Breeding Rapeseed for Oil and Meal Quality

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Abstract

Significant variation in fatty acid composition occurs within the seed oils of the *Brassica* genus, which includes the mustards and rapeseed. Research into the inheritance and biosynthesis of fatty acids has shown that at least two biosynthetic pathways exist in the developing rapeseed and some of the steps are under direct genetic control. The plant breeder has the basic knowledge in this oilseed crop to produce seed oils with defined fatty acid composition, and a practical example is the commercial development of Canbra oil, the rapeseed oil from which erucic acid has been eliminated. *Brassica* seed meals contain thioglucosides which may cause metabolic disturbances when fed to certain classes of livestock. The major thioglucosides in rapeseed meal are those giving rise to 3-butenyl and 4-pentenyl iso-thiocyanate and 5-vinyl-2-oxazolidinethione. Partial success in eliminating these compounds has been achieved by breeding strains of turnip rape (*B. campestris*) which do not contain the glucosides of 4-pentenyl isothiocyanate and oxazolidinethione, and the identification of a *B. napus* variety with very low levels of all three glucosides. These findings suggest that complete removal of these sulfur compounds may be possible through plant breeding.

Introduction

Plant breeding is moving at an accelerated pace, in step with other sciences. A few short years ago it took 15 to 20 years to develop a new variety. Today this can be shortened to 7 to 8 years, which still includes at least 3 years of extensive field tests. The success of a plant breeding program depends on the variation that is present or that can be induced in the crop and its close relatives, and accurate means of identifying the characteristic of interest. These principles apply to quality as well as quantity.

The application of gas chromatographs, integrators, computers, controlled environments and visible, ultraviolet, infrared and NMR spectroscopy to crop quality breeding has resulted in an extremely rapid genetic advance. Fortunately in oilseed crops many of the quality factors of major economic importance are relatively simply inherited. These developments have tended to make breeding for quality a more efficient process than breeding for quantity or yield. Much credit for the present advance must be given to the chemist, for without the new analytical techniques the breeder would be faced with an impossible task.

Rapeseed (*Brassica campestris* and *B. napus*) is Canada's most important oilseed crop, occupying 1.7 million acres in Western Canada. More rapeseed is exported from Canada than all other countries combined. Canadian utilization of rapeseed oil and meal is surpassed only by soybeans. To make rapeseed even more valuable and versatile requires that the chemistry of the plant be changed. This type of breeding is possible because of the new chemical techniques developed and the great chemical and morphological variation present in the *Brassica* genus.

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Oil Quality
The fatty acid composition of rape and other
Brassica seed oils differs from other vegetable oils
in having substantial amounts of the fatty acids
eicosenoic (6-15%) and erucic (20-61%). These
acids are not undesirable in human nutrition but
their presence may limit the usefulness of the oil
in some products. Inbreeding and selection for low
erucic acid values resulted in strains of B. napus
and B. campestris which did not contain erucic acid
in their seed oil (Table I) (5,10). Rape oils essentially
free of erucic have been named Canbra oil, a con-
traction of the words Canada and Brassica. Recipro-
cal crosses between plants containing no erucic and
normal high erucic acid types demonstrated that the
fatty acid composition was controlled by the genetic
constitution of the developing embryo, rather than
the maternal parent (8). Genetic investigations sup-
ported the hypothesis that erucic acid content of the
seed oil of B. napus is controlled by two genes and in
B. campestris by one gene (4,9). In both species
gene action was additive with no dominance. The
different inheritance pattern in the two species was
expected since B. napus is an amphidiploid and B.
campestris is a diploid.

The isolation of plants containing no erucic acid
in their seed oil gave simultaneous selection for low
eicosenoic acid. As the genetic capacity for erucic
and eicosenoic acids decreased there was an increase
in the percentage of oleic acid, with no decrease in
total oil content. Evidence from oil analysis following

TABLE I
Per Cent Fatty Acid Composition of the Standard Rapeseed Varieties

<table>
<thead>
<tr>
<th>Species</th>
<th>Variety</th>
<th>Carbon chain length and degree of saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassica</td>
<td>napus</td>
<td>16:0 18:0 18:1 18:2 19:0 20:0 20:1 22:1</td>
</tr>
<tr>
<td>Tanka</td>
<td>3.7</td>
<td>0.4 1.2 15.7 15.2 9.3 0.9 9.2 44.4</td>
</tr>
<tr>
<td>Nugget</td>
<td>3.3</td>
<td>0.3 1.5 22.5 23.3 5.4 1 14.2 40.4</td>
</tr>
<tr>
<td>Oro</td>
<td>4.8</td>
<td>0.5 2.4 63.1 19.4 9.9 1 0.5 6</td>
</tr>
<tr>
<td>Brassica</td>
<td>campestris</td>
<td>Echo</td>
</tr>
<tr>
<td>Yellow</td>
<td>Sarson</td>
<td>1.8</td>
</tr>
<tr>
<td>Selection</td>
<td>3.0</td>
<td>0.3 1.1 54.8 31.1 9.7 0 0 0</td>
</tr>
</tbody>
</table>

Included in this genus are the crop plants: cabbage, kale, turnips, mustards, and forage and oilseed rape. Plants of most of these species readily intercross and characteristics of interest can be transferred.

Meal Quality
Rapeseed meal is extensively used as a high protein
feed supplement and as such is an important by-
product of the rapeseed crushing industry. In the
development of nearly every oilseed meal, nutritional
problems have been encountered. Soybean has a
trypsin inhibitor, cotton seed has gossypol, and flax
has a cyanogen factor. Rapeseed meal is no exception.

TABLE II
Normal Ranges of Thiglucosides in Brassica Seeds Expressed as Milligram per Gram

<table>
<thead>
<tr>
<th>Crop name</th>
<th>p-OH</th>
<th>allyl</th>
<th>butenyl</th>
<th>pentenyl</th>
<th>OZT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow mustard</td>
<td>12-20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wild mustard</td>
<td>0</td>
<td>7-15</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Brown or leaf mustard</td>
<td>0</td>
<td>1-9</td>
<td>0-4</td>
<td>0</td>
<td>0-7</td>
</tr>
<tr>
<td>Black mustard</td>
<td>0</td>
<td>1-4</td>
<td>0.5-1.5</td>
<td>4-12</td>
<td></td>
</tr>
<tr>
<td>Abyssinian mustard</td>
<td>0</td>
<td>1-8</td>
<td>1-3</td>
<td>0.5-8</td>
<td></td>
</tr>
<tr>
<td>Kale, cabbage, etc.</td>
<td>0</td>
<td>0</td>
<td>1-8</td>
<td>1-3</td>
<td>0</td>
</tr>
<tr>
<td>Rape</td>
<td>0</td>
<td>0</td>
<td>1-8</td>
<td>1-3</td>
<td>0</td>
</tr>
<tr>
<td>Turnip rape</td>
<td>0</td>
<td>0</td>
<td>1-8</td>
<td>1-3</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ ^a \text{Personal communication from R. L. Wetter, Prairie Regional Laboratory of National Research Council, University of Saskatchewan, Saskatoon.} \]