Factors Affecting the Pressure Extraction of Oil from Flaxseed[1]

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ABSTRACT AND SUMMARY

The effects of moisture content, age, growing location, and genotype of flaxseed on the efficiency of pressure extraction of oil, when extracted in a Carver press cylinder, were examined. Decreasing the seed moisture content from 7.8% to 2.3% increased the proportion of oil extracted from 31.4% to 49.6%, respectively. Oil was more difficult to extract as the age of the seed increased. The proportion of the total oil extracted varied from 25.0% to 41.4% depending upon the location where the seed was grown. The effect of genotype was less pronounced, ranging from a mean of 46.9% in Redwing to 54.2% in Redwood 65 for samples analyzed at normal storage moisture. Samples with high oil contents usually yielded the highest proportion of total oil recovered ($r = 0.893^{**}$, 9 df).

INTRODUCTION

The oil content of flaxseed has been improved slowly by breeding and the introduction of new cultivars. Results from a test grown at 16 locations in Canada in 1975 indicated that Bison, licensed in 1930, had an average oil content of 41.6% while Dufferin, licensed in 1975, averaged 43.2% (E.O. Kenaschuk, personal communication). Likewise, oil recoveries have been improved both in expeller plants (1) and in prepress-solvent extraction plants. However, there is not always a direct relationship between total oil content based on laboratory tests and commercial oil recovery. Private communications with crushers indicated that they encountered considerable variability in the pressure required to extract oil from flaxseed originating in different countries. It was not known whether this variability could be attributed to cultivar or environmental differences.

Traditionally, the moisture content of flaxseed was raised to 9-11% prior to rolling or crushing. The flaked seed was then cooked at temperatures in excess of 90 C to facilitate the disintegration of seed particles. This material was subsequently dried to as low as 3% moisture and then pressed (1,2).

Most flaxseed crushing plants in the U.S. presently use a combination of prepressing and solvent extraction. The oil content is lowered to 12-16% with little control on seed moisture content. It is suggested that any improvement in efficiency of pressure extraction could increase plant capacity and decrease costs in plants employing either static pressure or continuous expellers.

Although considerable information is available on the physical factors affecting equipment operation (3), specific data are sparse on the impact of cultivars or environment on the amount of oil extracted by pressing. This study investigated the effect of moisture content, age of the seed, growing location, and genotype on the proportion of total oil expressed using a laboratory-type Carver press to simulate pressure extraction under commercial conditions. The relationship between total oil content, as estimated by nuclear magnetic resonance (NMR) analysis, and the amount of oil recovered following a single stage pressing also was determined.

EXPERIMENTAL PROCEDURES

Ten ml weighed flax samples were pressed in a 2.8 cm diameter cell using a motorized Carver press. The amount of oil expressed was determined by subtracting the weight of the drained press cake from the weight of the original sample and reporting the differences as percentage of total oil extracted. This technique gave more reproducible results than flushing the cake with a solvent before weighing. Seed from the cultivars Redwing, Linott, Redwood 65, Noralta, and Foster were subjected to pressures of 660, 885, 1180, and 1480 kg/cm^2. Several pressing times were tried on Redwing and Redwood 65 samples. These preliminary studies led to the selection of a pressure of 885 kg/cm^2 for 3 min in all subsequent experiments. Higher pressures and longer press times only slightly increased the amount of oil extracted.

The effect of moisture content on efficiency of extraction was studied by adjusting the moisture content of Linott seed over sodium hydroxide solutions of different concentrations. In addition, the seed of 10 cultivars and experimental lines grown at Morden, Manitoba and Beaverlodge, Alberta in 1974 were pressed at three different moisture levels: at laboratory storage conditions; after 3 hr drying at 70 C; and after 16 hr drying at 100 C. The effect of genotypic variation also was measured on these lines, dried 16 hr at 100 C.

The effect of growing location was examined by pressing

[1]Contribution No. 153, Morden Research Station.

TABLE I

Effect of Laboratory Press Hydraulic Pressure and Cultivar on Proportion of Total Oil Extracted

Pressure load kg/cm^2	Percentage of total oil extracted					
	Redwing	Linott	Redwood 65	Noralta	Foster	Mean
660	42.9[a]	47.6	52.6	48.1	48.5	47.9
885	46.3	50.8	54.6	47.7	48.4	49.6
1180	49.4	52.8	54.6	48.6	46.2	50.3
1480	49.1	52.3	54.8	51.2	47.4	51.0
Mean	46.9	50.9	54.2	48.9	47.6	
Original Oil content, %	38.5	41.2	41.9	41.3	42.7	

[a]Values are means of three samples dried at room temperature with 5 min pressing time.

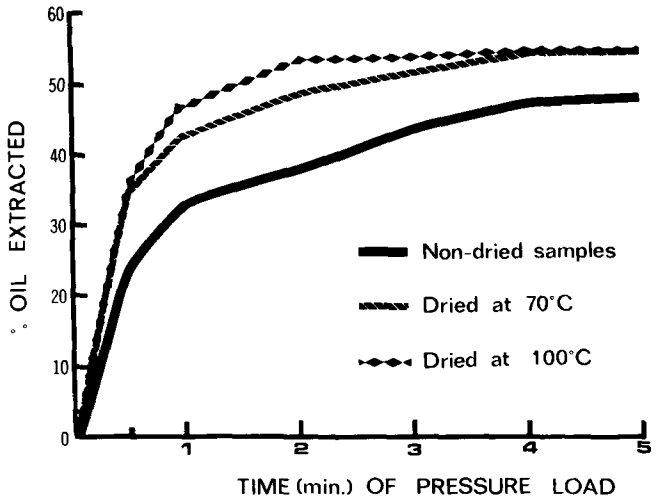

FIG. 1. Effect of time of applied pressure on proportion of oil extracted from flaxseed with a laboratory press. Values are means of Redwing and Redwood 65 cultivars.

TABLE II

Effect of Increased Moisture Content on Proportion of Total Oil Extracted from Linott Flax with a Laboratory Press

Source of humidity	Percentage of total oil extracted (%)[a]	Moisture content (%)
Normal atmospheric	54.7	8.2
10 M NaOH	49.5	9.3
4 M NaOH	13.6	13.9
Water	4.4	16.2

[a]Mean of two samples.

room-dried samples of the cultivar Raja and the line F.P. 647 grown at 13 locations in western Canada. These entries were considered to represent high and low oil recoveries based on earlier observations.

Three replicates were used except where noted in the tables. The total oil content of seeds was determined by NMR prior to pressing (4).

RESULTS AND DISCUSSION

Pressure and Time

Increasing the hydraulic pressure on the Carver cell above 885 kg/cm^2 had a relatively small but significant effect on the quantity of oil extracted from seed of several cultivars dried at room temperature (Table I). A similar trend was noted by Carter (3) who reported that raising the pressure from 105 to 175 kg/cm^2 increased the extraction of oil from cottonseed by only 1%. The amount of oil extracted increased with time of applied pressure (Fig. 1) with about half the total oil extracted from dried samples in 2 min.

Moisture Content

Increasing the moisture content of the seed from ca. 8 to 16% resulted in the percentage of total oil recovery dropping dramatically from 54.7 to 4.4% (Table II). Similarly, when 10 high yielding and genetically diverse lines with average moisture contents of 7.8, 3.1, and 0.5% were pressed, the oil recoveries increased from 35.1 to 52.2 and 54.4%, respectively (Table III).

The effect of moisture level on extraction efficiency may be related to the mucilage development in the outer epidermal cells (5). The addition of water resulted in the swelling of mucilage which, in turn, produced a cushioning effect of the seed which could have reduced rupturing of the seedcoat and internal tissue. The mucilage coating also could have impeded the flow of oil from the cotyledon tissue.

Genotype

The proportion of total oil extracted varied significantly among cultivars (Tables I and III). The most efficient extraction was achieved generally in the cultivar Redwood 65 and the line F.P. 646 which has Redwood 65 as a parent.

A strong relationship between total oil content as determined by NMR analysis of oil obtained by pressure extraction was observed. The correlation coefficient was 0.893** for samples dried at 70 C and 100 C (averaged). The exception to this relationship occurred in the yellow-seeded Foster where efficiency in oil extraction was lower than expected. When Foster was omitted from Table I, a highly significant correlation coefficient of 0.822 was obtained.

The lower oil extraction efficiency from Foster, in spite of its higher oil content, may be related to its susceptibility to splitting and cracking. Culbertson and Kommedahl (6) reported 53% split seeds compared with 5% for brown seeds. Foster is known to have a lower hull content and more oil in the cotyledons, therefore, oil extraction should be easier. Since the reverse is true, there must be other

TABLE III

Mean Effect of Cultivar and Seed Moisture Content on the Proportion of Total Oil Extracted with a Laboratory Press from Flaxseed Grown in Morden, Manitoba and Beaverlodge, Alberta, 1974

Entry	Original oil content (%)	Percentage of total oil extracted			
		Non-dried samples	70 C dried samples	100 C dried samples	Mean of 70 and 100 C samples
Bison	41.6	34.1	51.1	52.7	51.9
Redwing	40.9	34.8	49.0	54.9	51.9
Raja	40.9	33.2	50.0	51.0	50.5
Redwood 65	42.4	34.5	54.6	55.9	55.2
Linott	42.1	35.5	54.4	54.7	54.5
Noralta	41.0	36.5	50.3	50.3	50.3
Culbert	42.2	35.3	52.7	56.5	54.6
F.P. 645	41.4	33.9	52.6	55.5	54.1
F.P. 646	43.4	34.0	55.1	57.3	56.2
F.P. 647	42.0	39.6	52.2	55.4	53.8
Mean		35.1	52.2	54.4	53.3
L.S.D.		3.2	2.8	3.2	2.1
Moisture, % (mean)		7.75	3.07	0.5	

TABLE IV

Effect of Environment on Proportion of Total Oil Extracted with a Laboratory Press from Two Flax Cultivars Grown in 1974

Location	Initial oil content (%)			Percentage of total oil extracted		
	Raja	F.P. 647	Mean	Raja	F.P. 647	Mean
Edmonton, Alberta	42.2	45.6	43.9	34.1	39.5	36.8
Indian Head, Saskatchewan	41.6	45.2	43.4	31.9	41.8	36.9
Portage la Prairie, Manitoba	42.4	43.5	42.9	30.7	34.9	32.8
Melfort, Saskatchewan	40.9	44.6	42.7	28.0	36.8	32.4
Saskatoon, Saskatchewan	40.4	44.4	42.4	33.5	37.5	35.5
Regina, Saskatchewan	41.5	43.2	42.3	30.6	37.5	33.9
Lethbridge, Alberta	40.6	43.6	42.1	27.3	22.7	25.0
Scott, Saskatchewan	41.0	43.1	42.0	31.4	39.1	35.3
Brandon, Manitoba	40.9	43.0	41.9	30.0	29.9	30.0
Morden, Manitoba	41.2	42.1	41.6	32.2	33.8	33.0
Winnipeg, Manitoba	40.6	42.6	41.6	31.4	41.0	36.2
Beaverlodge, Alberta	41.7	41.1	41.4	36.6	42.6	39.6
Swift Current, Saskatchewan	40.1	41.4	40.7	37.4	45.4	41.4
L.S.D.						6.5
Mean	41.2	43.3		31.9	37.1	

anatomical and physical factors that negate these advantages.

Environment

Growing location strongly affects the content and quality of flaxseed oil (7). When Raja and F.P. 647 were grown at 13 locations in western Canada the proportion of oil extracted varied from an average of 25% for Lethbridge samples to 41.4% for those from Swift Current (Table IV). It is difficult to explain the large differences in the amount of oil extracted from seed grown at these two dryland locations less than 450 km apart, particularly since the yields differed by only 15%. The impact of specific environmental conditions such as relative humidity during the last stages of maturation should be examined.

There is some indication that oil becomes more difficult to extract in older seed. When seeds from three cultivars grown in 1970, 1972, and 1973 were pressed, the extraction efficiency was the greatest in the most recent seed. Although seed for all cultivars for each year was not available, an overall year average indicated that 5-year-old seed yielded 49.6% while 3- and 2-year-old seed yielded 52.5 and 54.8%, respectively. While all seed was grown at the same location, it should be recognized that part of these differences could be attributed to environmental effects since the flaxseed was produced in different years.

This study confirmed that moisture content of the seeds affects the amount of oil extracted by pressure, regardless of genotype. At controlled moisture contents, old seed, seed produced in certain locations, and some genotypes produced less oil than expected following a single pressing. Thus, it is possible that certain shipments of seed could exhibit different extraction characteristics. This study also demonstrated that while it would be possible to breed for improved response to pressure extraction, selection for increased oil content would, in most cases, result in improved oil recovery.

ACKNOWLEDGMENTS

J. Peters provided technical assistance and E.O. Kenaschuk supplied the flaxseed.

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[Received February 23, 1977]