# Grain conditioning for dehulling of canola

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Ikebudu, J.A., Sokhansanj, S., Tyler, R.T., Milne, B.J. and Thankor, N.S. 2000. **Grain conditioning for dehulling of canola**. Can. Agric. Eng. **42**:027-032. Several conditioning treatments to promote dehulling of canola grain (*Brassica napus* L.) were investigated. The tested treatment sequences were: (1) moistening, heating; (2) heating, moistening; and (3) heating. Moistening was done by spraying a predetermined quantity of water on the grain. A thin layer dryer and a fluidized bed dryer were used to heat/dry the grain. Following each treatment, the samples were dehulled in an abrasive dehuller. The dehulled samples were fractionated on an aspirator. A dehulling index was evaluated considering four mass fractions of cotyledon, hulls, undehulled grains, and fines. The maximum dehulling index of 0.88 (dehulling index ranges from –1 to +1) was achieved by moistening the grain to about 15% moisture content (wet basis) for 10 min followed by heating at 70-75°C for 5 min. A similar dehulling index was achieved by heating the grain at 120°C for 5 min without moistening. The control grain had a dehulling index of -0.47. **Keywords**: canola, dehulling, conditioning, splitting, oilgrain, rapeseed. abrasive, fractionation, dry separation.

Plusieurs traitements de conditionnement facilitant le dépelliculage des grains de canola (*Brassica napus* L.) furent étudiés. Les séries de traitements examinées étaient les suivantes : (1) humidification, chauffage; (2) chauffage, humidification; et (3) chauffage. L'humidification des grains fut faite en les vaporisant d'une quantité d'eau prédertiminée. Un appareil de séchage sur couche mince et un appareil de séchage par lits fluidisés furent utilisés pour chauffer/sécher les grains. A la suite de chaque série de traitements, les échantillons furent dépelliculés avec une machine abrasive à dépelliculer. Les échantillons dépelliculés furent séparés avec un aspirateur. Un indice de dépelliculage fut établi en fonction des masses de quatre fractions obtenues lors de la séparation : cotylédons, pellicules des grains, grains avec pellicule et fractions fines. L'indice maximal de dépelliculage de 0.88 (indice variant de –1 à 1) fut obtenu en humidifiant le grain durant 10 min jusqu'à une teneur en humidité de 15 % (base humide), et en le chauffant ensuite à 70-75 °C pendant 5 min. On obtint une valeur d'indice comparable en chauffant le grain à 120°C pendant 5 min, sans l' humidifier. L'échantillon de contrôle avait un indice de dépelliculage de –0.47. **Mots-clés** : canola, dépelliculage, conditionnement, séparation, oléagineux, colza, abrasif, fractionnement, séparation à sec.

## INTRODUCTION

Canola (*Brassica Sp.*) is the major oilgrain crop grown on the Canadian prairies. The grain is a dicot made up of a fibrous hull encompassing a large embryo. Table I summarizes the constituents of a canola grain and its fractions. The grain contains more than 40% oil. The residual meal after oil extraction contains 38 to 43% protein (Ikebudu 1996; Thakor et al. 1995). The oil is used for human consumption and the meal is used for animal feed. Canola meal and soy meal are competing feedstuff as rich sources of animal protein. Soy meal is generally considered to be of superior quality due to its high protein and low fiber content compared to that of canola meal.

Dehulling canola and excluding the hull from grain prior to oil extraction increases the protein content of the meal from 35 to 50% and reduces the fiber content from 11 to 6%, thus increasing the value of the meal. The removal of the hull also improves the color and quality of the extracted oil (Leslie et al. 1973; Jones and Sibbald 1979; Niewiadomski 1990).

At present, canola is not dehulled commercially in Canada. The small grain size and the oil loss in the hulls are among the reasons why whole grain crushing is preferred. Moreover, the close association between the cotyledon and the hull makes dehulling a difficult operation. Unlike other oil grains such as soybean, sunflower, and peanut, literature on canola dehulling is scarce. Tape et al. (1970) and Diosady et al. (1986) removed the hulls from canola meal by air classification. Sosulski and Zadernowski (1981) conducted experiments on wet dehulling. They used liquid cyclone fractionation to remove the hulls from defatted canola meal. Schneider (1979) suggested a canola dehulling process in which the grain is pressed between two surfaces causing it to deform by 20 - 50% of its original diameter, thereby breaking the hull and separating it from the cotyledon. Jones and Holmes (1982) and Baudet et al. (1983) used a patented technique of cracking and air classification prior to oil extraction for dehulling of canola.

In spite of these successes, industry has been reluctant to adopt canola dehulling prior to oil extraction due to the additional capital and operating costs. The present work is a step towards finding a method of canola dehulling which has more commercial appeal than the previously reported

**Table I. Chemical composition of the whole grain and dehulled grain fractions (Thakor et al. 1995).**

| Fraction | Moisture content (%) | Protein content (%) | Oil content (%) | Crude fibre content (%) |
|---|---|---|---|---|
| Whole grain | 5.2 | 28.5 | 44.5 | 9.5 |
| Cotyledon | 5.7 | 30.1 | 49.1 | 2.6 |
| Hull* | 11.9 | 17.1 | 17.6 | 24.4 |
| Fine | 6.7 | 26.8 | 39.7 | 9.5 |

*Hull is about 15% of grain mass

Table II. Summary of grain treatment sequences prior to dehulling.

| Test | Description |
|---|---|
| Treatment 1 | Moistening the grain for 30 s to 15 minutes, drying at 70-75 °C to 6% m.c. in the thin layer dryer, dehulling |
| Treatment 2 | Heating the grain a120°C for 5 minutes in the fluidized bed dryer, tempering the heated sample for 4 h, dehulling |
| Treatment 3 | Heating the grain at 120°C for 5 minutes in the fluidized bed dryer, moistening the grain to 9% m.c., tempering for 4 h, dehulling |
| Treatment 4 | Heating at 60°C, 80°C, 100°C, 120°C in the fluidized bed dryer, tempering for 4 h, dehulling |
| Control | No conditioning treatment, dehulling |

processes. For example, Thakor (1993) achieved a high degree of dehulling when the grain was soaked in water to a moisture content of about 30% wet mass basis (in this paper the grain moisture content is expressed on a wet mass basis). This high moisture grain required substantial heating which could limit the economic feasibility of the process. The objective of this research was to test several new grain treatment methods with minimum heating requirements.

## MATERIALS and METHODS

### Canola samples

The canola grain used for testing was *Brassica napus* L., cultivar Excel from the 1994 crop year. The moisture content of the grain was about 7.5% (wb). The grains were hand-cleaned and stored in an air-tight container at room temperature.

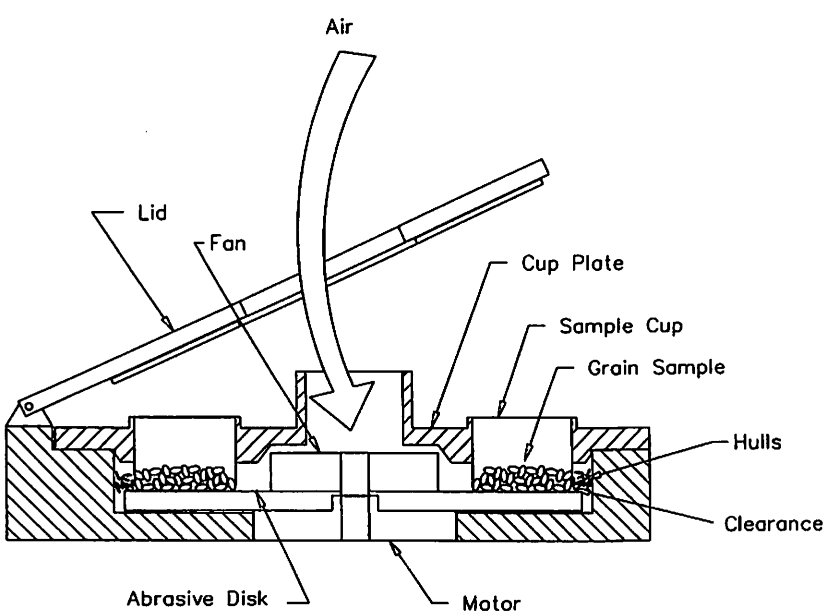


**Fig. 1. Cross-section of the Tangential Abrasive Dehulling Device (TADD).**

**Moisture content** The moisture content of the grain samples prior to each treatment was determined in triplicate using the air oven method according to the ASAE Standard S352.2 (ASAE 1997a) for rapeseed. About 10 g grain were dried in a convection oven at 130°C for 4 h.

**Bulk density** Grain was poured into a pre-weighed 0.5 liter container until the sample overflowed. The container was leveled off with a round stick and then re-weighed. The bulk density was calculated by dividing the mass of the grain by the container volume. This measurement was repeated three times on each grain sample.

**Particle density** An air comparison pycnometer (Model 930, Beckman Instruments Inc., Fullerton, CA) was used. About 32 g of grain were weighed and placed into the sample cup of the pycnometer. The volume of the grain was measured and the particle density was found from the ratio of mass to particle volume. This measurement was repeated three times on each sample.

**Particle size** The dimensions of the grain were determined by measuring the major and minor axes using digital imaging (Inspector software, MATROX Corp. Montreal, QC). These measurements were made on 100 kernels.

**Grain mass** The mass of 1000 kernels was measured using an electronic balance readable to 0.01g. The measurement was repeated on three samples.

### Conditioning treatments

Grain was conditioned by either heating/drying, moistening, tempering, or a combination of these treatments as summarized in Table II. Equipment for grain conditioning consisted of a water spray bottle, wide mouth glass jars, and two dryers. Moistening was done by spraying a quantity of water onto the grain. The moistened grain was dried in a laboratory thin layer dryer (Ikebudu 1996) where the grain was spread in a thin layer of about 2-3 kernels deep. In another treatment, the grain at original moisture content was heated/dried for five minutes in a laboratory fluidized bed dryer (Model 23850 Lab-Line Instruments Inc. Melrose Park, IL). Tempering treatment consisted of leaving grain in a sealed glass jar for 4 h.

### Dehulling and separation

Dehulling equipment consisted of a tangential abrasive dehuller device (TADD) developed by Reichert et al. (1986). Figure 1 shows the dehuller which consisted of an abrasive disk rotating horizontally. A stationary lid held a number of open-bottomed grain cups over the rotating disk. The degree of abrasiveness of the rotating disk was 80, previously determined to be of optimum grit size for canola dehulling (Thakor 1993). Figure 2 shows the diagram of the Bate aspirator (Rapsilver Supply Co. Inc., Brookshire, TX) which consisted of a feed cone aspirator for seprating cotyledon from hulls and a cyclone to recover hulls and fines from the air stream.

Figure 3 shows the flow diagram for dehulling and fractionation of the grain.

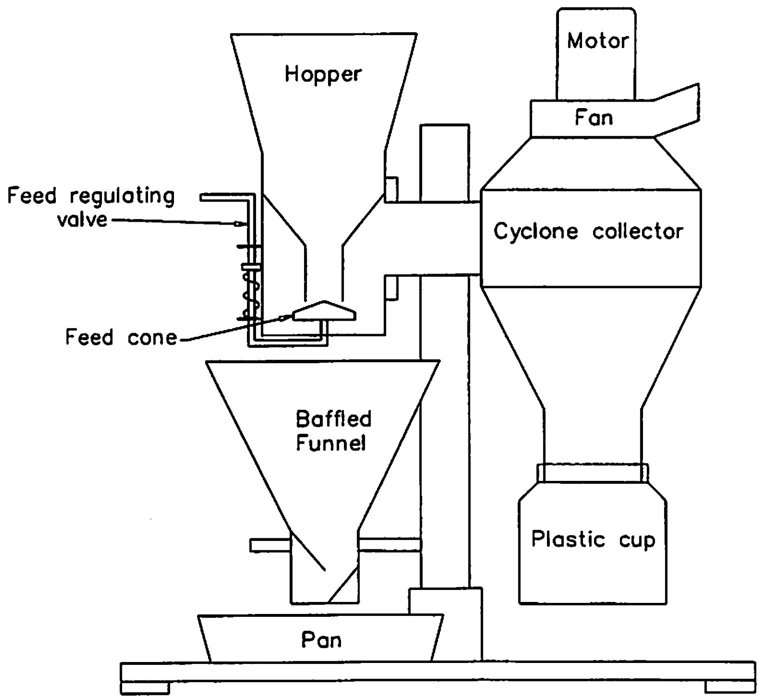


**Fig. 2. Aspirator used to separate the hulls from cotyledons.**

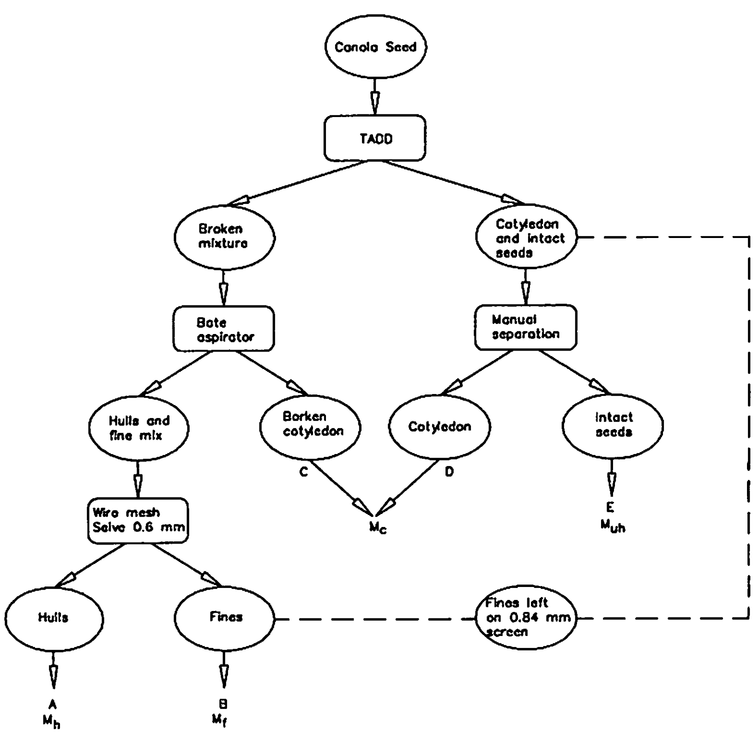


**Fig. 3. Flow diagram for dehulling and fractionation of the grain.**

About 20-g grain samples were placed in the sample cups of the TADD. The samples were milled for 60 s. Part of the broken mixtures consisting of hulls, broken cotyledon and fines were blown into a collecting bag during dehulling. The remaining milled mixtures which consisted mainly of cotyledons and intact grain were vacuumed out. The fines were collected on a 20 mesh screen (hole size 0.84 mm). The undehulled kernels were removed manually from the mix of cotyledons and undehulled. The remaining mixture of hulls and dehulled (broken) grain was introduced into the feed cone of the Bate aspirator. The hull and fines fractions passing through the cyclone collector were recovered. The broken cotyledon fraction that passed through the hopper was collected on a pan. The mixture of fines and hulls collected from the cyclone were further separated using a 0.6 mm wire mesh sieve (No. 40) into hulls and fines fractions. The fines were added to the fines recovered from TADD.

### Dehulling effectiveness

The fractionation as shown in Fig. 3 consisted of (A) hulls (B) completely dehulled kernels (cotyledon), (C) broken cotyledon, (D) fines, and (E) undehulled kernels. The completely dehulled kernels were considered the kernels with about 95% of the grain coat removed and included the broken cotyledon fraction. The 95% removal was assessed visually. A dehulling index, η, was defined using:

$$\eta = \frac{(M_c + M_h) - (M_{uh} + M_f)}{M_g} \quad (1)$$

where:

$M_c$ = mass of cotyledons and broken cotyledons,
$M_h$ = mass of removed hulls,
$M_{uh}$ = mass of kernels that remained undehulled,
$M_f$ = mass of fines in the final product, and
$M_g$ = total mass of original grain fed into the dehuller.

The dehulling index (η) may vary from a maximum of +1 to a minimum of -1. Maximum +1 indicates that all of the grain sample is successfully dehulled into two fractions of cotyledon ($M_c$) and hull ($M_h$) with no fines and undehulled grain. A minimum -1 indicates that the dehulling is not successful, i.e., the grain has broken into fines ($M_f$) and/or not at all dehulled ($M_{uh}$).

## RESULTS

### Physical characteristics of the grain samples

The physical characteristics of the canola grain samples are given in Table III. The major and minor diameters of the kernel of Excel variety were within the range of 1.28-1.62 mm and 1.12-1.53 mm, respectively. The closeness of major and minor diameters indicates that the grain was almost spherical. The bulk density of the grain was 670 kg/m$^3$, which is in close agreement with the value of 669 kg/m$^3$ reported in ASAE D241.4 (ASAE 1997b). The particle density of 1054-1061 kg/m$^3$ was slightly less than the particle density of the popular Polish variety Tobin (1150 kg/m$^3$) as measured by Thakor (1993).

### Conditioning treatments

Figure 4 shows the data from Treatment 1 where the grain was moistened for periods of up to 15 min followed by heating

**Table III. Physical characteristics of Excel canola samples used in the experiments.**

| Physical characteristics | Mean | Range |
|---|---|---|
| Initial moisture (%wb) (n=3) | 7.5 | - |
| Bulk density ($kg/m^3$) (n=3) | 670 | 668-673 |
| Particle density ($kg/m^3$) (n=3) | 1059 | 1054-1061 |
| Major diameter (mm) (n=100) | 1.47 | 1.28-1.62 |
| Minor diameter (mm) (n=100) | 1.32 | 1.12-1.53 |
| 1000 grain mass (g) (n=3) | 2.88 | 2.83-2.94 |

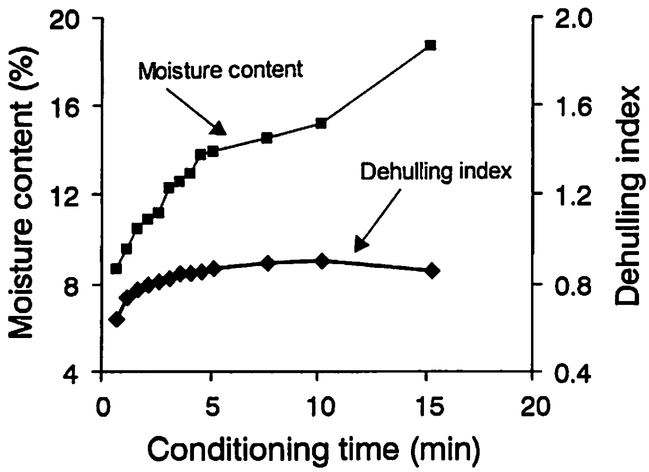


**Fig. 4. Plot of moisture content and dehulling index vs time for treatment 1 grain. The dehulling index for control sample was -0.47.**

at 70°C for 5 min. The moisture content absorbed by the grain kernels increased as the tempering time increased from 30 s to 15 min. Conditioning for 10 min resulted in a maximum of 0.88 dehulling index. Further conditioning to 18.5% m.c. for 15 min resulted in a decrease in dehulling index to 0.83. For a 20 g grain sample, the hull fraction at the maximum dehulling index was 2.82 g compared to the hull fraction for the control sample (not conditioned) which was 0.83 g. The dehulling index for the control sample was –0.47 which was calculated from: $M_g$=20.1 g, $M_c$=4.34 g, $M_{uh}$=13.57 g, $M_h$=0.83 g, and $M_f$=1.03 g.

Table IV lists the data resulting from treatments 2-4 (see Table II) where grain samples were heated for 5 min in the fluidized bed dryer. Samples in treatment 3 were moistened to 9% m.c. following the heating period. All of the reported treatments in Table IV included a tempering period of 4 h prior to dehulling. The dehulling index for treatment 2 was 0.84 and that for treatment 3 was 0.10. Treatment 3 generated an average of 1.77 g of hull from 20 g of the dehulled grain. Treatment 2 generated an average of 2.76 g of hull. The control sample produced a dehulling index of –0.44.

Table IV also lists the dehulling fractions and the dehulling index when the grain was heated/dried at temperatures from 60°C to 120°C. Increasing the heating temperature from 60°C to 120°C led to 13% increase in the yield of hulls and 50% decrease in the yield of fines. The dehulling index increased from 0.76 at 60°C to 0.88 at 120°C. Out of 20 g grain dried at 60°C, an average of 2.49 g of hull and 0.97 g of fines were generated. Heating at 120°C generated an average of 2.80 g hulls and 0.47 g fines.

## DISCUSSION

From Fig. 4, a moistening time of 10 min followed by heating at 70°C resulted in the highest dehulling index of 0.88. Heating the untreated grain at 60°C without moistening resulted in a dehulling index of 0.76. Heating at 120°C, on the other hand, resulted in a dehulling index of 0.88. Moistening followed by heating/heating offers the advantage of lower heating temperature which will not affect the quality of the oil, protein, and perhaps other heat sensitive ingredients of the grain. Because of the adverse effects, the high temperature heating might have on the quality of the oil and proteins (Shahidi 1990), heating at temperatures higher than 120°C may not be desirable. This needs further testing.

Heating followed by moistening (treatment 3, Table IV) resulted in a decrease in the dehulling index and therefore this treatment should not be considered an effective dehulling method. The reason for the decrease in the dehulling index of the grain subjected to moistening (treatment 3) may be that the moisture added to the grain resulted in the toughening of the

**Table IV. Dehulling data for grain samples that were either heated or heated and remoistened.**

| Treatment | Sample mass (g) | Cotyledon fraction (g) | Undehulled fraction (g) | Hull fraction (g) | Fines fraction (g) | Dehulling index |
|---|---|---|---|---|---|---|
| Heating at 120°C | 20.02 | 15.35 | 0.82 | 2.76 | 0.42 | 0.84 |
| Heating at 120°C, moistening | 20.00 | 9.09 | 8.72 | 1.77 | 0.21 | 0.10 |
| Heating at 60°C | 20.01 | 14.91 | 1.31 | 2.49 | 0.97 | 0.76 |
| Heating at 80°C | 20.00 | 15.39 | 1.02 | 2.46 | 0.66 | 0.81 |
| Heating at 100°C | 20.00 | 15.38 | 0.92 | 2.77 | 0.59 | 0.83 |
| Heating at 120°C | 20.01 | 16.09 | 0.81 | 2.80 | 0.47 | 0.88 |
| Control | 20.01 | 4.97 | 13.97 | 0.61 | 0.40 | -0.44 |

**Table V. Physical characteristics of a Polish variety of canola (Tobin) (Thakor et al. 1995).**

| Fraction | Bulk density (kg/m$^3$) | Particle density (kg/m$^3$) | Porosity (%) | Geometric mean diameter (mm) | Entrainment velocity (m/s) | |
|---|---|---|---|---|---|---|
| | | | | | Minimum | Maximum |
| Whole grain | 680 | 1129 | 39.7 | 1.83 | 0.98 | 1.89 |
| Cotyledon | 554 | 1170 | 52.6 | 1.30 | 0.99 | 1.83 |
| Hull | 148 | 1279 | 88.4 | 0.75 | 0.68 | 0.85 |
| Fine | 302 | 1259 | 76.0 | 0.29 | 0.75 | 0.94 |

seedcoat due to an increased tissue elasticity. Dorrell (1968) reported that when a plant tissue loses moisture it becomes brittle due to either an increase in crystallization or a change in cellulose orientation. However, the reverse may be the case when tissues begin to gain moisture. A similar effect was observed by Ehiwe et al. (1987) when they studied the seedcoat durability of field pea using TADD. They reported a reduction in seedcoat breakage with an increased kernel moisture.

The four fractions $M_c$, $M_h$, $M_{uh}$, and $M_f$ generally did not add up to the mass of original grain sample (20 g). This was due to losses during the recovery of the fractions. These losses were less than 0.2 g which influences the dehulling index by less than 0.01.

Table V lists the physical characteristics of the grain fractions measured by Thakor (1993). As bulk densities indicate, hulls had a small bulk density of 148 kg/m$^3$ compared to cotyledon of 554 kg/m$^3$. The particle densities were not much different suggesting that air aspiration may not be an adequate means of separating the grain. The geometric mean diameters of all fractions were significantly different so the fractions might be separable by sieving. The fuidization velocities were smaller for hull and fine fractions than for whole grain and cotyledon fractions. Separation by a combination of sieving (to remove fines) and a gravity table (fluidization) might be the best way to separate various fractions of canola.

## CONCLUSIONS

1. The grain moistened to 15% m.c. for 10 min followed by heating at 70-75°C for 5 min yielded a dehulling index of 0.88. This indicates that most of the grain was fractionated into hulls and cotyledon. The dehulling index of the unconditioned control sample was –0.47 indicating that most of the grain sample was either broken or remained undehulled.
2. Increasing the heating temperature from 60°C to 120°C (witout moistening) led to a 13% increase in the generation of hulls and a 50% decrease in the generation of fine fractions. The dehulling index at 120°C heating was 0.88.
3. Heating at 120°C followed by moistening to 9% m.c. resulted in a dehulling index of 0.11.
4. Heating at 120°C or moistening/drying at 70-75°C resulted in similar high dehulling index of 0.88. Because of uncertainties in the oil yield of the seed at 120°C treatment, however, moistening for 10 min followed by heating/heating at 70°C is recommended. Further experiments are recommended to evaluate the oil yielding qualities of canola heated to 100-120°C.


## ACKNOWLEDGMENT

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