has a partially yellow seed coat, no yellow seed coated *B. napus* lines have yet been released. Only 40% to 50% of seed planted in Canada in recent years has been to *B. campestris* varieties, and since *B. napus* and *B. campestris* seed is mixed in the grain handling system, the proportion of yellow or partially yellow seed in Canadian seed exports has been small. Fully yellow seed coated lines have been isolated in both *B. campestris* and *B. napus*, however, and once these lines have been developed the visual character of Canadian seed exports may change further.

Although the advantages of yellow seed coats have been documented for breeding material, there is little information available on their performance in commercial production. This study compares the quality of yellow and dark seeds from the two partially yellow canola varieties using both pedigreed and commercially grown seed lots.

MATERIALS AND METHODS

Pedigreed seed of both Candle and Tobin varieties was obtained from the plant breeder (breeder's seed) and from certified seed growers (foundation and certified seed). Commercially produced seed samples were obtained through the Grain Research Laboratory's New Crop Surveys. In these annual surveys, samples representative of producers' deliveries for that crop year were obtained from primary elevator agents. The agent was requested to indicate the variety of seed submitted on the sample envelope, if possible. Samples submitted were composited by variety and, if sufficient samples were available, by province of origin. Only those samples identified by variety as well as containing yellow seeds were used in making varietal composites.

Yellow- and dark-seeded subsamples of 8–10 g were produced by hand separations (Fig. 2). The percentage of dark seeds and 1000 seed weights were determined by averaging the results from 5 × 200 seed aliquots.

Oil contents were determined by grinding the seed in a high-speed grinder (4) and extracting for 6 hr with diethyl ether on a Goldfisch extractor. Protein content (% N × 6.25) was determined by Kjeldahl (5); glucosinolates (6) and fatty acid composition, including iodine value (7) by gas liquid chromatography; crude fiber by a micro procedure (8), chlorophyll by reflectance spectrophotometry (9) using a Dickey-john NIR instrument equipped with 674 and 696 nm filters with a 200 nm reference.

TABLE 1

Overall Quality Factors for Samples of *Brassica campestris* Cultivars Used in the Study

Seed type	Year grown	Province	No. of samples		Dark seeds		1000 seed weight		Oil content[a]		Protein content[b]		Chlorophyll		Glucosinolates[b]		Crude fiber[c]		Fatty acid composition					
																			C22:1		C18:3		Iodine value	
			Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin	Candle	Tobin
					%		g		%		%		ppm		μM/g		%		%		%			
Breeders	1980	–	–	–	14.4	35.6	(1.62)	2.28	(35.0)	41.0	–	–	–	–	17	17	13.0	–	1.2	0.1	14.3	13.4	127	123
	1981	–	–	–	–	33.8	–	2.41	–	42.0	–	38.4	–	–	–	17	–	15.2	–	0.1	–	14.5	–	126
Certified	1979	–	–	–	24.4	–	2.45	–	41.6	–	35.0	–	–	–	15	–	16.0	–	0.8	–	14.6	–	127	–
	1982	–	–	–		27.5	–	2.73	–	38.1	–	38.1	–	9	–	28	–	13.6	–	0.1	–	14.0	–	124
	1983	–	–	–	26.8	–	2.27	–	41.2	–	33.8	–	4	–	12	–	12.0	–	1.0	–	13.8	–	125	–
	1984	–	–	–		32.1	–	2.73	–	40.6	–	–	22	–	–	–								
Commercial	1982	Alberta	166	20	44.5	48.1	2.55	2.77	39.9	40.1	34.1	34.1	13	14	33	37	16.0	15.9	2.5	2.1	13.8	14.2	123	124
	1982	Sask.	16	–	33.1	–	2.42		40.0		33.7		5	–	25	–	16.4	–	2.4	–	13.0		122	–
	1982	W. Canada	182	–	43.5	48.1	2.26	2.77	39.9	40.1	34.1	34.1	12	14	32	37	16.0	15.9	2.5	2.1	13.7	14.2	123	124
	1983	W. Canada	53	182	40.1	35.5	2.30	2.12	39.8	38.9	34.1	34.0	9	9	32	28	15.2	15.5	1.3	0.8	12.1	11.7	120	120
	1984	Alberta	20	245	50.2	43.8	2.07	2.10	39.4	38.8	36.8	36.6	3	4	33	32	13.5	13.8	1.0	0.8	11.1	11.3	118	118
	1984	Sask.	25	13	30.7	41.3	2.06	2.04	38.2	38.1	36.2	36.4	4	4	22	27	13.6	13.1	0.2	0.7	10.3	10.8	117	118
	1984	W. Canada	45	258	39.4	43.7	2.06	2.10	38.7	38.8	36.5	36.6	4	4	27	32	13.6	13.8	0.6	0.8	10.7	11.3	117	118
	1985	Alberta	9	308	43.2	38.9	2.48	2.34	38.8	38.4	37.4	35.6	5	4	39	33	17.5	15.6	0.9	1.0	13.1	12.7	122	121
	1985	Sask.	4	97	39.6	33.9	2.18	2.16	40.3	39.2	32.9	32.6	6	4	21	25	18.5	15.9	0.6	0.7	12.5	12.7	121	121
	1985	Manitoba	–	2	–	29.9	–	2.07	–	37.0	–	33.4	–	6	–	14	–	14.5	–	0.1	–	13.8	–	125
(calculated)	1985	W. Canada	13	407	42.1	37.7	2.39	2.30	39.3	38.6	36.0	34.9	5	4	33	31	17.8	15.7	0.8	0.9	12.9	12.7	122	121
(composite)	1985	W. Canada	–	407		39.0	–	2.32	–	38.7	–	35.8	–	4	–	32	–	15.5	–	0.9	–	12.7	–	121
Mean pedigreed					21.9	32.3	2.36	2.54	41.4	40.4	34.4	38.3	13	9	15	21	13.7	14.4	1.0	0.1	14.2	14.0	126	124
Mean commercial					41.3	41.2	2.25	2.32	39.4	39.1	35.2	34.9	8	8	31	32	15.6	15.2	1.3	1.2	12.4	12.5	121	121

[a]8.5% moisture basis.

[b]Oil-free, 8.5% moisture basis.

[c]Oil-free, dry basis.

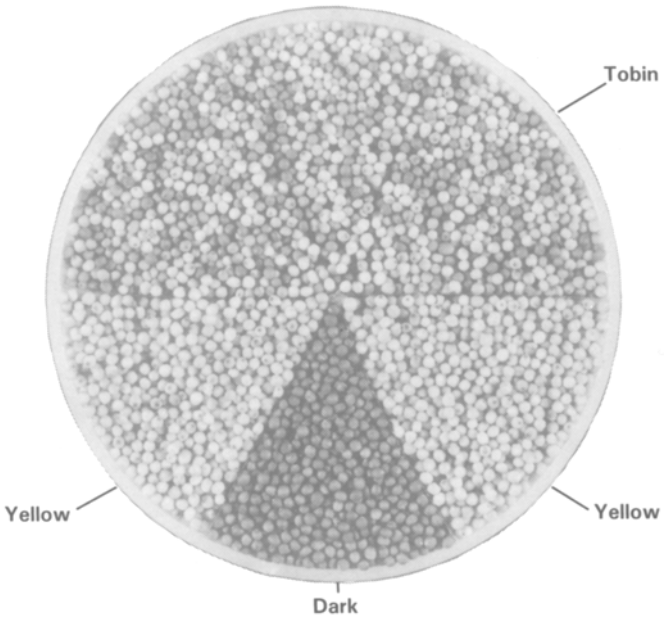

FIG. 2. *Brassica campestris* cv. Tobin and its yellow and dark fractions.

RESULTS AND DISCUSSION

Unseparated samples. There was little difference in the quality of Candle and Tobin commercial seed samples (Table 1). Tobin seeds were slightly heavier and had slightly less erucic acid. It is not appropriate to make other quality comparisons between the pedigreed seeds because of the limited number of samples and the different growing years and locations.

Despite the limited number of pedigreed samples, some significant differences between pedigreed and commercial seeds were observed. Commercial seed lots averaged significantly higher in amounts of dark seeds, glucosinolates, erucic acid and fiber, all undesirable characteristics.

Differences in oil content, protein content, linolenic acid content and iodine value were more likely the result of environmental differences between the years in which the pedigreed seed was grown (1979–1984) and the years for which the commercial seed was grown (1982–1985). In particular, the severe drought experienced in Western Canada during 1983 and 1984 caused reduced oil content, iodine values and linolenic acid contents. Similarly, much of the seed grown in 1982 had high levels of chlorophyll due to an early August frost (10).

Yellow and dark seed comparisons (Table 2): 1000 seed weights. In general the yellow seed weighed more than the dark seed. This was also noted by Stringham et al. (8). The notable exception in our data was the 1983 commercial sample of Candle where the dark outweighed the yellow significantly. Other than this sample the differences in 1000 seed weight between dark and yellow seeds for both certified and commercially grown seed were similar for both varieties.

Oil content. One of the objectives in developing yellow-seed canola lines was the increase in oil content associated with yellow seeds (1,11). The yellow seeds contained substantially (2.5%) more oil than dark seeds in all three of the breeders samples and in two of the four certified samples tested. Yellow seed in two of the certified samples had only slightly (0.4%) less oil than the dark seeds. Overall, there were no differences in the mean commercial yellow and dark seed oil contents. The yellow seed, however, has increased in oil content from 0.5% less than the dark in 1982 to about 1.0% more than the dark in the 1985 crop year.

The lower oil content of yellow seeds compared to black seeds in the same sample in certain years could have been due to a combination of:

(i) admixture with dark seeds with higher oil content;
(ii) failure of yellow seeds to maintain oil content advantage over dark seeds under stress growing conditions as occurred in 1982 (frost), 1983 (drought) and 1984 (drought).

While there was a slight tendency for samples with more dark seeds to have smaller differences in oil content, it is unlikely admixture with other dark-colored varieties accounts totally for the oil content differences in pedigreed and commercial seeds. The partially yellow-seeded varieties were reported to contain at least 2% more oil than dark-seeded *B. campestris* lines and only 1% less oil than the *B. napus* lines (1). It seems that the change in oil content difference between breeders' and commercial seed was due at least partially to some change in the seed itself, either through loss of quality (outcrossing) or failure to adapt to the stressful growing conditions of 1982–1984.

Protein content. Yellow seeds from both commercially grown and pedigreed Tobin and Candle had higher protein contents than the dark-colored seeds (Table 2). The differences were least in 1982 and 1983, especially in Alberta where maximum admixture with other varieties is suspected. In order to decrease the protein differences between yellow and dark fractions, the dark admixed seeds would have to have been *B. napus* varieties. *B. napus* varieties have been shown to contain 3 to 5% more protein than *B. campestris* varieties (1).

Chlorophyll content. Dark seeds contained at least as much as if not more chlorophyll than yellow seeds in all but one of the samples. Unlike *B. napus* varieties, *B. campestris* varieties have not been associated with problems due to high chlorophyll levels. The one high level in the yellow seed occurred in the 1982 Alberta Tobin and could be attributed to the frost problem that year. If the lower chlorophyll trend should also be observed when yellow *B. napus* lines are developed, this would be an additional quality bonus.

Glucosinolate content. Meals from dark seeds had equal or more glucosinolates than meals from yellow seed in all samples examined. The small differences for pedigreed seed had not been reported previously. The larger differences in commercial seeds probably were due to admixtures with older non-canola varieties, principally *B. campestris* cv. Torch.

Crude fiber. The oil-free meals from the yellow seeds had about 5% less crude fiber than those from the dark seeds tested. This difference was consistent with published values (1).

Fatty acid composition. Dark-colored seeds had higher erucic acid levels than the light-colored seeds in commercially grown samples, but differed very little in pedigreed samples. This suggests the commercial

TABLE 2

Quality Differences Between Yellow and Dark Seeds (Yellow-Dark)

Seed type	Year grown	Province	No. of samples	Dark seeds	1000 seed weight	Oil content[a]	Protein content[b]	Chlorophyll content	Glucosinolate content[b]	Crude fiber[c]	Fatty acid composition		
											C22:1	C18:3	Iodine value
				%	g	%	%	ppm	μM/g	%	%	%	
Candle													
Breeders	1980			14.4	0.10	2.6			-4	-5.4	-0.7	1.1	3
Certified	1979			24.4	0.00	2.7	2.3		-5	-8.6	-0.1	0.9	3
	1983			26.8	0.02	-0.3	0.0	-1	0	-2.8	0.0	0.3	1
Commercial	1982	Alberta	166	44.5	.00	-0.5	0.1	0	-11	-4.1	-0.2	0.6	2
		Sask.	16	33.1	0.09	-0.7	1.2	-2	-8	-5.1	-0.3	0.6	2
		W. Canada	182	43.5	0.01	-0.5	0.2	0	-11	-4.2	-0.2	0.6	2
	1983	W. Canada	53	40.1	-0.53	-0.2	0.9	-2	-7	-3.6	-0.7	0.5	3
	1984	Alberta	20	50.2	0.11	-1.4	1.8	-3	-16	-6.1	-1.6	1.0	3
	1984	Sask.	25	30.7	-0.06	0.6	0.9	-4	-4	-4.6	-0.2	1.3	4
	1984	W. Canada	45	39.4	0.02	-0.3	1.3	-	-9	-5.3	-0.8	1.2	4
	1985	Alberta	9	43.2	0.18	1.0	2.2	-5	-10	-5.3	-0.6	1.2	3
	1985	Sask.	4	39.6	-0.03	0.9	3.4	-7	2	-4.4	-0.1	1.6	4
	1985	W. Canada	13	41.2	0.02	0.9	2.9	-6	-3	-4.8	-0.3	1.4	4
Mean pedigreed				21.9	0.03	1.2	1.6	-1	-3	-5.7	-0.6	0.6	2
Mean commercial		W. Canada		41.0	-0.12	0.00	1.3	3	-8	-4.5	-0.5	0.9	3
Tobin													
Breeders	1980			35.6	0.19	2.7			-1	-6.2	0.1	1.2	3
	1981			33.8	0.10	1.8	1.3		-3	-5.3	0.0	1.1	2
Certified	1982			27.5	0.08	-0.4	0.5	-6	-1	-2.3	-0.2	0.9	3
	1984			32.1	0.13	2.5	0.0	-13	0	0.0	0.0	0.0	0
Commercial	1982	Alberta	20	48.1	0.13	-0.5	0.1	3	-17	-3.7	-2.3	1.2	4
	1983	W. Canada	182	35.5	-0.07	-0.7	0.2	-4	-10	-5.5	-0.7	0.6	3
	1984	Alberta	245	43.8	0.05	0.3	2.2	-3	-15	-5.5	-1.0	0.2	1
	1984	Sask.	13	41.3	0.02	0.9	0.6	-5	-10	-4.6	-0.5	0.5	3
	1984	W. Canada	258	43.7	0.05	0.3	2.1	-3	-15	-5.5	-0.9	0.2	1
	1985	Alberta	308	38.9	0.03	1.0	2.1	-4	-10	-6.0	-1.1	1.0	3
	1985	Sask.	97	33.9	-0.06	0.7	1.5	-5	-6	-5.2	-0.3	0.8	2
(calculated)	1985	W. Canada	407	38.6	0.03	1.0	2.1	-4	-10	-6.0	-1.1	1.0	3
(composite sample)	1985		407	39.0	0.05	1.0	2.1	-5	-10	-6.0	-0.8	1.0	2
Mean pedigreed				32.3	0.10	1.7	0.6	-10	-1	-3.5	.0	0.8	2
Mean commercial		W. Canada		41.5	0.03	0.0	1.1	-2	-13	-5.2	-1.2	0.8	3

[a]8.5% moisture basis. [b]Oil-free, 8.5% moisture basis. [c]Oil-free, dry basis.

samples were contaminated with higher erucic acid material such as *B. campestris* cv. Torch.

Yellow seeds had more linolenic acid and higher Iodine Values than dark seeds in both the commercial and pedigreed samples of both varieties. Since the linolenic acid content and Iodine Value of the yellow *B. juncea* parent is higher than the *B. campestris* parent (11), it is possible the yellow seeds were expressing the *B. juncea* parentage more than the dark seeds.

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