Environmental Effects on Oil Quality of High Oleic-Low Linolenic (HOLL) and Low Linolenic (LLIN) Spring Canola

Megan Wingerson, Jim B. Davis, and Jack Brown
University of Idaho

Abstract

Specialty oil (LLIN or HOLL) canola cultivars must exhibit oil quality stability over the range of environments where they will be produced. HOLL, LLIN and traditional canola lines were grown at different locations throughout the Pacific Northwest over 2 years to determine oil quality and seed yield. Despite some significant interaction effects, the effects of genotypes were large compared to non-genetic effects. Breeding lines were identified with stable oil quality and content, and high seed yield.

Introduction

Partially hydrogenated vegetable oils, which contain *trans* fats, have adverse effects on human heath. Traditional canola oil requires partial hydrogenation to avoid off-flavors when used for high temperature frying and to increase shelf life. Rancidity and off-flavors in oil are caused by high linolenic content, which is caused by the higher oxidative potential of the double bonds compared to oleic acid (Figure 1). This has led to the development of high oleic - low linolenic acid (HOLL) and low linolenic acid (LLIN) canola. Availability of these cultivars in the Pacific Northwest would be of particular interest to the potato fry industry which requires large volumes of these oils. However, researchers must show that the oil characteristics of these new HOLL and LLIN cultivars are stable over the varying environments in the Pacific Northwest.

Material and Methods

Four University of Idaho LLIN lines and four University of Idaho HOLL lines were grown along with two standard canola cultivars ('Westar' and 'Profit') over 2 years in multiple location field trials throughout the Pacific Northwest. Test locations included: Moscow, Genesee, and Craigmont, Idaho; Dusty and Dayton, Washington; and Pendleton, Oregon. Each trial was planted as early as practical in the spring. Two later plantings were made at Moscow and Genesee to simulate increased biotic and abiotic factors such as heat stress and insect infestation. Each trial was a randomized complete block design with 4 replicates of 1.5m by 5m plots. Prior to flowering, developing racemes were covered with Delnet® pollination bags to avoid cross pollination. At harvest, seeds from these racemes were harvested by hand and used for fatty acid testing. Fatty acid profiles were determined using gas chromatography. The remainder of each plot was combine harvested, weighed to determine yield potential, and analyzed for oil content.

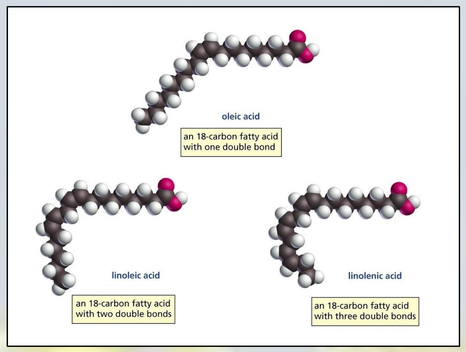

Figure 1. Molecular structures of 18C fatty acids in canola

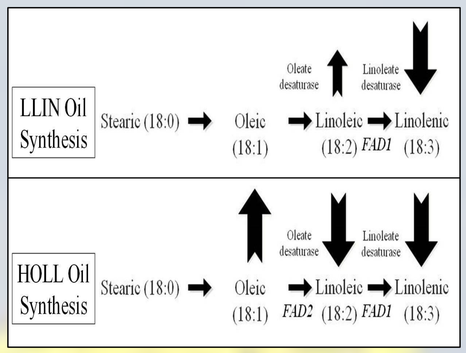

Figure 2. Fatty acid synthesis of LLIN and HOLL canola

Source of Variation	d.f.	Oleic acid 18:1	Linoleic acid 18:2	Linoleneic acid 18:3
Cultivar	9	39% ***†	56% ***	84% ***
Cultivar x year	9	5% *	3% n.s.	1% n.s.
Cultivar x site	63	31% **	19% n.s.	9% *
Cult x year x site	53	25% **	15% n.s.	6% n.s.

† n.s. = not significant; * = 0.01<*P*< 0.05; ** = 0.001<*P* <0.01; *** = *P* <0.001

Table 1. Percentages of the ANOVA total sum of squares attributed to cultivar and environmental interactions.

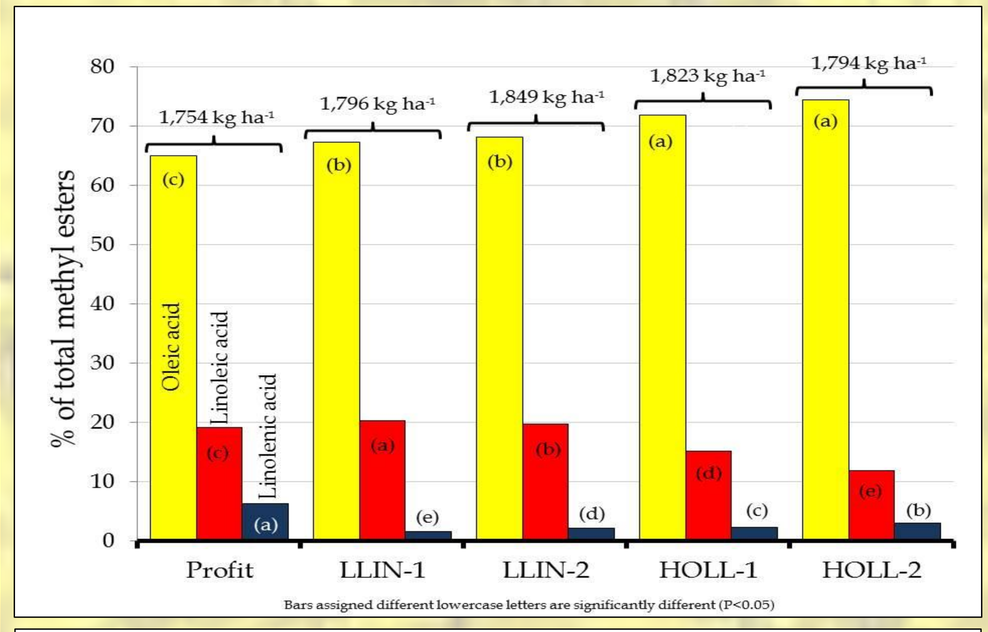

Figure 3. Fatty acid profile and yield potential of traditional, LLIN and HOLL canola cultivars.

Results & Discussion

Interactions between cultivars and environments were often significant, though they were usually small in comparison to the main effects of differences between cultivars. Cultivar x site and cultivar x year interactions were not significant for linoleic and linolenic acid, indicating genetic stability over a wide range of environments. Cultivar x site and cultivar x year interactions were observed for oleic acid indicating a potential environmental interaction (Table 1).

We have not determined if the LLIN and HOLL lines in this study have the documented alleles of the *FAD-1* (resulting in reduced levels of linolenic acid) or *FAD-2* (resulting in reduced levels of linolenic acid and increased levels of oleic acid) genes (Figure 2) that have shown instability in some previous studies. Early LLIN and HOLL cultivars with mutated *FAD-1* and *FAD-2* genes tended to show poor adaptability, either from genetic drag from the mutagenesis techniques used in their development, or from their novel fatty acid profiles interfering with seedling development and growth. However, the HOLL and LLIN lines in this study showed good adaptability for yield (Figure 3) and oil quality. Therefore negative genetic drag resulting from mutagenesis has been reduced by selection or these lines have been selected in such a manner that the they are no longer negatively impacted by the modified fatty acid profile.

Conclusion

The results from this study have shown that these recently developed, high quality LLIN and HOLL cultivars are adapted to a wide range of environments in the Pacific Northwest and maintain high quality fatty acid profiles suitable for non-hydrogenated fry oils while producing competitive seed yield and seed oil content (data not shown). Availability of these new cultivars in the region will offer growers greater potential profits and incentives to increase canola acreage in the region.