Chlorophyll in Canadian Canola and Rapeseed and its Role in Grading

Dr. James K. Daun
Agriculture Canada
Canadian Grain Commission
Grain Research Laboratory Division

Abstract

Between 1980 and 1986, average chlorophyll levels in farm deliveries of top-grade Canadian rapeseed varied from 9 ppm to 16 ppm. Blending with lower grades of seed within the transportation system raised the average chlorophyll level in No. 1 Canada export shipments to between 16 ppm and 20 ppm. Comparison of chlorophyll levels in processed seed and oil samples showed that seed chlorophyll levels of 24 ppm or less yielded oil that met the industry standard of 30 ppm. Although few top grade export shipments exceeded 24 ppm chlorophyll, a significant proportion of farm deliveries to country elevators and rail car deliveries to export terminals have been graded No. 2 Canada with less than 24 ppm chlorophyll (particularly Brassica campestris samples) or No. 1 Canada with more than 24 ppm chlorophyll. The present Canadian grading system, which relies on visual assessment of green seeds and overall color, might be improved by instrumental measurement of chlorophyll.

Introduction

Chlorophyll always has been a major quality problem for the Canadian rapeseed and canola industry. Chlorophyll has been assessed in rapeseed grading by a visual estimation of the percentage of distinctly green seeds and the overall color of a minimum sample of 500 individually crushed seeds. In a previous study (Daun/1982/) the relationship between distinctly green seeds and chlorophyll was shown to be poor (correlation coefficient r = 0.6 to 0.7). The impact of this poor correlation in grading rapeseed was that 30% of the samples in the study qualified for the top grade by green seed count but had sufficient chlorophyll to give oils with green color in excess of the Canadian Trading Standard (Pritchard/1983/).

This study reviews the levels of chlorophyll in Canadian rapeseed and estimates the amount of chlorophyll allowable in top grade rapeseed in order to meet the industry standard of 30 ppm chlorophyll in the oil. The effect of replacing the current grading system with chlorophyll assessment is also discussed.

Materials and Methods

Chlorophyll in rapeseed was determined by reflectance spectroscopy (Daun/1976/, Tkachuk et al/1987/). Results for samples analyzed prior to August 1983 were adjusted to correspond to the calibration in the more recent method by multiplying by 1.55. Chlorophyll in rapeseed oils was determined by a modification of the AOCS Official Method Cc 13d-55 (81) (Yuen and Kelly/1980/).

Grade assessment and green seed counts were carried out by grain inspectors of the Canadian Grain Commission (Canadian Grain Commission/1986/).

Samples were selected from New Crop Surveys and Cargo Surveys (Daun/1978/). Seed and oil samples were also received from Canadian crushing plants on approximately a monthly basis over the period 1979 to 1986.

Results and Discussion

Relationship Between Seed and Oil Chlorophyll

Canadian Trading Rules for canola oil have established 25 ppm chlorophyll as a maximum for top grade crude oil although in years where the seed chlorophyll was extremely high a maximum level of 30 ppm has been used. The CGSB Standard for crude or degummed canola oil specifies 30 ppm chlorophyll.

The relationship between seed chlorophyll and oil chlorophyll cannot be calculated simply from the oil content and oil or seed chlorophyll level. The components measured as "oil chlorophyll" by the AOCS Method have been shown to be chlorophyll breakdown products, probably pheophytins (Daun/1982/) while the component measured in the seed is chlorophyll a (Tkachuk et al/1987/). Since the actual composition and absorptivities of the oil components are different from that used in the AOCS Method, results from the AOCS oil chlorophyll do not directly correspond to the true mass of chlorophyll pigments present in the original seed.

In order to determine the relationship between seed chlorophyll as measured by reflectance spectroscopy (Tkachuk et al/1987/) and oil chlorophyll (AOCS), chlorophyll contents of seed and oil from Canadian crushing plants were plotted (Fig. 1) and a weighted linear fit was found for those oil chlorophyll levels which had three or more seed chlorophyll values. The regression line showed that an oil chlorophyll level of 25 ppm was equivalent to a seed chlorophyll level of 22 ppm while and oil chlorophyll of 30 ppm was equivalent to a seed chlorophyll level of 24 ppm. For the remainder of this report, 24 ppm will be used as a maximum chlorophyll level for No. 1 Canada rapeseed.

Chlorophyll in Canadian Rapeseed

The overall average chlorophyll level in Canadian rapeseed has varied over the past 7 years from a high of 28 ppm in 1982 when a severe early frost damaged much of the crop, to a low of 11 ppm in 1984, the second year of a severe drought (Table 1). The chlorophyll level of No. 1 Canada export shipments was somewhat higher than for the corresponding grade for farm deliveries in the country due to some admixing of grades in the handling system but the average level of chlorophyll in top grade exports did not exceed 20 ppm in any year. Between August 1985 and February 1987, during a period when rapeseed from the high-chlorophyll 1985 and 1986 crops was being shipped, the chlorophyll level of individual

top grade export shipments ranged from 10 ppm to 25 ppm with only one shipment of top grade seed having more than 24 ppm chlorophyll.

The distribution of chlorophyll in farm-deliveries to country elevators (Table 2) was somewhat different, however, as a substantial portion of the samples graded No. 1 Canada had more than 24 ppm chlorophyll while a larger portion of the samples graded No. 2 Canada had less than 24 ppm chlorophyll. This suggested that, at the farm delivery level, the grading system was not doing an adequate job in segregating rapeseed by quality as measured by chlorophyll.

A plot of chlorophyll levels against green seeds for 1319 samples of rapeseed from the 1986 crop (Fig.2) shows that chlorophyll increased about 3 ppm for each increase in % green seeds. There was, however, a wide range in chlorophyll (about 22 ppm) at each level of green seeds. This range in chlorophyll may be due to the variation in background chlorophyll in the samples as well as the inaccuracy of the estimation of distinctly green seeds.

It is the variation in chlorophyll at any given level of green seeds which has been the major cause of the problem in grading rapeseed by the present Canadian system. Even at 0% green seeds, some samples had chlorophyll values exceeding 24 ppm.

The grading problem was found to be worse for individual species. Brassica napus varieties have been shown to have more chlorophyll than B. campestris varieties (Table 3). Because of their lower background chlorophyll, a large proportion of B. campestris varieties with less than 24 ppm chlorophyll have been graded No. 2 Canada while very few samples of B. campestris graded No. 1 Canada had more than 24 ppm chlorophyll. This inequity was not found for B. napus varieties although significant numbers of B. napus samples were found with less than 24 ppm and graded No. 2 Canada or with more than 24 ppm chlorophyll and graded No. 1 Canada.

The Canadian grading system for chlorophyll is able to segregate export shipments with acceptable levels of chlorophyll mainly because of the averaging effect of the handling system. If No. 1 and No. 2 Canada farm deliveries of rapeseed were all combined into export shipments, the resulting export shipments would not be much higher in chlorophyll than the present No. 1 Canada shipments (Table 1). The averaging effect seems to take place mainly at the export terminals. In a sample of 108 rail car shipments graded No. 2 Canada 74 samples had less than 24 ppm chlorophyll.

Until recently, it would have been difficult to consider grading Canadian rapeseed on the basis of chlorophyll content. The development of NIR based instrumentation for chlorophyll determination (Tkachuk et al/1987/) makes such a system possible and its adoption would help to ensure more equable grading to rapeseed producers and would enable Canadian crushers and export customers to obtain a more uniform quality product.

References

Canadian Grain Commission, 1986. Official Grain Grading Guide. Office of the Chief Grain Inspector, Inspection Division, Winnipeg.

Daun, J.K., 1976. A rapid procedure for the determination of chlorophyll in rapeseed by reflectance spectroscopy. Journal of the American Oil Chemists' Society, 53:767-780.

Daun, J.K., 1978. Rapeseed quality surveys - 1955-1977. Proceedings of the 5th International Rapeseed Conference, Volume 2 pp. 48-50.

Daun, J.K., 1982. The relationship between rapeseed chlorophyll, rapeseed oil chlorophyll and percentage green seeds. Journal of the American Oil Chemists' Society, 59:15-18.

Pritchard, J.R., 1983. Oilseed quality requirements for processing. Journal of the American Oil Chemists' Society, 60:274A-284A.

Tkachuk, R., V.J. Mellish, J.K. Daun and L.J. Macri, 1987. Determination of chlorophyll in ground rapeseed using a modified reflectance spectrophotometer. Journal of the American Oil Chemists' Society, In Press.

Yuen, W. and P. Kelly, 1980. The determination of chlorophyll in rapeseed oil. Analytical Chemistry of Rapeseed and its Products - a Symposium. Canola Council of Canada, Winnipeg pp.139-143.

Table 1.
Chlorophyll contents of Western Canadian Rapeseed from New Crop and Export Cargo Surveys.

	Chlorophyll (ppm) in Seed					
	Crop Survey - W. Canada			Export Shipments		
Year	No. 1 Can.	No. 2 Can.	No. 3 Can.	No. 1 Can.	No. 2 Can.	No. 3 Can.
1980	17	31	45	19	34	37
1981	17	31	53	20	29	53
1982	9	29	51	16	33	54
1983	11	24	53	15	34	78
1984	9	18	36	14		
1985	12	27	59	19	32	58
1986	15	26	42	18	26	43

Overall averages for New Crop Surveys were calculated from individual provincial averages utilizing averages from surveys in conjunction with estimates of production (by province) and the Grain Commission's estimate grade distribution for Western Canadian Rapeseed.

Table 2.
Distribution of chlorophyll in samples of rapeseed in New Crop surveys

Grade	Chlorophyll	Percentage of Samples within Grade 1986	1985	1980
		All Varieties		
No. 1 Canada	> 24 ppm	21	7	23
No. 2 Canada	< 24 ppm	50	32	23
		B. napus Varieties		
No. 1 Canada	> 24 ppm	23	16	41
No. 2 Canada	< 24 ppm	35	19	8
		B. campestris Varieties		
No. 1 Canada	> 24 ppm	8	2	6
No. 2 Canada	< 24 ppm	99	100	98

Data on individual samples not available for 1981 to 1984.

Table 3.
Average Chlorophyll Content of Western Canadian Rapeseed By Variety
1980 to 1986

Year	Variety Tower	Regent	Altex	Westar	Species B.napus	Variety Torch	Candle	Tobin	Species B. campestris
1980	26	25	28		26	11	12		12
1981	28	22	19		23	9	5		7
1982	20	31	23		25	12	9	11	11
1983	18	14	21	11	16	8	9	10	9
1984		19	16	18	18		5	6	6
1985		17		19	18	10		7	9
1986				22	12		5	9	7

Chlorophyll values for 1980 to 1982 are averages for all grades. Values for 1983 to 1986 are for No. 1 Canada. Samples from New Crop Surveys with varieties as declared on submitted sample.

Figures

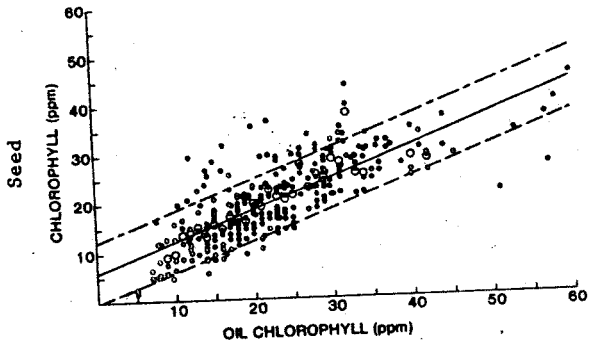

Figure 1. Relationship between seed chlorophyll and oil chlorophyll for samples from Western Canadian Crushing plants, 1979-1986. Dots show individual samples; open circles show the points for levels of Oil Chlorophyll with more than 2 Seed Chlorophyll measurements used to calculate the weighted fit line (solid line, 1/SEM (standard error of the mean) used as weights); dashed lines show the mean range in Seed Chlorophyll at any level of Oil Chlorophyll.

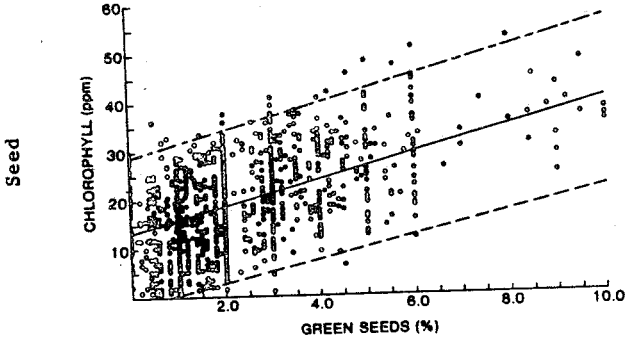

Figure 2. Relationship between distinctly green seeds and seed chlorophyll for samples from the 1986 Western Canadian canola crop. Dots show individual samples; solid line shows weighted fit (1/SEM used as weights) for % Green Seed levels with more than 3 measurements; dashed lines show the mean range in Seed Chlorophyll at any level of % Green Seeds.