CARBON DIOXIDE AND CUMULATIVE HEAT PRODUCTION OF CANOLA STORED UNDER ADIABATIC CONDITIONS

BY

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A Thesis
Submitted to the Faculty of Graduate Studies
In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

Department of Biosystems Engineering
University of Manitoba
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FACULTY OF GRADUATE STUDIES

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ABSTRACT

The main objective of this study was to measure and relate respiration and heat production of canola to its quality. Experiments were conducted under adiabatic conditions using canola (*Brassica napus* L.) at three moisture contents (m.c.) of 10, 12, and 14% wet mass basis and two temperature regimes of 25 to 30°C and 30 to 35°C. Quality of the canola was related to levels of microflora, germination, ergosterol, and fat acidity values.

Respiration data showed no difference ($P > 0.05$) between freshly harvested canola and canola that was dried, cooled, and stored for more than 6 months. Carbon dioxide production was dependent on storage time, moisture content, and temperature ($P < 0.001$) and increased with increasing levels of each. Germination was successfully modelled using CO_2 production, moisture, and temperature data. Carbon dioxide production rates at the time of a drop to 95% germination were 500 (mg/d)/kg d.m. for 14% m.c., 192 (mg/d)/kg d.m. for 12% m.c., and 185 (mg/d)/kg d.m. for 10% m.c. canola between 30 and 35°C and 290 (mg/d)/kg d.m. for 14% m.c. and 172 (mg/d)/kg d.m. for 12% m.c. canola between 25 and 30°C. These CO_2 production rates may be taken as the maximum safe rates for sound canola under the conditions described above. First signs of visible mould did not always precede a 5% drop in germination. Ergosterol levels correlated weakly with CO_2 production but strongly with FAV. At ergosterol levels greater than 2 ppm germination has dropped significantly and spoilage has occurred.

Cumulative heat production followed an increasing linear trend with time and moisture. Directly measured cumulative heat production was less than calculated heat production from CO_2 production for carbohydrate and lipid metabolism.

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1. INTRODUCTION

Canola (low erucic acid, low glucosinolate rapeseed) has become an increasingly important crop in Canada and the world. It is grown primarily for its oil, which is used in margarine, salad dressings, cooking oils, and other food products. After the oil is extracted the leftover meal can be sold as a high protein feed supplement to poultry and livestock producers. In 1999 world-wide production of canola reached 42.6 million tonnes (Mt), up from 25.0 Mt in 1990. Canada is the world's second largest producer of canola behind China and in this period saw its production of canola more than doubled from 3.2 Mt in 1990 to a high of 8.8 Mt in 1999 (FAO 2002). Traditionally, almost half of this production is exported to other countries throughout the year at values exceeding 890 million US dollars (FAO 2002). Before canola is exported it can be stored for periods of up to a year or more. Most of this is stored on the farm by the producer in cylindrical, galvanised-steel bins. During this time the potential for spoilage can be high, depending on the moisture and temperature at which the canola is stored.

The main causes of deterioration in stored canola are fungal infection and mites (Brogan 1986). Other pests such as birds, rodents, and insects are not a concern because canola does not constitute a suitable food source (although insects may be associated with dockage in bulk canola). Fungi need water activities above 0.65 to grow, which corresponds to a moisture content of approximately 9% wet basis for canola at temperatures above 25°C (Sauer et al. 1992). Mites, who prefer moist and mouldy grain, are not a problem until the canola has become mouldy because mites need a high water activity to survive, so fungal growth should occur before mite infestations (Sinha and Wallace 1977). Acceptable storage conditions for canola are considered to be 10%

moisture content (m.c.) for cool seed although 8% m.c. is recommended for prolonged storage (Canadian Grain Commission 2000). Some canola may be harvested and stored above these safe storage limits if; unsatisfactory drying conditions at harvest occur; immature seeds originating from wet spots in the field are binned; seed from the first swaths around the field are collected; or if moisture content is determined on faulty equipment (Mills 1980). With an oil content above 40% and oil being hydrophobic, all moisture in the canola seed is stored in the protein and carbohydrate containing portions (Moysey 1973). If canola is stored at the Canadian limit of 10% or higher and at warm temperatures, the risk of canola deteriorating due to growth of fungi is very likely.

Adverse changes may occur rapidly in freshly harvested canola with the seeds going through a period of post-harvest maturation and active respiration known as the "sweating process". The heat and moisture of respiration may quickly cause the stored canola to spoil if steps are not taken to mitigate its effects. Stored canola must not be allowed to spoil as heat damaged and deteriorated canola has little value because the oils produced from these seeds is of a poor quality (Paetkau and Lapp 1972). Moulds growing on grain have a high lipolytic activity that breaks down lipids into free fatty acids, which affects the quality of oil extracted from the seed (Pomeranz 1992). As well, fungal growth can impart odours and colour changes to oil extracted from mouldy seed, which makes the oil less desirable to consumers. Under favourable conditions some fungi may produce mycotoxins which can adversely affect the health of those that consume them. For this reason, a better understanding of the processes and conditions which canola undergoes during deterioration is necessary.

Knowledge of the processes and conditions during deterioration of canola is required to manage storing, drying, and aerating systems for the oilseed. Heat production can be predicted from respiration and used with storage life equations in expert systems to manage crop storage. Determination of fungal contamination of canola can also be useful for quantification of deterioration during storage. This may be accomplished by measuring secondary indicators of fungal contamination like carbon dioxide production, or by measuring fungal-specific chemicals like ergosterol, the predominant sterol found in fungal cell membranes. There has been extensive research done in determining the deterioration and storability of rapeseed and canola (Sinha and Wallace 1977, Mills et al. 1978, Mills and Sinha 1980, Mills 1980, White et al. 1982b). Methods used to determine these factors have examined visible fungi, fungal species present, number of seeds infected with fungi, free fatty acids, conductivity, pH, moisture content, storage temperature, insect and mite infestations, odour, colour of crushed seeds, and seed germination. These methods show deterioration after it has occurred and do not predict spoilage or storability. As well, they often require expert knowledge, long testing periods, or they are largely subjective. A quick and reliable method for determining quality of stored canola would be beneficial to farmers to help prevent deterioration and help predict the potential for storage losses. If farmers were able to predict the storage condition or any potential problems in their bins of stored canola they could take steps to mitigate any potential losses. Steps they may wish to undertake include operating their aeration system to cool or dry their canola, drying the canola in a portable dryer, selling the canola immediately, or choosing to do nothing. For this reason a better understanding

of the processes and conditions which canola undergoes during deterioration, as it affects quality of the seeds, is necessary for farmers to make better management decisions.

The objectives of this study were:

(1) To mathematically model the storage life of canola as indicated by a reduction in germination based on measured factors of storage time, moisture, and carbon dioxide production.

(2) To measure carbon dioxide production of respiring canola and associated microflora and to relate these measurements to the grain condition indicated by germination, fungal infection, and fat acidity.

(3) To observe whether the "sweating process" in freshly harvested canola is a post-harvest maturation process of canola or is it the result of moisture and heat transfer in any bulk of canola at the same moisture content, temperature, and fungal infection.

(4) To measure heat production in a computer-controlled calorimeter under adiabatic conditions and to determine the correlation between heat production of canola and carbon dioxide production as measured in the experiment.

(5) To analyse canola samples to determine the concentration of ergosterol, which is the predominant sterol in the cell walls of fungi. This will be used to quantify and relate the levels of ergosterol to fungal infection and deterioration of canola seeds.

2. LITERATURE REVIEW

2.1 Respiration

2.1.1 Respiration equations All living organisms respire, including canola seeds and the fungi and organisms that consume them. Respiration of the canola seeds is negligible when compared with the respiration of the fungi growing on them (Hummel et al. 1954). As fungi consume the canola, it is possible for different substrates to be consumed, either carbohydrates or lipids. Under aerobic conditions the combustion of a typical carbohydrate, D-Glucose, and a typical lipid, tripalmitin, will produce different respiration equations (Pomeranz 1992):

D-Glucose:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2835\ kJ \quad (1)$$

Tripalmitin:

$$(C_{15}H_{31}COO)_3C_3H_5 + 72.5\ O_2 \rightarrow 51CO_2 + 49H_2O + 31890\ kJ \quad (2)$$

To determine which substrate is being consumed one would have to determine the respiratory quotient for the system. This is accomplished by measuring both the carbon dioxide production as well as the oxygen consumption and then determining the respiratory quotient (RQ) as the ratio of moles of CO_2 produced to moles of O_2 consumed. An RQ of one would indicate metabolism of carbohydrates is occurring, whereas an RQ of less than one indicates lipid metabolism.

As fungi consume canola, dry matter is converted to CO_2, water, and heat. The loss of dry matter is a loss of profits for farmers when the time comes to sell their crop by reducing the saleable mass of the crop. The production of water increases the moisture content (m.c.) of the canola and along with the produced heat promotes increased fungal

growth and spoilage. The production of CO_2 has the potential to be an indicator of fungal levels and spoilage of stored canola.

2.1.2 Sweating process Some reports have indicated that freshly harvested canola may go through a period of post-harvest maturation that is known as the "sweating process" or "post-harvest ripening" (Paetkau and Lapp 1972, Mills 1989, Trisvyatskii 1969, Adolphe 1979). It is theorized that freshly harvested seeds are still metabolically active so that their heat production and respiration are still very high. When this seed is stored in an enclosed bin, the high respiration will increase the moisture and temperature of the bulk and cause the canola to spoil. It is said that this period of active respiration may continue up to 6 wk after harvest (Adolphe 1979) at which time the seeds will become largely dormant if moisture and temperature of the seeds is low enough (Mills 1989). Canola stored within 24 h of harvest in 205-L drums had a period of active respiration during the first 2 wk of storage before respiration levels fell (Mills 1980). It is important to determine if the sweating process is really a post-harvest maturation process of canola or is it the result of moisture and heat transfer in any bulk of canola at the same moisture content, temperature, and fungal infection.

2.2 Carbon dioxide concentration as an indicator of spoilage

Many researchers have observed the relationship between spoilage of stored grain and increased levels of carbon dioxide. Muir et al. (1980) observed that the largest changes in CO_2 concentration occurred in areas of grain bulks where the greatest spoilage was occurring. In another study, Muir et al. (1985) were able to detect CO_2 concentrations above ambient in 87% of bins containing wheat, rapeseed, barley, and

corn where grain was spoiling. Types of deterioration the study was able to find were infestations of insects, mites, postharvest fungi, increased fat acidity values (FAV), and decreased germination. Determining CO_2 concentrations of grain bulks is still not a good quantitative assessment of spoilage because CO_2 may move in a grain bulk or it may be absorbed by the grain itself (Cofie-Agblor et al. 1998). At best, CO_2 concentration is a good parameter to detect spoilage but it does not give a quantitative answer about the quantity of spoilage occurring in a large bulk.

2.3 Carbon dioxide production as an indicator of spoilage

2.3.1 Gas chromatography To get an indication of the state of spoilage the rate of carbon dioxide production from a sample must be determined. White et al. (1982a and 1982b) studied cumulative carbon dioxide production as an indicator of spoilage and deterioration of wheat and rapeseed. At regular intervals, gas samples were drawn and analysed in a gas chromatograph for CO_2 and O_2 concentrations. The rate of CO_2 production was then determined from the change in concentration divided by the time between samplings. For wheat the cumulative CO_2 production could be related to the dry matter loss using the respiration equation and assuming only carbohydrate metabolism and aerobic reactions. According to White et al. (1982b), determination of dry matter loss in rapeseed is not practical because the seed is composed of mostly oil and a smaller proportion of carbohydrates. At moisture contents below 11.3% they found RQ values of 0.7 to 0.8 for rapeseed which suggested that lipid metabolism was indeed taking place. White et al. (1982b) related CO_2 production to independent factors of temperature,

storage time, and moisture content (m.c.) of the seeds to produce prediction equations for CO_2 production. The equation they developed to predict CO_2 production was:

$$RCO_2 = \left(10^{-1.317 + 0.037(T) - 0.037(\theta) + 0.001(\theta)^2 + 0.154(M)}\right) \quad (3)$$

where:
RCO_2 = predicted rate of CO_2 production per unit dry mass of seed ((mg/d)/kg dry matter)
T = temperature (°C)
θ = time in storage (d)
M = moisture content of seed (%)

The use of CO_2 concentrations to calculate the CO_2 production rate is a problem because of absorption of CO_2 by the canola and reduced respiration rates at high concentrations of CO_2 (Cofie-Agblor et al. 1998, Cofie-Agblor et al. 1997). As CO_2 partial pressure increases in the storage vessel, CO_2 will be absorbed into the seed, reducing the CO_2 concentration. If the CO_2 concentration is high, CO_2 may be prevented from leaving the seed and a lower respiration rate will be measured than is occurring. The sorption of CO_2 by canola is greater and quicker than for cereal crops like wheat, oats, and barley with sorption equilibrium being reached within 24 h with significant sorption within the first couple of hours (Cofie-Agblor et al. 1998). A more precise method to determine the CO_2 production rate would be to measure the amount of CO_2 produced by a sample in a short period of time and to prevent a large accumulation of CO_2.

2.3.2 Absorptive respirometers A respirometer is an instrument for studying the character and extent of respiration by measuring the rate of CO_2 accumulation. Absorptive respirometers operate as an open system where a CO_2-free air stream is

passed through a sample. The air stream picks up all the CO_2 produced by the sample then it is dried before being passed through an absorptive substance, which removes the CO_2 from the air. The absorptive substance is then weighed periodically to determine the mass of CO_2 absorbed. This change in mass is then used to calculate the CO_2 production of the sample. Absorptive respirometers have been used to calculate CO_2 production rates of wheat (Al-Yahya 1999) and of shelled corn (Steele et al. 1969 and Fernandez et al. 1985).

The benefit of absorptive respirometers is the constant flow of low CO_2 air through the system. This limits the amount of CO_2 accumulation in the sample and the likelihood of anaerobic respiration from occurring, thus providing more accurate readings of CO_2 production. Al-Yahya (1999) used a mixture of vermiculite and potassium hydroxide solution as the absorbing agent whereas Steele et al. (1969) and Fernandez et al. (1985) used a combination of asbestos particles and sodium hydroxide, trade named Ascarite. These substances need replacing at regular intervals and are prone to false readings if water released by the absorption of CO_2 or water not being removed from the air stream enters the absorbing agent. Other problems with this method is that it takes several days to accumulate enough CO_2 to determine CO_2 production, accurate and expensive scales are necessary for weighing, and potentially dangerous chemicals are used.

2.3.3 Nondispersive infrared respirometer It is possible to measure CO_2 concentrations directly and almost instantaneously with a nondispersive infrared respirometer. Two successive readings in a short period of time could then be used to calculate CO_2 production rates. Nondispersive infrared respirometers can operate as an

open or closed system, depending on what is being measured. In its basic form the respirometer equipment consists of a sample pump and a CO_2 sensor. The pump draws air from the sample container through a drying column or dew point apparatus, where the moisture is removed from the air stream. The air is passed through the gas sensor by the sample pump, then humidified and returned to the sample container or vented after the readings are taken. Infrared gas sensors operate on the principle that most gases have unique infrared signatures. An infrared beam is passed through a gas sample and a photodetector measures radiation reaching it from the light source with a particular wavelength. The amount of infrared radiation absorbed by the air stream is proportional to the number of CO_2 molecules (partial pressure of CO_2) present in the chamber, according to the Beer-Lambert Law, which states that when a sample is placed in the beam of a spectrometer, there is a direct and linear relationship between the concentration of its constituents and the amount of energy it absorbs (Ion Optics 2002). With knowledge about the partial pressure of CO_2 in the chamber, the CO_2 concentration may be calculated.

Karunakaran (2001) used a single beam, nondispersive infrared respirometer to measure the CO_2 production of wheat. Karunakaran (2001) was able to determine CO_2 production in 2 h and predicted germination capacity of wheat based on the rate of CO_2 production given by the equation:

$$Y = 100 - 0.1RCO_2 + 0.93M \quad (4)$$

where:
Y = germination capacity (%)

The problem with this particular respirometer is the extensive calibration that needs to be done to assure accurate readings and the trouble with maintaining an aerobic

environment in a closed system. The advantages to a nondispersive infrared respirometer are that it can detect small changes in CO_2 concentration in a short period of time, it is unaffected by changes in temperature and humidity, and there are no mechanical or chemical parts that need changing. Thus, using a direct measurement respirometer to measure CO_2 production has the potential to be a quick and reliable method for determining the state of spoilage of canola.

2.4 Fungal-specific chemical constituents of fungal biomass

2.4.1 Chitin concentration When examining CO_2 production and its relation to grain quality it is useful to be able to quantify the amount of fungal growth on the seeds as it is chiefly responsible for the respiration of the system. However, it is difficult to determine fungal biomass in a seed crop because of difficulties in separating fungus from on and below the seed coat. As such, secondary indicators of fungal contamination must be examined to quantify contamination. One possible method is to determine fungus-specific chemical constituents and relate one or more of them to mycelial dry matter. Chitin, a polymer of N-acetyl-D-glucosamine, has been proposed as a measure of fungal growth in stored grain (Donald and Mirocha 1977, Lung-Chi and Stahmann 1975). It is found in spores and mycelium of fungi as well as the exoskeletons of insects. The presence of chitin has not become widely accepted due to possible contamination from insect parts, and due to a more consistent relationship between ergosterol and fungal contamination (Seitz et al. 1979, Sauer et al. 1992, Newell 1992).

2.4.2 Ergosterol concentration Ergosterol is the predominant sterol found in fungal cell membranes. It is specific to fungi and is rarely found in animal and plant tissues (Seitz et

al. 1979). The ergosterol assay will determine the history of invasion by fungi, as it will detect both viable and nonviable fungus. A limitation of the ergosterol assay is that it does not distinguish between fungal species. It will not differentiate between invasion by benign pre-harvest fungi and invasion by harmful storage fungi. However, different fungi may produce different levels of ergosterol and levels are also affected by substrate composition, extent of aeration, and growth phase of the mycelium (Tothill et al. 1992).

Seitz et al. (1979) found that species belonging to the *A. glaucus* group produced less ergosterol in milled rice than other fungi. This may be related to rate of growth as *A. glaucus* grew less and was less aggressive or destructive than other fungi in grain (Sauer et al. 1992). Tothill et al. (1992) found that grain with microscopic mycelial growth contained nearly twice as much ergosterol as non-mouldy grain and that levels in visible mouldy grain were higher yet. A highly accurate method for assaying the ergosterol content of canola has been found (Abramson and Smith 2002). A recovery rate on artificially inoculated seeds was greater than 94%. There is potential that ergosterol levels may correlate well with fungal biomass and the level of deterioration in stored canola.

2.4.3 Free fatty acids and fat acidity value (FAV) The fat acidity value is a measure of the free fatty acids in the oil content of a seed and is expressed as mg of KOH to neutralise the free fatty acids in 100 g moisture free grain. While not a chemical compound of fungal biomass, FAV is a measure of deterioration occurring in seeds during storage. Free fatty acid formation in oilseeds represents a direct loss in oil quality and is usually associated with increased respiration and fungal growth (Mills and Sinha 1980, White et al. 1982, Dhingra et al. 1998). Dhingra et al. (1998) found that FAV

increased with time of storage and moisture content of soybeans and that the trend was similar to that of ergosterol. Mills and Kim (1977) and Mills and Sinha (1980) determined FAV in sound, heat damaged, and deteriorated canola. They found that sound canola with over 95% germination had FAV of less than 20 mg KOH/100g and values over 30 to 50 mg KOH/100 g for germination below 90% depending on moisture and temperature during storage.

2.5 Modelling deterioration of canola

With knowledge of the processes and effects of deterioration it is possible to predict the outcome of future storage situations for stored products with the use of empirical models of the data. Results can be used to formulate storage equations that may be used to predict germination or drop in germination given a set of factors (Steele et al. 1969, White et al. 1982a and 1982b, Karunakaren et al. 2001, Chen and Jayas 2000). Studies by White et al. (1982b) produced equations for storage of canola until a 5% drop in germination or the first visible sign of moulding using data published by Kreyger (1972):

$$\text{Log}_{10}\theta = 6.224 - 0.302M - 0.069T \qquad 6.5\% < M < 11\% \qquad (5)$$

$$\text{Log}_{10}\theta = 5.278 - 0.206M - 0.063T \qquad 11\% < M < 17\% \qquad (6)$$

where:
θ = estimated storage time (days) until a 5% drop in germination
M = moisture content of seeds (% wet mass basis)
T = temperature (°C)

Studies have shown that a plot of germination will follow an asymmetric sigmoid pattern (Schroth 1996, Karunakaren et al. 2001). This pattern may be described using a five parameter logistic function:

$$Y = \frac{a - d}{\left[1 + \left(\frac{\theta}{c}\right)^{b}\right]^{e}} + d \qquad (7)$$

where:
a = asymptotic maximum
b = slope parameter
c = θ value at the inflection point
d = asymptotic minimum
e = symmetry parameter

Data collected from studies on heat production and respiration may be included in computer models to estimate microbial heat production in grain bins for management purposes (Thompson 1972, Lissik and Latif 1986). However, many models assume that the internal heat generation of the system is negligible (Metzger and Muir 1983, Longstaff and Banks 1987, Sanderson et al. 1989, Alagusundarum 1990). Improvements in computer models will follow the gathering of respiration data to predict internal heat generation of grain bulks.

3 MATERIALS AND METHODS

3.1 Grain and treatments

Tests were conducted using canola (*Brassica napus* L., cultivar 'LG3295') at three moisture contents (m.c.) of approximately 10, 12, and 14% wet mass basis and two temperature regimes of 25 to 30°C and 30 to 35°C. Freshly harvested canola was obtained directly from a farmer near MacDonald, Manitoba on August 29, 2000 at a moisture content of 8.5%. All moisture contents were determined using the oven-dry method (ASAE 1993) by weighing 10 g of seed into an aluminium dish and drying the sample at 130°C for 4 h. The dried sample was then weighed and the amount of moisture removed was divided by the original sample weight to determine the moisture content on a wet mass basis. The canola was sieved and cleaned by hand to remove foreign material. Samples were conditioned by adding the appropriate amount of distilled water to bring it up to the desired moisture and were stored for 24 h at the desired initial temperature for the trial. Moisture contents were checked at the beginning and conclusion of the experiments.

Testing at an initial temperature of 30°C was conducted on the freshly harvested samples starting on 30 August 2000 to compare with canola that was dried and stored for later testing. Due to equipment limitations only two samples could be tested for respiration per day so the second and final samples were tested on August 31 and September 1, 2000 respectively. For this trial all three moisture contents were tested at once. Later trials for stored samples consisted of a single moisture content being tested at a time.

3.2 Experimental apparatus

Storage tests were performed in six insulated boxes constructed inside an environmental chamber (Fig. 1). There were three flasks per box and six boxes in the environmental chamber (Fig. 2). Canola samples of 600 g were placed in identical 1-L insulated flasks labelled temperature and sample flasks. The third insulated flask labelled respiration flask was filled with 200 g of canola.

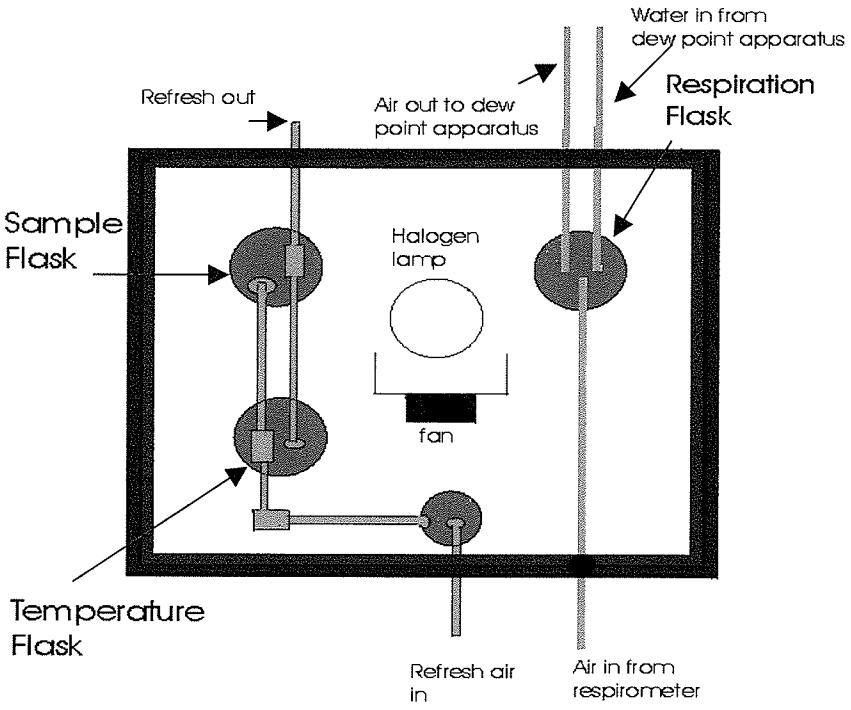


Fig. 1. Schematic of experimental box setup.

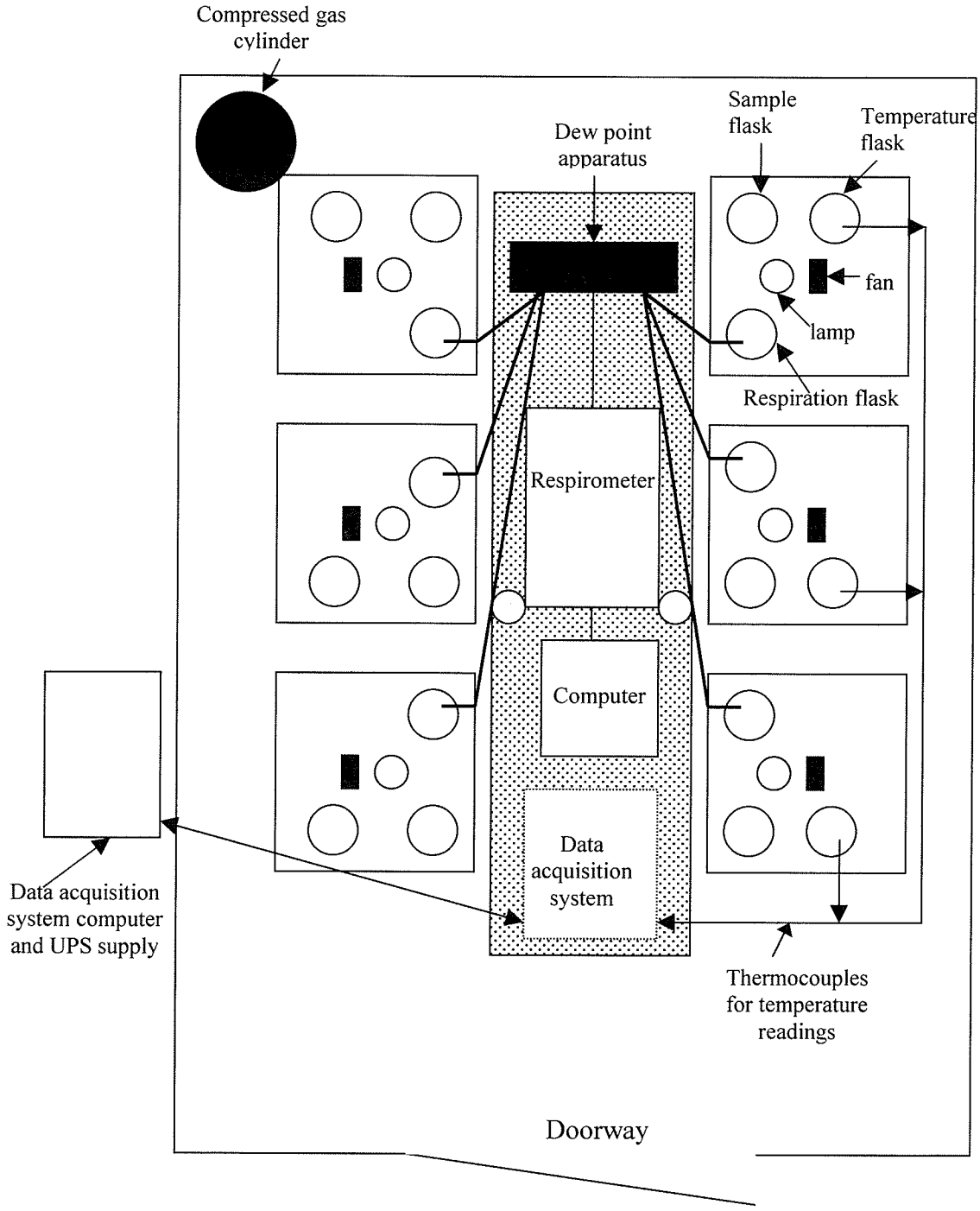


Fig. 2. Equipment setup for storage, respiration, and heat production experiment.

3.2.1 Data acquisition system Temperatures were continuously monitored using thermocouples and a Datascan 7010 data acquisition system (Firmware v2.0 Measurement Systems Ltd., Newbury, Berkshire, U.K.). The Datascan 7010 data acquisition system was connected to a computer running a Qbasic program for control of a halogen lamp (GE, 75-W, 1050-Lumen, indoor long-neck tracklight) and a fan used to heat and mix the air inside of the box. Up to 46 thermocouples are supported by the data acquisition system. The lamp and fan units were plugged into a central power control box. This box acts as an on/off switch that was controlled by the data acquisition system and computer.

3.2.2 Temperature flask The temperature flask was used to measure heat production and to control the temperature in each box. There were seven thermocouples per box, with three thermocouples placed inside of the temperature flask. The temperature was monitored once every 8 s by the data acquisition system. If the temperature difference between the inside and outside of this flask was greater than 0.5°C, the halogen flood lamp was turned on to heat the inside of the box and the program would write the box number, time, date, flask temperature, and box temperature to a computer file. This was done to maintain an adiabatic environment between the canola and surroundings to allow for the determination of heat production. The temperature inside the temperature flask was allowed to rise to 30 or 35°C depending on the regime being followed before it was cooled and the cycle was repeated for the duration of the experiment. The program was set up to give the user a choice of using the default settings or entering the thermocouple groupings manually. The default thermocouple settings are meant for adiabatic control of the boxes and are as follows: Box 1 – #'s 1, 2, and 3 in flask, #'s 4, 5, 6, and 39 in the

box; Box 2 – #'s 7, 8, and 9 in flask, #'s 10, 11, 12, and 40 in the box; Box 3 – #'s 13, 14, and 15 in flask, #'s 16, 17, 18, and 41 in the box; Box 4 – #'s 19, 20, and 21 in flask, #'s 22, 23, 24, and 42 in the box; Box 5 – #'s 25, 26, and 27 in flask, #'s 28, 29, 30 and 43 in the box; Box 6 – #'s 31, 32, and 33 in flask, #'s 34, 35, 36, and 44 in the box.

3.2.3 Sample flask The sample flask contained canola that was sampled for germination, microflora, and ergosterol. The respiration and temperature flasks were not sampled because they needed a constant mass of canola so that CO_2 production and heat production could be determined. The experiment was considered completed when it was confirmed that germination had decreased to 85% or lower.

3.2.3 Respiration flask Carbon dioxide production was measured in the respiration flasks over a 3-h period, using a Micro-Oxymax respirometer (Model V 6.03, Columbus Instruments International Corporation, Columbus, OH, USA). The amount of CO_2 produced was adjusted to standard temperature and pressure conditions (STP at 1 atm and 273 K). This respirometer measures CO_2 concentration using a single beam, nondispersive infrared sensor. The respirometer equipment consists of a sample pump, CO_2 sensor, and a dew point apparatus. The sample pump draws air from the sample container through the dew point apparatus, where the moisture is removed and returned to the sample container. The air is passed through the gas sensors by the sample pump and then returned to the sample container after the readings are taken. Carbon dioxide production rates are calculated from the change in concentrations between readings. The respirometer is run for 3 h, and readings are taken every 20 min. A tank of compressed air is used to purge the sensors after each reading and serves as a reference gas sample for the respirometer. If the CO_2 concentration goes over 0.90% then the sample flask is

purged with the compressed air. For the 10 and 12% m.c. samples carbon dioxide production was measured once every 3 d for the first 2 wk and once every 6 d for the remainder of the experiment and for the 14% m.c. samples carbon dioxide production was measured every 3 d for the duration of the experiment.

To maintain aerobic conditions the flasks were refreshed from five to seven times a week for a period of 2 to 3 min with an aquarium pump that had a flow rate of 0.5 L/min. This refresh period was chosen to completely replace the air in the flasks at least four times (Columbus Instruments, Inc. 1996). At first, experiments were run with flasks of water to humidify the air entering the canola samples. It was found that samples gained water so the flask was removed which meant that samples lost moisture. Finally, to prevent drying samples with the refresh air, the air was humidified before entering the flasks by bubbling it through saturated salt solutions of KCl for 12% m.c. samples and $K_2Cr_2O_4$ for 14% m.c. samples (Winston and Bates 1960).

The effectiveness of the refreshing was validated by testing gas samples taken with a syringe from all the flasks and analyzing them in a gas chromatograph. A Perkin-Elmer Sigma 3B gas chromatograph with a thermal conductivity detector and a Hewlett-Packard 3380S integrator were used to analyze the gas samples. The carrier gas used was helium with the oven held at 70°C and the detector at 150°C. Carbon dioxide was separated from other gases by a 1.8-m column packed with Porapak N. The highest reading recorded was 3.6% CO_2 with most concentrations below 1% CO_2. The literature suggests that 15% CO_2 is necessary to reduce fungal growth by 50% above a temperature of 23°C, so the refresh regime wass adequate so that fungal growth was not affected (Magan and Lacey 1984).

3.2.4 Respirometer calibration and diagnostics The respirometer had to be calibrated and diagnostics run often to ensure proper operation and readings were being taken. Before the respirometer was used the pressure from the compressed gas bottle must be regulated to ensure that less than 145 Pa of pressure would enter the calibration port of the respirometer. There were three steps necessary to calibrate the CO_2 sensor to correctly read the CO_2 concentrations from the sample. First, air was drawn into the respirometer through a soda lime column to remove all the CO_2 from the air. After 1 min passed to allow the sensor to stabilise, the offset on the respirometer was adjusted so the reading was 0.000% CO_2. Next a bottle of precision gas with a mixture of 0.6% CO_2, 21.5% O_2, and the balance N_2 was attached to the respirometer and allowed to flow for 1 min. Finally, the gain on the respirometer was adjusted to read the appropriate gas concentrations. To check the validity of CO_2 production readings, an experiment was run as suggested by the manufacturer (Columbus Instruments, Inc. 1996). First, distilled water was purged with ambient air for 15 min to allow the dissolved CO_2 to reach equilibrium. Next 500 mg of sodium bicarbonate (baking soda) was dissolved into 100 mL of distilled water. A 2 mL aliquot was placed into the sample flask and an experiment was started. The respirometer was allowed to take at least one reading after which a 5 mL of 1 N HCl acid solution was injected just before the system started to sample the chamber for it's CO_2 concentration. Carbon dioxide production for this interval should be 2678 μL of CO_2.

Before a storage experiment was run the respirometer's diagnostics program was run. The first diagnostic was for basic operations, which tested temperature probes, pressure, and flow characteristics. The second diagnostic was for valves and sensors,

which tested the system sample pump valves, sensor leakage, and gas sensor stability. Experiments were only conducted when all the diagnostics had passed.

Before a sample was tested for respiration, the respiration flask and respirometer were tested for air leaks greater than 2 mL/min as specified by the manufacturer (Columbus Instruments, Inc. 1996). If any leaks greater than 2 mL/min were discovered the test would not commence until the leak was found and fixed.

3.3 Grain quality assessment

3.3.1 Germination Germination of the canola was determined by placing 50 seeds on Whatman no. 3 filter paper placed in a petri dish with 5.5 mL of distilled water (Wallace and Sinha 1962). The plates were covered and incubated in a growth chamber at 25°C for 4 d after which the plates were uncovered and the plates were incubated for another 3 d. At this time the number of seeds germinated were counted and recorded.

3.3.2 Microfloral identification Mould identification and infection rates were determined at the beginning and conclusion of each experiment. For each sample 3 plates of 50 seeds were plated on Whatman no. 3 filter paper in a petri dish with 5.5 mL of 7.5% aqueous sodium chloride solution (Mills et al. 1978). The incubation regime is the same as that for germination. After 7 d the fungi growing on the seeds were identified.

3.3.3 Ergosterol assay Ergosterol levels were assayed at the beginning, approximately two thirds of the way through, and at the conclusion of the 30 to 35°C experiments using liquid chromatography (Abramson and Smith 2002). Ergosterol assays were not done on the 25 to 30°C temperature regime samples at this time due to equipment and time factors

but will be done at a future date. Both esterfied and free ergosterol were measured and the result was presented as total ergosterol. In the procedure, ground seed was refluxed in methanol, and the methanol extract was saponified with potassium hydroxide. After addition of water, the mixture was partitioned into *n*-hexane. The *n*-hexane extract was dried, reconstituted, and applied to a silica solid-phase extraction cartridge, which was then washed with carbon tetrachloride, and eluted with acetone. The acetone elute was acetylated, and the ergosterol determined as the acetate by liquid chromatography using reverse-phase column and absorbency detection at 282 nm.

3.3.4 Free fatty acid extraction Fat acidity values (FAV) were determined at the beginning, 1/3, 2/3 of the storage period, and completion of each storage experiment. Samples for extraction of free fatty acids were oven dried for 4 h at 130°C before the FAV were determined (Schroth 1996). Samples were ground in a rotary mill (Model M-2, F. Stein Labs Inc., Atchison, KS, USA) and 4.5 g were placed in a folded sheet of Whatman no. 5 filter paper and capped with a second sheet of folded filter paper. The sample was placed into an aluminium cylinder that was placed into a Goldfisch extractor (LabConco Corporation, Kansas City, Missouri, USA, 115V, 5.2 A, phase 1, cycle 50/60) and beakers containing 30 mL of petroleum ether were attached over the cylinders. The extractor operated for a period of 6 h after which the petroleum ether was evapourated from the extracted oil. To the oil, 25 mL of TAP solution (50% toluene, 50% ethanol (95%), and 0.04% phenolphthaline) was added and the solution was then titrated with 0.0197 N potassium hydroxide until the solution just turned pink. The FAV was then calculated as mg KOH to neutralise the free fatty acid in 100 g of dried grain.

3.4 Determination of heat production

For this experiment heat production could be determined while respiration was measured under an approximately constant temperature. The heat production of the canola can be calculated by taking the temperature rise in the insulated flask and using the equation (Zhang et al. 1992):

$$h = \Delta T(m_g c_p + C_f) \quad (8)$$

where:
- h = cumulative heat production (kJ)
- ΔT = cumulative temperature increase (°C)
- m_g = mass of grain in flask (kg)
- c_p = specific heat of grain ($kJ \cdot kg^{-1} \cdot °C^{-1}$)
- C_f = heat capacity of calorimeter (kJ/°C)

The specific heat of grain will vary with both moisture and temperature, so an empirical equation proposed by Muir et al. (1991) for the specific heat of canola above 10% m.c. was used where:

$$c_p = 1270 + 34M \quad (9)$$

where :
- c_p = specific heat [J/(kg•°C)]
- M = moisture content (% wet mass basis)

Heat capacity of the calorimeter, which included the flask and thermocouples, was determined by using electric resistance heaters and a constant power supply to heat 750 g of distilled water in the flasks. Temperature was constantly monitored and recorded by the data acquisition system every 0.5°C increase in temperature. Five flasks were measured and their heat capacities were averaged. The heat capacity may be calculated by balancing the heat equation:

$$Q = E \bullet I \bullet \theta = (m \bullet c_p \bullet \Delta T)_{water} + C_f \bullet \Delta T \quad (10)$$

where :
Q = total heat supplied (J)
E = electric potential (V)
I = current (A)
θ = time (s)
m = mass (kg)
ΔT = change in temperature (°C)

The average heat capacity of the five calorimeters was determined to be 310.3 J/°C with a standard deviation of 48 J/°C.

Accuracy of the heat production equation (8) is dependent on factors involved with measuring T, m, c_p, and C_f. The maximum error possible due to instrumentation was derived by Zhang et al. (1992) from Dally et al. (1984) and estimated as:

$$\varepsilon = \frac{dh}{h} = \sqrt{2\left(\frac{d\Delta T}{\Delta T}\right)^2 + \left(\frac{dm}{m}\right)^2 + \left(\frac{dC_f}{C_f}\right)^2 + \left(\frac{dc_p}{c_p}\right)^2} \quad (11)$$

where :
ε = overall error in heat production measurement

Based on results from Zhang et al. (1992) and Cofie-Agblor (1994) where similar equipment was used the expected overall error in heat production measurement is between 4% and 5.8%.

To test the operation of the system to provide an adiabatic environment the temperature flasks were filled with water between 25 and 30°C and the temperatures monitored for 5 d. After 5 d only one flask had lost 0.5°C in temperature and the rest had kept a constant temperature.

3.5 Assumptions

The following assumptions were made regarding this study:

(1) The prestorage life of the canola samples that were cleaned and dried from freshly harvested samples did not significantly affect the storage life during the experiments.

(2) The initial fungal contamination was typical of freshly harvested canola in other areas and years and that all samples started with similar species and levels of contamination.

(3) The cultivar of canola chosen is representative of most cultivars grown in Canada.

(4) Differences between flasks in the experiment were insignificant so that comparisons of quantities measured from one could be compared with those from another.

(5) The small masses of canola used in this experiment were valid representations of large masses of stored canola or that they can be an accurate depiction of a sample drawn from a large bulk.

4. RESULTS

4.1 Final condition of the sample, temperature, and respiration flasks

One of the inherent assumptions of this study is that the same processes would occur in all three flasks and between each replicate in this experiment. To compare quantities from one flask with another, or between replicates, the condition of each should be similar at all stages of the experiment. Canola for each experiment came from the same source so initial conditions were the same for all samples with only minor variations in moisture (Appendices B, D, E, and F).

Differences between the sample and temperature flasks were minimal for all experiments, but there were problems during the experiments with the respiration flask gaining or losing moisture. The respiration flasks for the 10% m.c. trials at 30 to 35°C all dried to an average of 8.0% (Table E6). As well, for box 4 (replicate 4) at 12% m.c. the samples stored between 25 to 30°C and 30 to 35°C in the respiration flask all dried (Tables E2 and 4). This may have occurred due to the wrong salts being stored in the bottles used to create the salt solution for the refresh flask. Differences in microflora, germination and FAV were also significant when compared with other flasks. As a result, the respiration data were not used for these replicates. In other experiments, the respiration flask would show a gain of up to 1% in moisture content. Canola from the respiration flask had lower values of germination than from the sample and temperature flasks, with higher levels of FAV and different frequency of microfloral species occurring. Even though respiration is dependent on moisture content all the data was used because changes in moisture occurred over a long period of time. Therefore, early

storage time data can be considered good and later storage time data would be viewed as having a larger error associated with it.

In the following sections only microflora, germination, and FAV data from the sample flask are used for analysis.

4.2 Microflora

Initial microflora counts showed that canola seeds were infected with high levels of pre-harvest fungi *Alternaria alternata* (Fr.) Keissler and *Cladosporium* (Tables 1 and 2) and low levels of storage fungi *Aspergillus glaucus* group, *Aspergillus candidus* Link, and *Penicillium* spp. There was a high initial infection with *A. candidus* for three samples which is odd because they all came from the same source. This can probably be attributed to natural variability of the canola sample being used. *Alternaria alternata* and *Cladosporium* are both common field fungi and do not damage the seed during storage whereas the presence of the other moulds is of a concern because they are storage moulds that will decompose the canola. Tables 1 and 2 show that as storage time increases the incidence of pre-harvest fungi decreases and storage fungi increase. Final microflora counts showed that canola at 10 and 12% m.c. had nearly 100% infection with *A. glaucus* group except for the freshly harvested 12% m.c. sample. High levels of *A. candidus* and *Penicillium* spp. were associated with 12 and 14% m.c. canola. This is consistent with the literature, which shows that *A. glaucus* group grows at a lower relative humidity than *A. candidus* and *Penicillium* spp. (Sauer et al. 1992).

One of the important signs of deterioration is the first visible sign of moulding. When averaging values for freshly harvested and stored samples, mould became visible within 6 d for 14% m.c., 9 d for 12% m.c., and 54 d for 10% m.c. all between 30 to 35°C

(Appendix B). These values increased to 7 d and 12 d for 14 and 12% m.c. samples respectively, when stored between 25 and 30°C.

Table 1. Microfloral infection for trials using freshly harvested canola

Moisture Content (%)	Temperature (°C)	Sampling Time	Microfloral Infection (% of seeds)				
			Cladosporium	*Alternaria alternata*	*Aspergillus glaucus* gr.	*Aspergillus candidus*	*Penicillium*
14	30 - 35	initial	36 (1.8)	74 (3.8)	2 (1.0)	2 (0.8)	2 (0.8)
		conclusion	0 (0)	0 (0)	34 (13.4)	94 (2.4)	70 (12.1)
12	30 - 35	initial	28 (3.8)	55 (5.3)	6 (1.4)	30 (2.7)	2 (0.6)
		conclusion	0 (0)	1 (0.3)	32 (3.6)	96 (2.1)	53 (11.7)
10	30 - 35	initial	20 (5.0)	55 (3.5)	5 (0.7)	18 (4.2)	5 (1.8)
		conclusion	0 (0)	0 (0)	98 (1.3)	28 (4.9)	1 (1.0)

( ) = standard error

Table 2. Microfloral infection for trials using canola that has been stored before testing

Moisture Content (%)	Temperature (°C)	Sampling Time	Microfloral Infection (% of seeds)				
			Cladosporium	*Alternaria alternata*	*Aspergillus glaucus* gr.	*Aspergillus candidus*	*Penicillium*
14	30 - 35	initial	14 (1.2)	53 (2.5)	7 (1.2)	20 (1.8)	6 (1.0)
		2/3	0 (0)	5 (1.3)	91 (2.3)	82 (3.0)	8 (2.2)
		conclusion	0 (0)	2 (0.5)	86 (2.4)	84 (4.1)	77 (6.2)
12	30 - 35	initial	27 (2.0)	56 (2.4)	2 (0.5)	4 (0.5)	4 (0.6)
		2/3	0 (0)	4 (0.9)	99 (0.5)	6 (0.5)	0 (0)
		conclusion	0 (0)	1 (0.4)	99 (0.8)	16 (3.5)	18 (4.7)
10	30 - 35	initial	14 (1.3)	45 (1.7)	6 (1.1)	3 (0.6)	5 (0.9)
		conclusion	0 (0)	2 (0.5)	100 (0.2)	5 (0.9)	2 (0.5)
14	25 - 30	initial	19 (1.2)	61 (2.1)	7 (2.1)	5 (0.7)	2 (0.5)
		2/3	0 (0)	5 (0.7)	95 (0.9)	69 (4.2)	2 (0.8)
		conclusion	0 (0)	4 (0.6)	46 (6.7)	97 (0.9)	23 (5.0)
12	25 - 30	initial	27 (1.4)	53 (2.2)	4 (0.8)	2 (0.6)	3 (0.7)
		2/3	0 (0)	10 (1.4)	90 (2.5)	46 (8.8)	42 (5.9)
		conclusion	0 (0)	1 (0.4)	95 (0.8)	63 (3.6)	22 (2.0)

( ) = standard error

4.3 Germination

4.3.1 Germination rate A plot of the germination data (Appendix B) showed that the data followed an asymmetric sigmoid pattern as described by Eq. 7 (Figs. 3 and 4). The data was fitted using a five-parameter logistic function using the nonlinear regression package in SigmaStat (V2.0, Jandel Corporation 1995). The asymptotic maximum was fixed at 98% to represent the average maximum germination of the samples in this experiment and the asymptotic minimum was set to zero to represent the lowest germination possible. The equation was solved separately for each temperature regime and moisture content and is given as:

$$Y = \frac{98}{\left[1+\left(\frac{\theta}{c}\right)^{b}\right]^{e}} \tag{12}$$

where:
Y = germination (%)
θ = storage time (d)
b,c,e = coefficients (Table 3)

Table 3. Coefficients for Eq. 12.

Temperature (°C)	Moisture Content (%)	Coefficients			R^2
		b	c	e	
25 - 30	14	3.47	73.43	7.00	0.96
	12	2.51	233.97	10.04	0.99
30 - 35	14	2.58	37.26	6.50	0.99
	12	3.71	26.01	0.36	0.99
	10	2.70	156.92	2.06	0.98

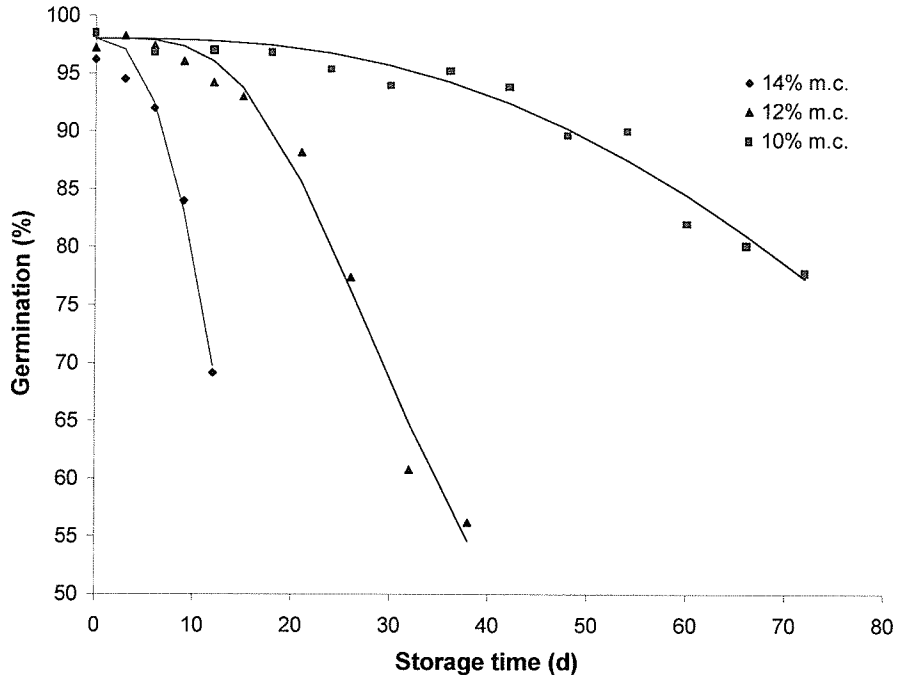


Fig. 3 Germination of canola stored at 10, 12, and 14% m.c. between 30 and 35°C. ‡

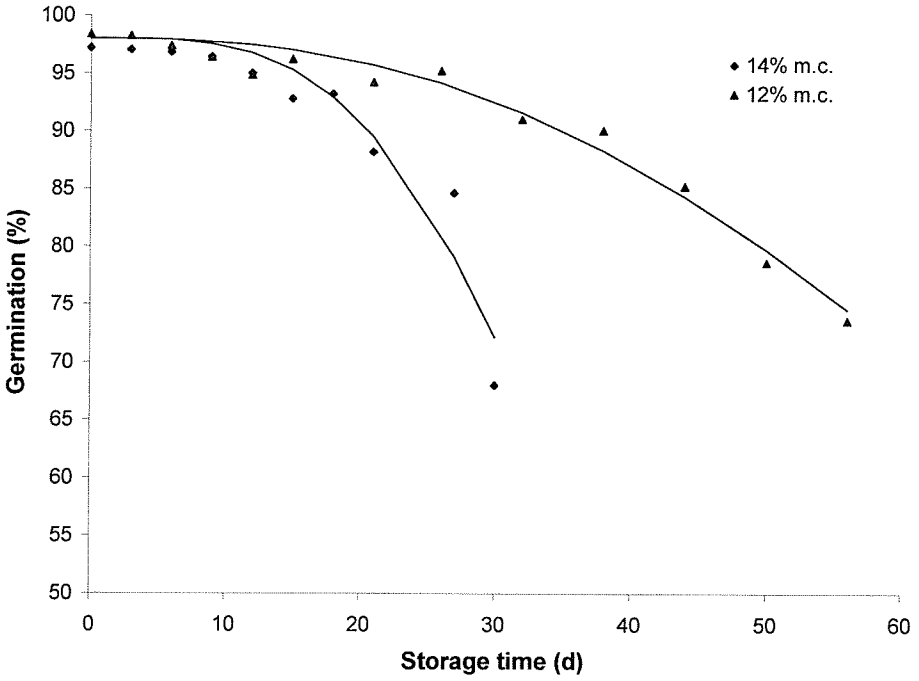


Fig. 4. Germination of canola stored at 12, and 14% m.c. between 25 and 30°C. ‡

‡points represent average experimental values
lines represent the fitted equations (Eq. 12)

The equations were plotted with the average germination data for all trials (Figs. 3 and 4). The high temperature regime (30 to 35°C) represents the average of eight observations and the lower temperature regime (25 to 30°C) represents the average of six observations.

4.3.2 Allowable storage time The time until a 5% drop in germination has been reached is often taken as the safe storage time (White et al. 1982b). For this experiment germination dropped to 95% in 3 d for 14% m.c., 10 d for 12% m.c., and 24 d for 10% m.c. between 30 and 35°C and in 12 d for 14% m.c. and 26 d for 12% m.c. between 25 and 30°C. Safe storage times on this basis are less than or equal to the number of days until the first appearance of mould for the high temperature regime and more than the number of days for the low temperature regime.

The allowable storage time until a drop in germination to 95% was calculated using average temperatures of 32.5 and 27.5°C for the high and low temperature regimes respectively and following the form of allowable storage time Eqs. 5 and 6 from White et al. (1982b). A multiple linear regression was conducted in SigmaStat and the resulting equation was:

$$\log_{10} \theta = 6.83 - 0.214M - 0.102T \quad (13)$$

where:
θ = estimated storage time (days) until a 5% drop in germination
M = moisture content of seeds (% wet mass basis)
T = temperature (°C)

Moisture and time were both significant ($P < 0.05$) in predicting storage time and the coefficient of determination (R^2) was 0.985.

4.4 Respiration

4.4.1 Respiration readings Respiration trials were conducted for a period of 3 h, with gas samples taken by the respirometer every 20 min. Carbon dioxide production decreased during each respiration trial (Table 4) so CO_2 production rates for each trial were determined by averaging the last four readings, which were approximately constant. Carbon dioxide concentration and accumulation were not used in analysing the experiment.

Table 4. Sample output from the data acquisition system for one respiration trial.

Reading	Date	Time	CO_2 Concentration (%)	Production ((mg/min)/kg material)	Accumulation (mg/kg material)
1	31-Aug	12:50:06	0.150	0.16073	5.5504
2	31-Aug	13:10:06	0.096	0.32435	12.0374
3	31-Aug	13:30:06	0.129	0.22334	16.5042
4	31-Aug	13:50:06	0.149	0.18397	20.1836
5	31-Aug	14:10:06	0.164	0.16843	23.5521
6	31-Aug	14:30:06	0.175	0.16108	26.7738
7	31-Aug	14:50:06	0.183	0.15658	29.9054
8	31-Aug	15:10:06	0.190	0.15390	32.9833

4.4.2 Sweating process Carbon dioxide data (Fig. 5) for freshly harvested and stored canola between 30 and 35°C was compared to determine if there is a post-harvest maturation process of canola known as the "sweating process". Data for each day and moisture was compared using SigmaStat and an unpaired *t*-test using the null hypothesis that the means of the populations are the same (i.e. there is no sweating process). In some cases the data failed the tests for normality and constant variance so a Mann-Whitney Rank Sum test was used instead because assumptions of normality and constant variance are not necessary for the *t*-test. Tests showed that there was no significant

difference ($P > 0.05$) for 12 and 14% m.c. except for 12% m.c. and day 0. In this case the respiration was lower for the freshly harvested sample, which should be higher if the sweating process existed. The 10% m.c. samples showed no significant difference for the first 12 d at which time the freshly harvested samples had a significantly higher CO_2 production than the stored samples. However, a moisture check of the respiration flask for the stored sample showed that the sample dried out over the course of the experiment (Table E6).

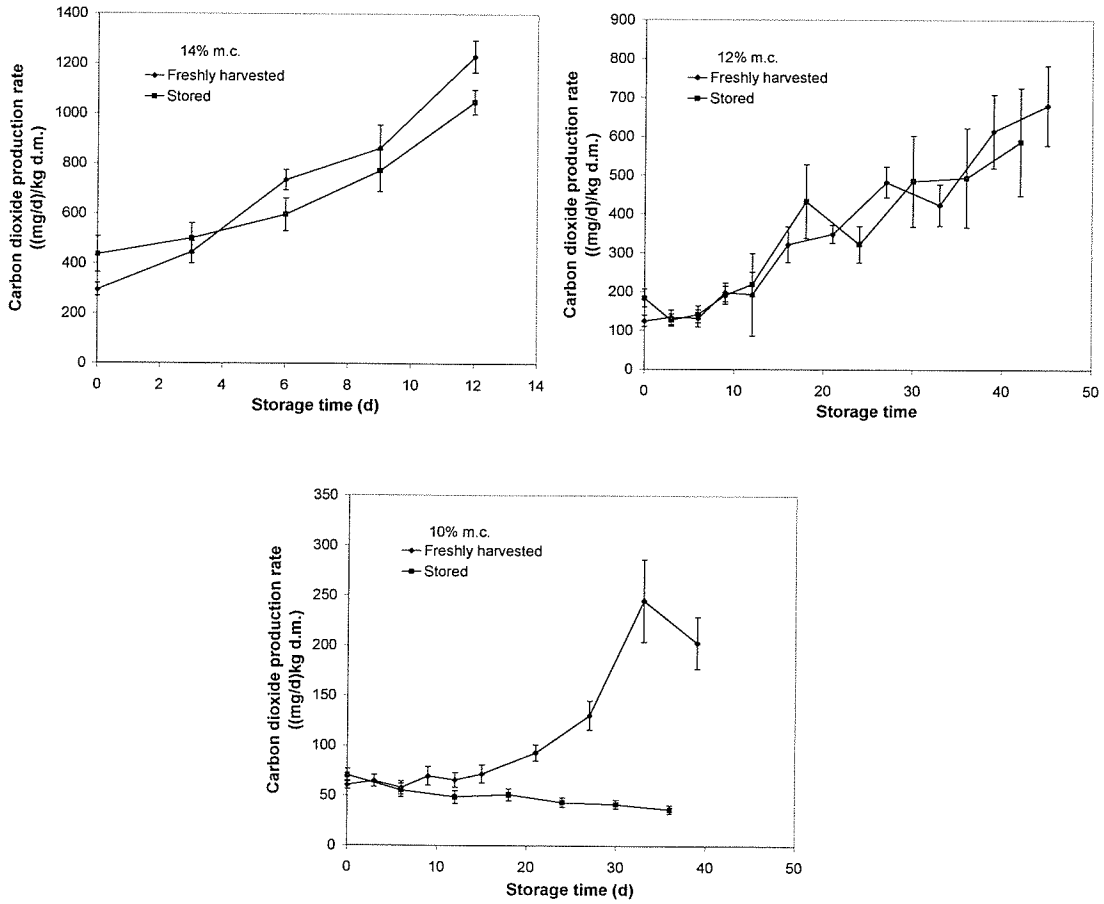


Fig. 5. Carbon dioxide production rates for freshly harvested and stored canola of 10, 12, and 14% m.c. at temperatures between 30 and 35°C.

4.4.3 Carbon dioxide production Respiration data (Appendix A) from the freshly harvested and stored trials were combined because there was found to be no significant difference between the two treatments and standardised to (mg/d)/kg dry matter (d.m.) for analysis. The exception was the 10% m.c. trials, where only the freshly harvested respiration data were used because the respiration flasks in the stored trials dried out. Results show that CO_2 production increases with storage time, moisture content, and temperature (Figs. 6 and 7). A backward stepwise regression conducted on the CO_2 production data using storage time, moisture content, and temperature as independent variables found all to be significant ($P < 0.001$). The following equation was developed using SigmaStat to predict CO_2 production ($R^2 = 0.765$):

$$RCO_2 = 10^{\left(-1.521 + 0.0462(T) + 0.0159(\theta) - 0.0000699(\theta)^2 + 0.187(M)\right)} \quad (14)$$

where:

RCO_2 = predicted rate of CO_2 production per unit dry mass of seed ((mg/d)/kg d.m.)

T = temperature (°C)

θ = time in storage (d)

M = moisture content of seed (%)

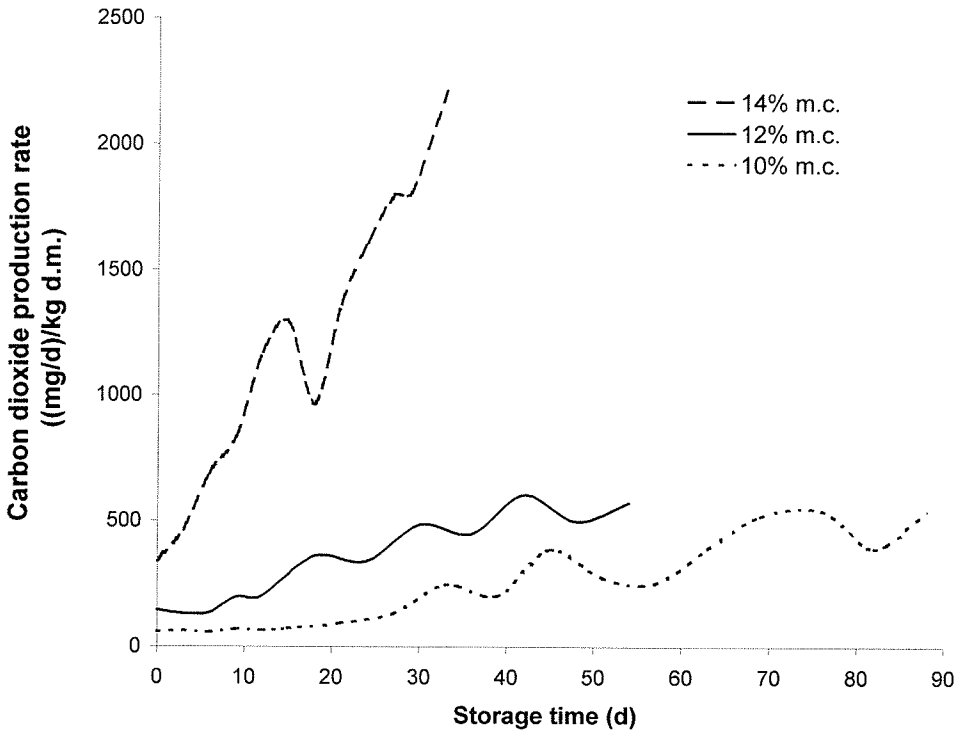


Fig. 6. Average CO_2 production rates for 10, 12, and 14% m.c. canola stored between 30 and 35°C.

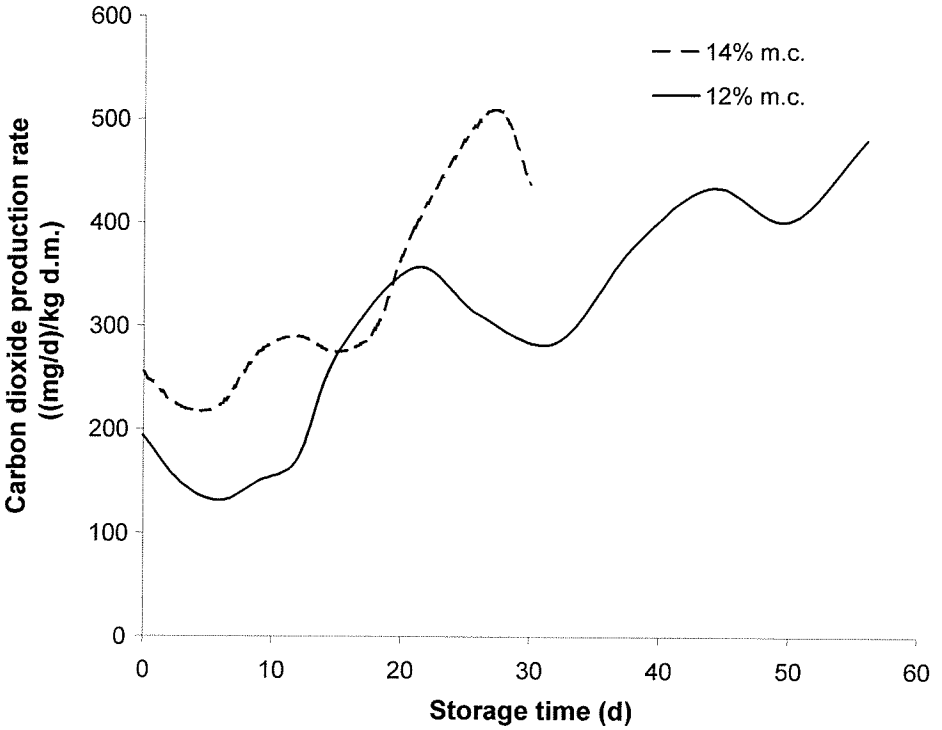


Fig. 7. Average CO_2 production rates for 12 and 14% m.c. canola stored between 25 and 30°C.

It would be beneficial to ascertain grain quality without having to wait the week it takes to plate and incubate seeds to determine germination. Calculating germination from instantaneous CO_2 production without knowledge of the storage life would be a benefit to managers of grain-handling facilities who may not know the storage history of the grain coming in. As well, farmers would benefit from the quick determination of quality to be able to make immediate management decisions to remedy any unfavourable storage conditions. An equation to predict germination using measured CO_2 production was derived using SigmaStat as:

$$Y = 100 - 0.0512(MRCO_2) + 2.489(M) - 2.118(T) + 0.0435(T)^2 \quad (15)$$

where:
$MRCO_2$ = measured rate of CO_2 production per unit dry mass of seed ((mg/d)/kg d.m.)

The coefficient of determination (R^2) for this equation is 0.678.

4.5 Heat production

4.5.1 Directly measured heat production Cumulative temperature increases in the temperature flask were measured over the course of the experiment in order to calculate the heat production of the canola and associated microflora (Appendix G). Only data for the freshly harvested 10% m.c. samples have been used as the other 10% m.c. trials did not maintain adiabatic conditions and the temperature flasks lost heat. As well, box 4 (replicate 4) lost heat from the temperature flask except for 14% m.c. samples stored in the high temperature regime so it was not used to calculate heat production. Plots of directly measured heat production for each replicate either calculated by Eq. 8 or shown by a trendline for directly measured points are represented in Figs. 8 and 9.

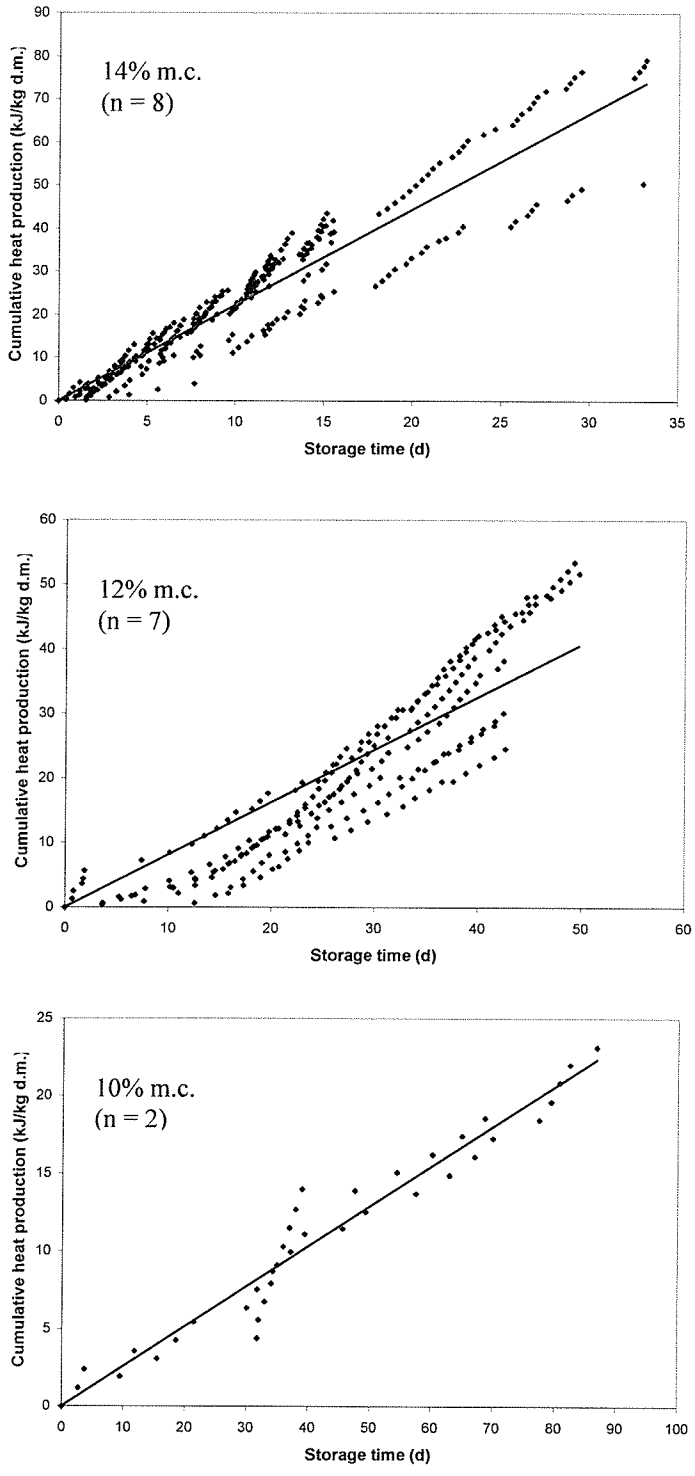


Fig. 8. Directly measured cumulative heat production for 10, 12, and 14% m.c. canola stored between 30 and 35°C, ♦ data point, ▬ trendline.

Even though overall error was estimated to be between 4 and 5.8% the data was scattered and at times had a large variation. Similar results were also seen by Zhang et al. (1992) with directly measured heat production of high moisture wheat.

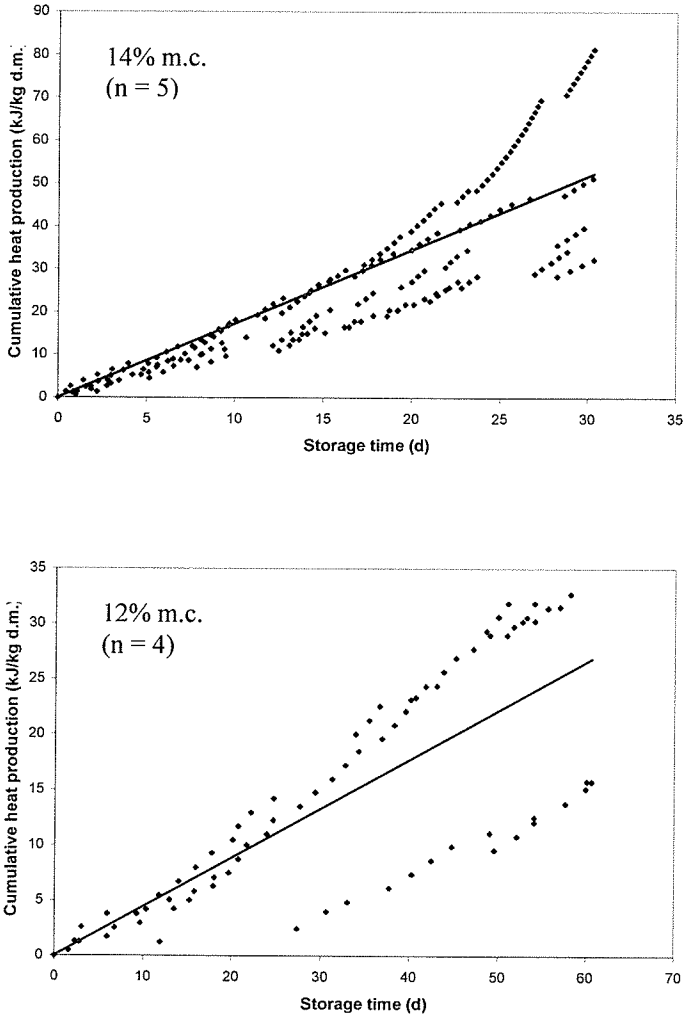


Fig. 9. Directly measured cumulative heat production for 12 and 14% m.c. canola stored between 25 and 30°C, ♦ data point, ▬ trendline.

Cumulative heat production may be estimated by a series of linear equations with intercept of zero and the form:

$$h = a(\theta) \tag{16}$$

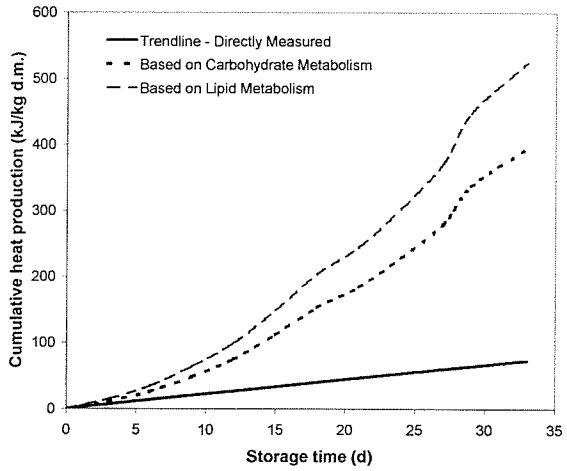
where:
h = cumulative heat production (kJ/kg d.m.)
a = coefficient, Table 5

Table 5. Coefficients for Eq. 16.

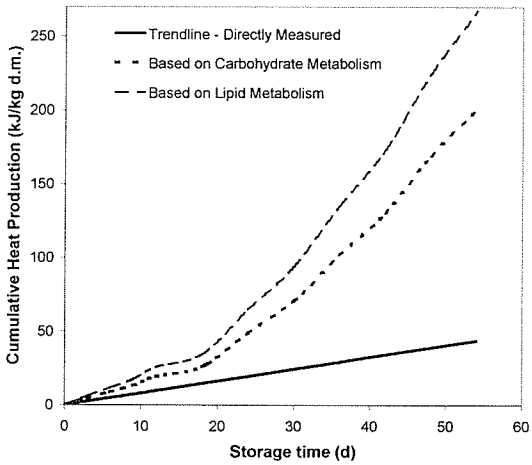
Temperature (°C)	Moisture Content (%)	Coefficients a	R^2
30 - 35	14	2.22	0.887
	12	0.81	0.777
	10	0.26	0.952
25 - 30	14	1.73	0.743
	12	0.44	0.602

4.5.2 Heat production measured from CO_2 production Heat production can be determined by measuring the temperature increase of a sample over time, or by measuring CO_2 production and applying Eqs. 1 and 2. If carbohydrate metabolism is assumed then 10.7 kJ of heat would be released for every gram of CO_2 produced. Released heat rises to 14.2 kJ for every gram of CO_2 produced for lipid metabolism. Cumulative heat production calculated from CO_2 production for carbohydrate and lipid metabolism is higher than directly measured cumulative heat production (Figs. 10 and 11).

a) 14% m.c.



b) 12% m.c.



c) 10% m.c.

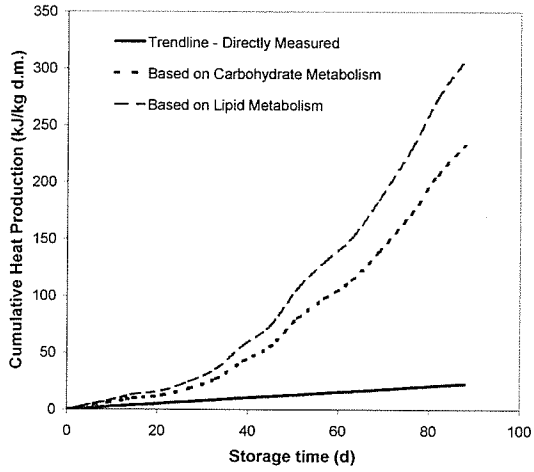


Fig. 10. Cumulative heat production from direct measurement and calculated with CO_2 production data for carbohydrate and lipid metabolism of 10, 12, and 14% m.c. canola stored between 30 and 35°C.

a) 14% m.c. b) 12% m.c.

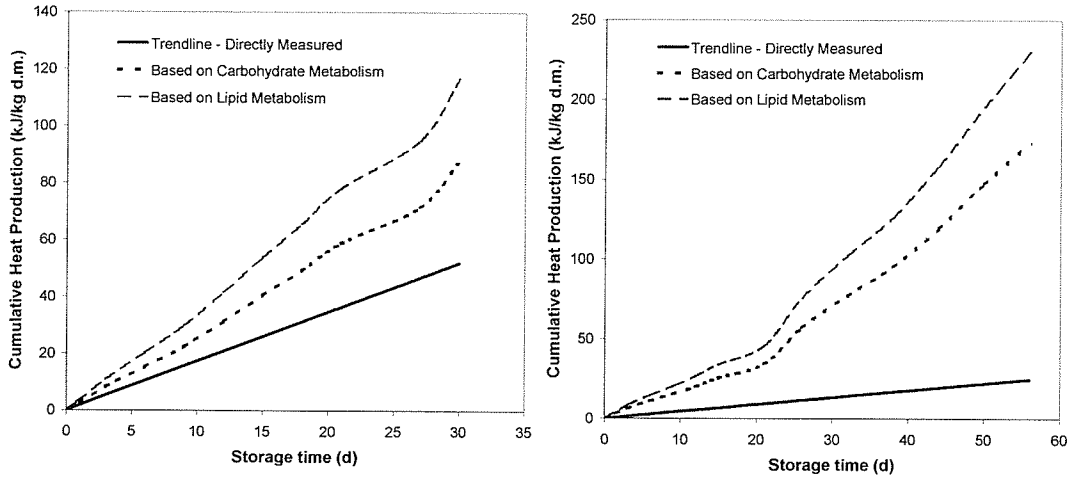


Fig. 11. Cumulative heat production from direct measurement and calculated with CO_2 production data for carbohydrate and lipid metabolism of 12 and 14% m.c. canola stored between 25 and 30°C.

4.6 Ergosterol

Ergosterol was only analysed for the 12 and 14% m.c. canola stored between 30 and 35°C due to time and equipment limitations (data Appendix C). Replicate 4 was not assayed due to the respiration flask drying out for the sample. In the future, samples of 12 and 14% m.c. stored between 25 and 30°C will be assayed. Average total ergosterol increased with time for both moisture contents (Fig. 12). Levels at the beginning, 60% storage time, and the conclusion were similar for both moistures, although ergosterol levels in the 14% m.c. canola rose more rapidly than the 12% m.c. samples. A two-way analysis of variance showed that moisture, time, and their interaction ($P < 0.05$) significantly affected ergosterol levels.

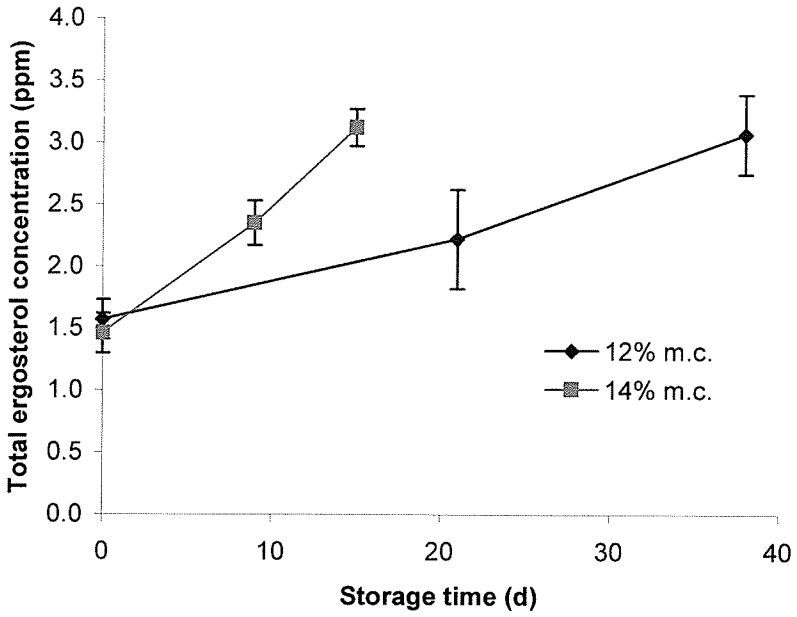


Fig. 12. Total ergosterol concentration in 12 and 14% m.c. canola samples stored between 30 and 35°C.

4.7 Fat acidity values

Free fatty acids formed by enzymatic activity of fungi consuming the seed represent a loss in oil quality of canola. For the experiment, the FAV of the samples increased with storage time, moisture, and temperature (Figs. 13 and 14, Appendix F). All samples started with levels below 20 mg KOH/100 g seed and increased rapidly at high moistures and temperatures. At lower temperatures there was not much difference between the samples of 12 and 14% m.c. that is probably the result of reduced fungal activity on the seeds.

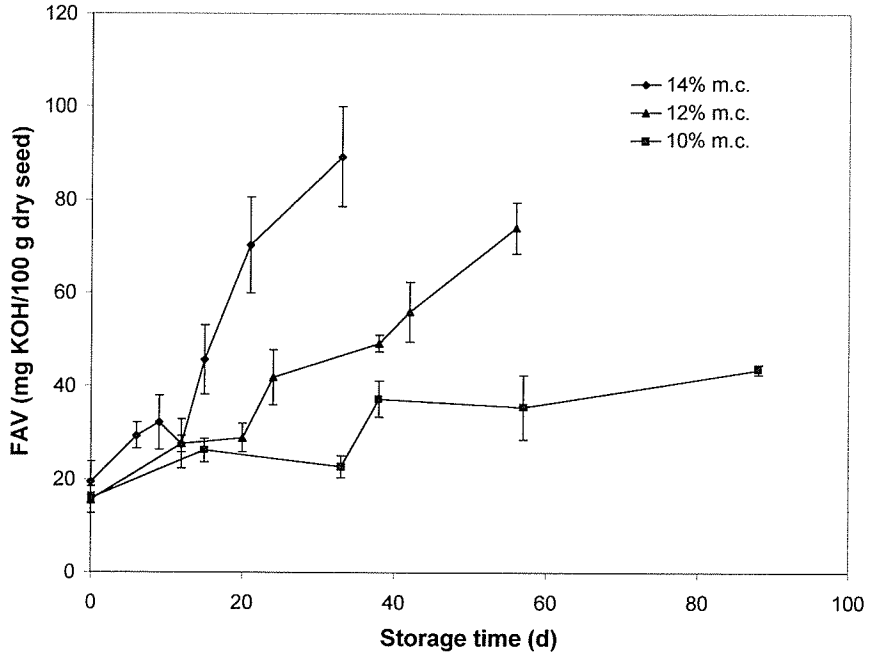


Fig. 13. Fat acidity values (FAV) of canola of 10, 12, and 14% m.c. stored between 30 and 35°C.

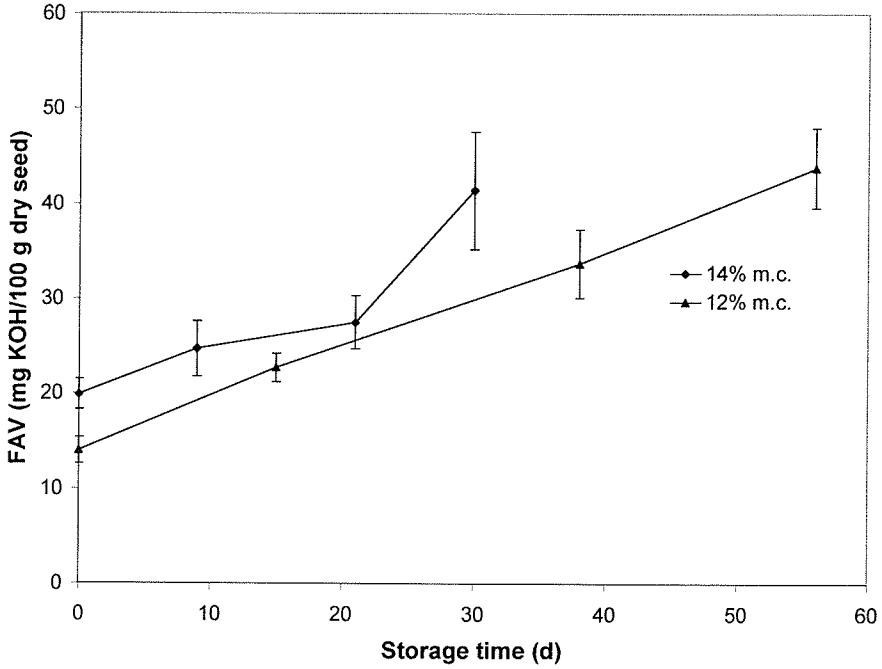


Fig. 14. Fat acidity values (FAV) of canola of 12 and 14% m.c. stored between 25 and 30°C.

5 DISCUSSION

5.1 Microflora

The predominant species of microflora, *Alternaria alternata* (Fr.) Keissler, *Cladosporium, Aspergillus glaucus* group, and *Penicillium* spp., in this experiment (Tables 1 and 2) were common to many studies of stored canola (Mills 1980, Mills and Sinha 1980,White et al. 1982b). High levels of *Aspergillus candidus* Link, the absence of *Wallembia sebi* (Fr.), and insignificant levels of *Aspergillus versicolor* (Vuill.) were in common with Burrell et al. (1980) but were seen in other studies (Mills 1980, Mills and Sinha 1980,White et al. 1982b). The literature suggests that *W. sebi* is specialised and not of practical significance in stored grain ecosystems (Sauer et al. 1992). The incidence of *A. glaucus* group decreased with increasing moisture while *A. candidus* and *Penicillium* spp. increased with increasing moisture and temperature. This is consistent with the literature, which shows that *A. glaucus* group grows at a lower relative humidity than *A. candidus* and *Penicillium* spp. (Sauer et al. 1992).

The first visible sign of mould can be an important tool for farmers to determine deterioration in a grain bulk because it is an instantaneous observation unlike germination testing that may take a week. Burrell et al. (1980) found that at temperatures below 25°C visible mould and seed clumping preceded a drop in germination. They also found that spoilage was more rapid at higher temperatures and moistures. However, for the samples tested in this experiment the first appearance of mould did not always precede a drop in germination (Table 6). It can be concluded that the first visible sign of mould is a good indicator of spoilage at temperatures below 30°C. At temperatures greater than 30°C,

spoilage occurs very rapidly and germination will be affected before visible mould is present (Table 6).

Table 6. Number of days until the first visible sign of mould or a 5% drop in germination

Moisture	Temperature	Spoilage symptom development period (d)	
		First Visible Signs of Mould	Drop of 5% in Germination
14%	30 - 35°C	6	3
12%	30 - 35°C	9	10
10%	30 - 35°C	54	24
14%	25 - 30°C	7	12
12%	25 - 30°C	12	26

5.2 Germination

5.2.1 Germination rate Even though respiration trials for each box were run until the germination in each sample flask reached 85%, the final germination values were often lower (Figs. 3 and 4). This is due to the length of time it takes to determine germination after a sample has been taken. Germination counts for trials were sometimes not determined until several more respiration trials had been conducted, and more germination samples taken. For all trials, germination dropped well below 85% before the experiment was stopped. This shows the limitations of using germination tests for determining the deterioration of canola if one wants to prevent storage losses because the state of the canola is only shown 1 wk after the germination samples are taken.

The germination rate of canola can be successfully modelled using an asymmetric sigmoid equation. Equations developed by Schroth 1996 and Karunakaren et al. 2001 yielded coefficients of determination of nearly 1 signifying their accurate predicting power. An equation such as Eq. 12 is an extremely powerful tool in the hands of a farmer or manager of a grain storage facility. With it they are able to make informed decisions

about storage management practices like aeration and drying if it is known that adverse germination losses will occur before the crop is utilised. However, for managers of grain storage facilities at primary and terminal elevators, the preceeding storage times and conditions of the crop are often not known.

If the time and conditions of storing a crop are unknown, then Eq. 12 is of no use for predicting germination. The only current option is to plate the seeds and incubate them for 7 d to determine germination. In an elevator this is unacceptable because of the high turnover rate and need to store the grain immediately, so poor quality grain may be mixed with sound grain. Research has shown that CO_2 is a strong indicator of spoilage and its measurement can be accomplished quickly (Muir et al. 1980, White et al. 1982b, Muir et al. 1985, Karunakaren et al. 2001). If CO_2 production data is used with Eq. 15, a quick method for determining germination is possible. Results are comparable with those obtained from Eq. 12 for germination predicted from storage time for each subset of moisture and temperature (Fig. 15). The benefit of Eq. 15 is that a single equation is used to predict germination for moisture contents between 10 and 14% and temperatures of 25 to 35°C instead of five different equations. While the coefficient of determination is lower, prediction is still reasonable, especially for high levels of germination. The exception is for 14% m.c. canola in the high temperature regime. This is not of a great concern because it is obvious that canola stored at such a condition is at a very high risk of spoiling. Good prediction at low levels of germination (<90%) is not a priority because canola at this level of spoilage is of low economic value anyway.

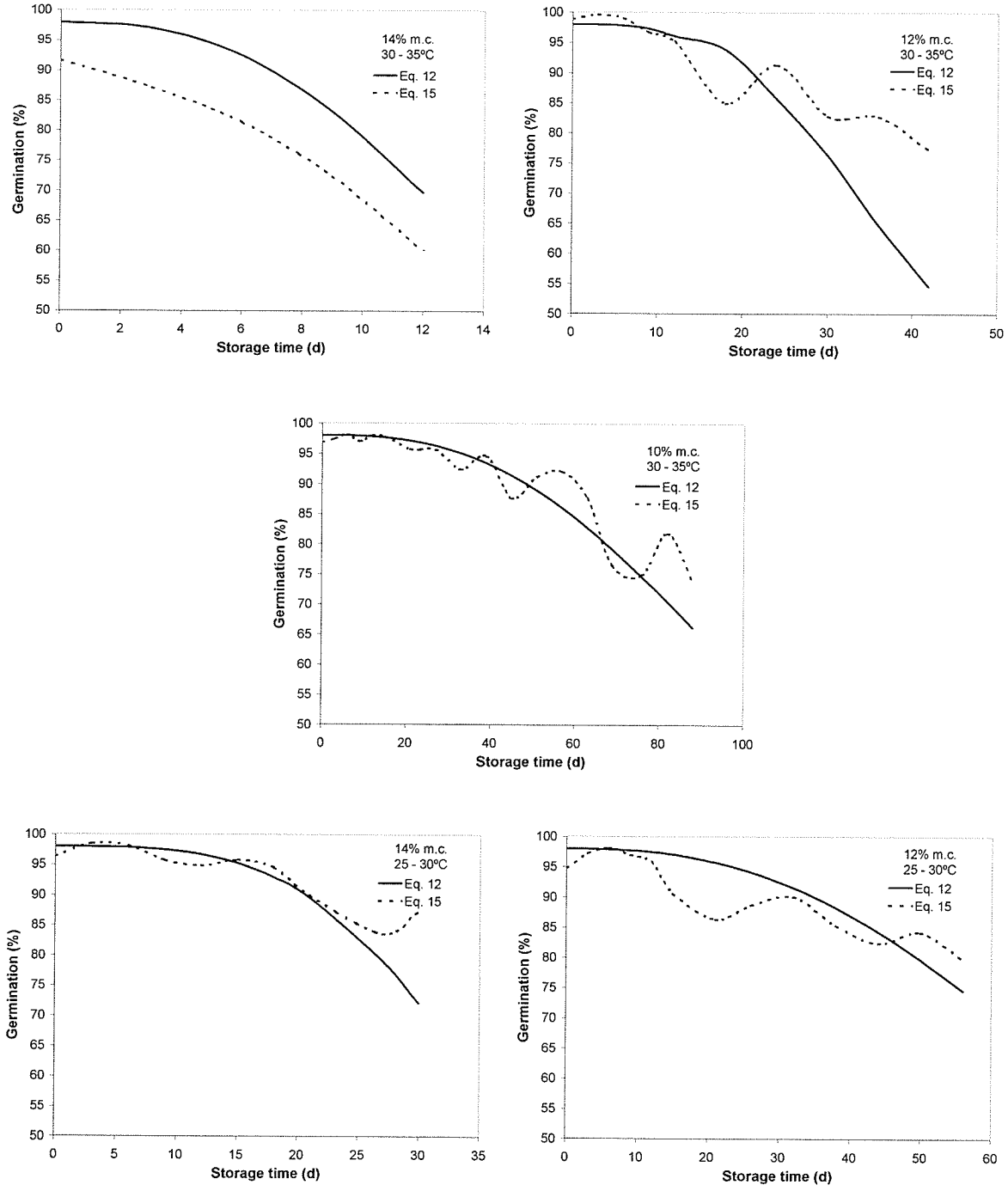


Fig. 15. Germination curves predicted from storage time (Eq. 12) and from CO_2 production (Eq. 15).

5.2.2 Allowable storage time The time until a 5% drop in germination has been reached is often taken as the safe storage time (White et al. 1982b). Using average temperatures of 27.5 and 32.5°C for the low and high temperature regimes, storage equations from White et al. (1982b) (Eqs. 6 and 7) predicated a 5% germination drop in 2 d for 14% m.c., 6 d for 12% m.c. and 9 d for 10% m.c. canola at 32.5°C and 5 d for 14% m.c. and 12 d for 12% m.c. canola at 27.5°C. For this experiment germination dropped to 95% in 3 d for 14% m.c., 10 d for 12% m.c., and 24 d for 10% m.c. between 30 and 35°C and in 12 d for 14% m.c. and 26 d for 12% m.c. between 25 and 30°C. Equations 5 and 6 are conservative for predicting storage life when compared to data from this experiment. However, differences may be related to different species and initial levels of microfloral infection. The experiments by White et al. (1982b) at the same temperatures and moisture contents showed nearly 100% infection with *A. glaucus* group, as did this experiment. However, their experiment only showed high activity of *W. sebi* with no activity by *A. candidus* and *Penicillium* spp, which were common in this study. The only species in common was *A. glaucus* group, which has been shown to be less destructive and respire less than other species (Sauer et al. 1992).

5.3 Respiration

5.3.1 Sweating process Literature and research on canola storage has suggested that canola undergoes a post-harvest maturation process known as the sweating process (Section 2.1.2). Respiration data from freshly-harvested canola and from canola that had been dried, cooled, and then stored for more than 6 months before testing were not statistically different ($P > 0.005$). Therefore, any increase in respiration and heat

production of stored canola is only a function of moisture content, temperature, and fungal infection of that bulk. Bins with a low average moisture content and temperature that display symptoms of the sweating process probably have localised regions in the bulk where the canola is wetter or hotter than the surrounding canola. Canola of high moisture may be collected from wet spots, immature areas of the field, weed seeds, dockage, or combining early in the morning or evening when dew is forming on the kernels. These conditions may result in a load of moist canola being stored in the bin. It would be this wet canola that would actively respire and could be confused with a sweating process occurring in the bin.

5.3.2 Carbon dioxide production Plots of CO_2 production show a small lag time before CO_2 production starts to increase except for 14% m.c. samples in the high temperature regime (Figs. 6 and 7). The same phenomenon was seen by Lacey et al. (1994) in studies of wheat, rapeseed, and linseed. The end of these lag times corresponds very closely with the time until a drop to 95% germination. This is not surprising as beyond this point deterioration begins to occur more rapidly and respiration should increase as moulds consume the seed coat, affecting germination. Carbon dioxide production rates at the time until a drop to 95% germination are 500 (mg/d)/kg d.m. for 14% m.c., 192 (mg/d)/kg d.m. for 12% m.c., and 185 (mg/d)/kg d.m. for 10% m.c. canola between 30 and 35°C and 290 (mg/d)/kg d.m. for 14% m.c. and 172 (mg/d)/kg d.m. for 12% m.c. canola between 25 and 30°C. These CO_2 production rates may be taken as the maximum safe rates for sound canola under the conditions described above.

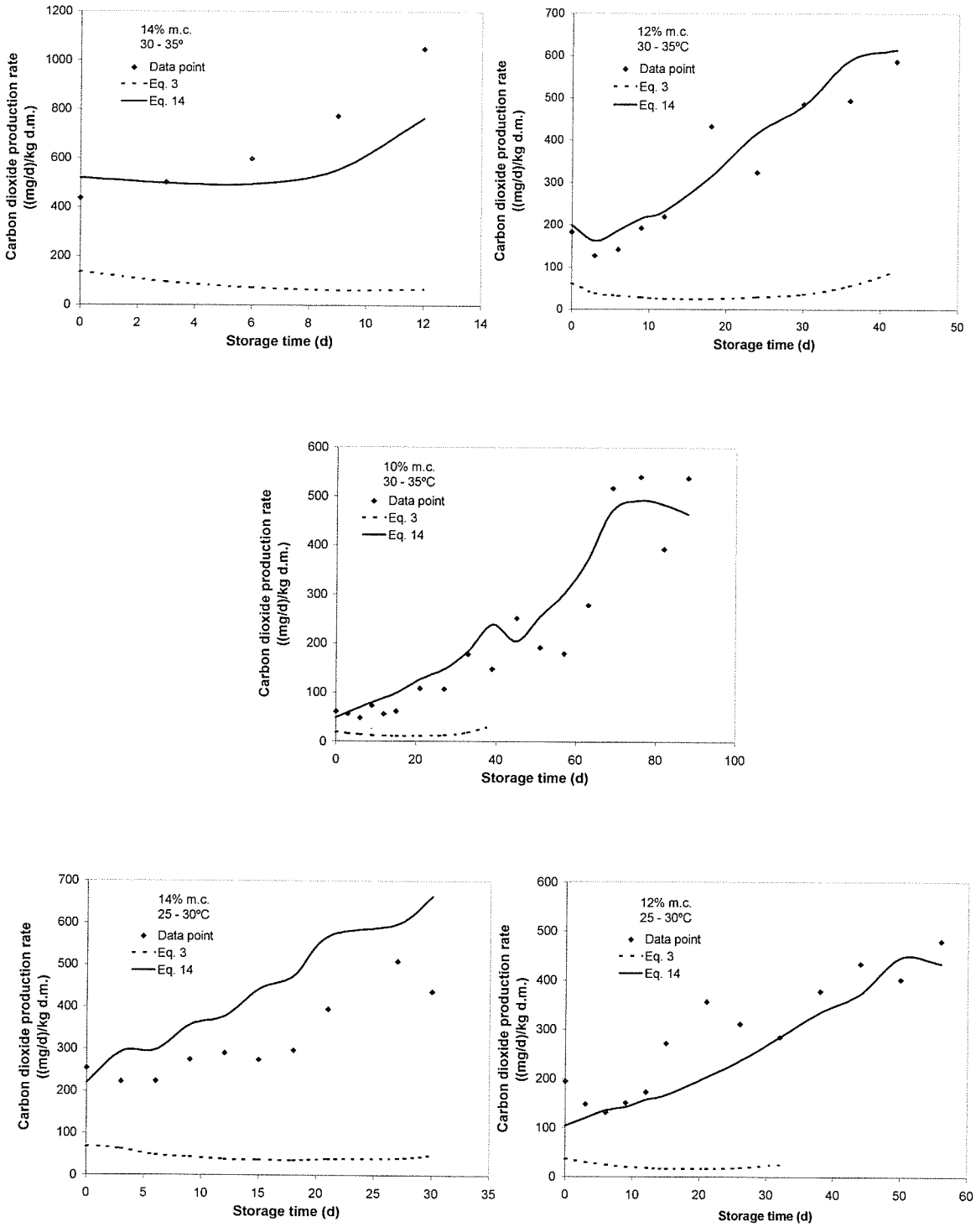


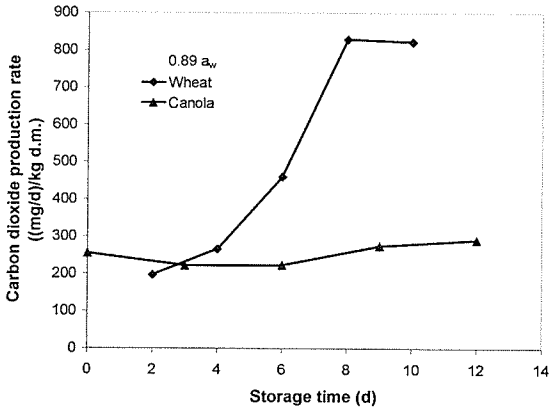
Fig. 16. Carbon dioxide production rates; observed values and prediction curves from Eq. 3 and Eq. 14‡.

‡Maximum time allowed for Eq. 3 was 35 d.

Values for CO_2 production from this experiment are much higher than the predicted values from Eq. 3 developed by White et al. (1982b) (Fig.16). Cofie-Agblor et al. (1997) stated that there were periods of depressed CO_2 production in the experiments conducted by White et al. (1982) due to excess CO_2 accumulation in the samples. Predicted values from Eq. 14 tend to be lower than observed values for 14% m.c. between 30 and 35°C and higher between 25 and 30°C. However, CO_2 production data from these experiments are probably more realistic than those determined by White et al. (1982b) because low concentrations of CO_2 were maintained at all times (Section 3.2.3).

5.3.3 Comparison of wheat and canola Carbon dioxide production collected by Karunakaran et al. (2001) for wheat was compared with data collected in this study. Data for wheat at 18 and 19% m.c. were selected because they had water activities (a_w of 0.84 and 0.89 respectively) that were similar to canola at 12 and 14% m.c. as calculated with the Modified Henderson equation (ASAE 1997). Even though both grains started with low levels of *A. glaucus* group, *A. candidus*, and *Penicillium* spp. CO_2 production of wheat was more than that of canola (Fig. 17). This occurred even though the wheat was stored at a constant 25°C and the canola was maintained between 25 and 30°C. However, the germination of the wheat dropped below 35% for both a_w whereas the canola only fell to 95%. Studies by Lacey et al. (1994) also found that respiration of oilseeds was less than that of cereal grains but no mention of levels of germination were made. It would be expected that respiration of canola, with its greater surface area to volume ratio allowing for rapid gas exchange with the atmosphere would be greater than wheat. But it was not, possibly due to the inability of moulds to thrive on lipids (Wallace 1973) or that

respiration is proportional to kernel size with canola seeds being smaller than wheat seeds (Lacey et al. 1994).



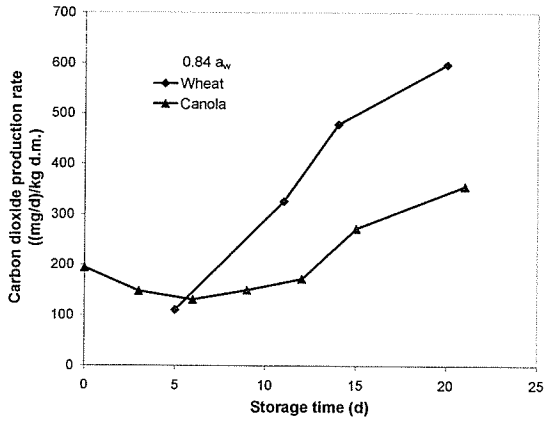


Fig. 17. Carbon dioxide production rates of wheat‡ and canola of water activites (a_w) of 0.89 and 0.84 between 25 and 30°C.
‡Data from Karunakaran et al. (2001) at constant 25°C temperature

5.4 Heat production

5.4.1 Directly measured heat production In all cases the directly measured cumulative heat production data followed an increasing linear trend with time (Figs. 8 and 9). Low coefficients of determination (Table 5) were caused by a large spread in the data. For 12% m.c. canola in the low temperature regime there were a few replicates that produced a lot of heat and some that produced very little. More replicates would improve the prediction equation (Eq.16).

The linear trend found in this experiment was also observed by Zhang et al. (1992) with high moisture wheat. However, their slope (rate of heat production) decreased part way through the experiment. In their system the temperature was allowed to rise unstopped until the completion of the experiment. When the system's temperature exceeded the most favourable conditions for the microorganisms present, some species may have been killed or had a reduced respiration and heat production. In this study the temperature was only allowed to vary in a small range so the adverse conditions experienced in Zhang et al. (1992) experiment would not be seen here and there would not be a change in the heat production rate. The limitation of this experiment is that as heat is produced in a system, the temperature of the system will increase. If the temperature increases beyond the parameters of this experiment, then heat production can no longer be predicted.

Directly measured heat production of canola was less than that of wheat although the wheat had a higher water activity than the canola samples in this experiment. Although as stated above, canola respires less than wheat so it would be expected that heat production would also be lower.

5.4.2 Comparison of measured and calculated heat production In this study heat production was determined by measuring the cumulative temperature increases over time and by using CO_2 production data and Eqs. 1 and 2. In all cases, heat production calculated assuming only carbohydrate or only lipid metabolism was more than the directly measured heat production of the system (Figs. 10 and 11). This was opposite the trend seen by Zhang et al. (1992), where directly measured heat production was more than calculated heat production. Directly measured and calculated heat productions are close initially but begin to deviate with time. Any errors encountered would be cumulative throughout the experiment because cumulative heat production is being measured. This would explain the large errors at the later times.

Trials for 10% m.c. canola between 30 and 35°C slowly lost heat and a few replicates for 12% m.c. trials between 25 and 30°C also lost heat. Even though a test for the effectiveness of the adiabatic environment showed no temperature loss (Section 3.4), it may be possible that the temperature flask did lose heat to the environment.

In this study a combination of carbohydrate and lipid metabolism is probably taking place, so the cumulative heat production should be a combination of the heat released from Eqs. 1 and 2. White et al. (1982b) found that respiratory quotients of 0.7 to 0.8 were common at moisture contents below 11.3% in canola, which suggests lipid metabolism could be taking place. If the actual proportions of lipid or carbohydrate metabolism were known, an accurate calculation of heat production from CO_2 production data could be conducted.

5.5 Ergosterol

The two moisture contents, 12 and 14%, had similar levels of ergosterol at the beginning, 60% storage time elapsed, and the conclusion of experimentation, although levels in the 14% m.c. canola rose more rapidly than the 12% m.c. samples. A two-way analysis of variance showed that moisture, time, and their interaction ($P < 0.05$) affected ergosterol levels. When germination is examined (Fig. 4) it can be seen that initial, 60%, and final germination levels are 97, 84, and 64% for 12% m.c. and 96, 88, and 56% for 14% m.c. canola. The relationship seems strong but when a backwards stepwise regression is conducted with germination as the dependent variable and moisture, time, ergosterol, and respiration as independent variables, results showed that only time and moisture significantly added to the ability to predict germination ($P<0.05$). The ability of ergosterol to predict germination might be limited because it measures cumulative fungal infection and cannot differentiate between species. Preharvest fungi, that add to the ergosterol content but do not affect germination, populate the seeds during the early part of storage and are later replaced by storage fungi that decompose and kill the seed. Hence, high levels of ergosterol may be due to benign preharvest fungi like *Alternaria* or harmful fungi like *Penicillium* spp. Initial levels of ergosterol of 1.57 and 1.46 ppm for 12 and 14% m.c. canola respectively, may be taken as ergosterol levels in sound canola as these are the levels found in canola with low levels of storage fungi. At levels greater than 2 ppm germination has dropped significantly and spoilage has occurred.

Quick deterioration and rapid accumulation of ergosterol for 14% m.c. canola may be occurring due to the high levels of fungi other than *A. glaucus* group, which has been shown to be less aggressive and destructive in other studies (Sauer et al. 1992).

Also, Seitz et al. (1979) found that *A. glaucus* group produced less ergosterol than other fungi so this explains similar ergosterol levels over different storage periods. It would take longer for *A. glaucus* growing on 12% m.c. canola to accumulate ergosterol and deteriorate the seed.

When compared to ergosterol levels, CO_2 production had an increasing trend at a constant moisture content. As more fungi, which influences ergosterol concentration, are produced then it can be expected that CO_2 production would also increase because the contribution to respiration of the seeds is negligible. A Spearman rank order correlation was conducted on the raw ergosterol and CO_2 production data. Results gave a Spearman correlation coefficient of 0.65 ($P < 0.05$) suggesting a weak correlation between ergosterol and CO_2 production. However, respiration rate is also dependent on temperature and fungal species present (Sauer et al. 1992). As fungi grow in warmer conditions they will respire at a greater rate even if there is not an increase in fungal biomass.

5.6 Fat acidity value

In this experiment, unspoiled canola had low values of FAV below 20 mg KOH/100g of seed. When seed had spoiled and germination dropped below 90%, FAV had risen to above 30 mg KOH/100g seed. These same results were seen in studies by Mills and Kim (1977) and Mills and Sinha (1980). The trend for FAV was similar to that of ergosterol, which was also seen by Dhingra et al. (1998). A Spearman rank order correlation was conducted on the raw ergosterol and FAV data. Results gave a Spearman correlation coefficient of 0.839 ($P < 0.05$) suggesting a good correlation between ergosterol and FAV. This is reasonable because both are a measure of fungal activity on

the seed. A problem with FAV is that as other nutrient sources in the seed are depleted, fungi will also consume portions of the fatty acids that they created (Christenson and Kaufmann 1969).

6. CONCLUSIONS

Many factors were measured during storage of 10, 12, and 14% m.c. canola stored between 25 and 35°C. The following conclusions may be drawn about this thesis work:

(1) The germination rate of canola can be successfully modelled using an asymmetric sigmoid equation with time as the independent variable for each moisture content and temperature regime. The coefficients of determination were all found to be greater than 0.96. Carbon dioxide production may be used as a quick method for determining germination without knowledge of the storage time. Results are comparable with those obtained from germination predicted using storage time.

(2) Carbon dioxide production was found to be dependent on storage time, moisture content, and temperature ($P < 0.001$) and to increase with increasing levels of each. Carbon dioxide production rates at the time of a drop to 95% germination were determined to be 500 (mg/d)/kg d.m. for 14% m.c., 192 (mg/d)/kg d.m. for 12% m.c., and 185 (mg/d)/kg d.m. for 10% m.c. canola between 30 and 35°C and 290 (mg/d)/kg d.m. for 14% m.c. and 172 (mg/d)/kg d.m. for 12% m.c. canola between 25 and 30°C. These CO_2 production rates may be taken as the maximum safe rates for sound canola under the conditions described above.

(3) Respiration data from freshly harvested canola and canola that has been dried, cooled, and then stored for more than 6 months before testing were not statistically different ($P > 0.05$). It may be concluded that the sweating

process is not post-harvest maturation but is the result of moisture and heat transfer in any bulk of canola at the same moisture content, temperature, and fungal infection.

(4) In this study, heat production was determined by two methods. The first method was to calculate heat production from the measured cumulative temperature increase of the system. The second method calculated heat production from the respiration equations with collected CO_2 production data. Heat production calculated assuming only carbohydrate or lipid metabolism was more than the directly measured heat production of the system. Errors in cumulative heat production would be cumulative as well but it is possible that adiabatic conditions were not maintained between the temperature flask and box environment.

(5) Ergosterol levels increased with time and were similar at equal germination rates and moisture contents. Initial ergosterol concentrations of 1.5 ppm may be taken as the level in sound canola. At levels greater than 2 ppm germination has dropped significantly and spoilage has occurred. Levels for the 14% m.c. samples increased more rapidly than the 12% m.c. samples due to the high moisture allowing for growth of more aggressive and destructive fungal species like *A. candidus* and *Penicillium* spp. There was a weak correlation between ergosterol and CO_2 production and a strong correlation between ergosterol and FAV.

7. RECOMMENDATIONS FOR FUTURE RESEARCH

(1) Respiration experiments should be conducted for other moisture contents to get a better understanding of canola storage. It may be feasible to do more samples over a longer period of time if an adsorptive respirometer is used instead of the Micro-Oxymax respirometer.

(2) A bin that is supposedly undergoing the sweating process should be tested for localised high moisture and temperature for a definitive answer to whether or not the sweating process exists under farm conditions.

(3) Heat production should be directly measured for other moisture contents and temperature ranges so that a model can be produced.

(4) Adsorption and desorption of CO_2 by canola should be conducted for low CO_2 concentrations and short time periods (20 min to 24 h).

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APPENDIX A: Respiration Data

Production data ((mg/min)/kg) is for total mass of the sample
Production data ((mg/d)/kg d.m.) is for mass of the dry matter in the sample

Table A1. Carbon dioxide production for 14% m.c. freshly harvested canola stored between 30 and 35°C, replicate 1

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.7	5	0.164	0.168	282
		6	0.175	0.161	270
		7	0.183	0.157	262
		8	0.19	0.154	258
3	31.3	5	0.326	0.282	472
		6	0.331	0.252	423
		7	0.332	0.234	392
		8	0.331	0.225	377
6	35.4	5	0.471	0.474	793
		6	0.489	0.441	739
		7	0.502	0.429	718
		8	0.513	0.430	719
9	33.9	5	0.676	0.465	778
		6	0.687	0.573	959
		7	0.695	0.560	937
		8	0.7	0.553	925
12	34.1	5	0.679	0.617	1032
		6	0.722	0.732	1226
		7	0.758	0.733	1228
		8	0.784	0.708	1186
15	34.9	R 5	0.951X	0.813	1362
		7	0.5	1.019	1706
		8	0.597	0.869	1455
18	28.6	5	0.552	0.608	1018
		6	0.584	0.576	964
		7	0.609	0.563	943
		8	0.628	0.553	927
21	32.5	5	0.703	0.664	1111
		6	0.752	0.783	1311
		7	0.793	0.781	1309
		8	0.826	0.774	1296
24	35.6	R 5	0.953X	0.999	1672
		7	0.609	1.312	2197
		8	0.707	0.959	1605
27	35.4	R 5	0.952X	0.894	1497
		7	0.594	1.264	2116
		8	0.687	0.913	1528
30	32.8	6	0.597	1.264	2116
		7	0.689	0.913	1529
		8	0.783	0.999	1673
33	34.2	5	0.682	1.408	2357
		6	0.83	1.288	2156
		R 7	0.946X	1.257	2104

X = Sensor out of range during measurement
R = Chamber refreshed after measurement

Table A2. Carbon dioxide production for 14% m.c. freshly harvested canola stored between 30 and 35°C, replicate 4

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.3	5	0.240	0.224	376
		6	0.247	0.196	328
		7	0.249	0.179	300
		8	0.249	0.170	285
3	30.1	5	0.347	0.323	541
		6	0.354	0.286	479
		7	0.356	0.268	449
		8	0.357	0.258	432
6	33.2	5	0.502	0.474	794
		6	0.515	0.439	736
		7	0.523	0.420	704
		8	0.527	0.412	689
9	30.8	5	0.701	0.575	963
		6	0.696	0.505	845
		7	0.683	0.460	770
		8	0.669	0.439	735
12	34.1	5	0.788	0.803	1345
		6	0.822	0.775	1298
		7	0.849	0.763	1277
		8	0.869	0.753	1261
15	35.2	5	0.755	0.913	1528
		6	0.816	0.898	1504
		R 7	0.865	0.880	1474
18	29.8	5	0.689	0.516	864
		6	0.706	0.612	1024
		7	0.717	0.595	997
		8	0.723	0.581	972
21	33.5	5	0.885	0.920	1541
		6	0.924	0.881	1475
		R 7	0.947X	0.828	1387
24	34.4	5	0.832	0.836	1399
		6	0.867	0.821	1374
		7	0.899	0.830	1389
		8	0.926	0.831	1391
27	34.3	5	0.867	1.048	1754
		R 6	0.938	1.029	1723
		8	0.595	1.293	2164
30	32.9	5	0.846	1.026	1718
		R 6	0.917	1.008	1688
		8	0.582	1.262	2113
33	33.4	6	0.696	1.453	2433
		7	0.861	1.368	2291
		R 8	0.956X	1.148	1922

X = Sensor out of range during measurement
R = Chamber refreshed after measurement

Table A3. Carbon dioxide production for 12% m.c. freshly harvested canola stored between 30 and 35°C, replicate 2

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.7	5	0.099	0.071	116
		6	0.102	0.066	108
		7	0.105	0.062	102
		8	0.107	0.059	97
3	29.5	5	0.125	0.090	147
		6	0.127	0.078	127
		7	0.127	0.071	116
		8	0.125	0.063	103
6	29.9	5	0.125	0.083	136
		6	0.127	0.073	120
		7	0.128	0.067	110
		8	0.128	0.062	101
9	30.3	5	0.125	0.098	160
		6	0.127	0.085	139
		7	0.127	0.075	123
		8	0.126	0.069	113
12	30.8	5	0.142	0.116	190
		6	0.144	0.101	165
		7	0.144	0.090	148
		8	0.143	0.084	138
15	32.2	5	0.192	0.161	263
		6	0.194	0.136	222
		7	0.192	0.120	196
		8	0.190	0.110	180
20	32.8	5	0.171	0.147	241
		6	0.175	0.131	214
		7	0.176	0.118	193
		8	0.175	0.110	180
26	32.7	5	0.150	0.125	205
		6	0.156	0.114	186
		7	0.160	0.106	174
		8	0.162	0.105	172
32	31.1	5	0.223	0.203	332
		6	0.227	0.173	283
		7	0.226	0.152	249
		8	0.223	0.138	226
38	35.5	5	0.276	0.247	404
		6	0.280	0.211	345
		7	0.278	0.185	303
		8	0.272	0.165	270
44	35.6	5	0.318	0.280	458
		6	0.320	0.235	385
		7	0.315	0.200	327
		8	0.307	0.181	296
56	33.5	R 5	0.137	0.504	825
		R 6	0.121	0.419	686
		R 7	0.108	0.353	577
		R 8	0.098	0.300	491

R = Chamber refreshed after measurement

Table A4. Carbon dioxide production for 12% m.c. freshly harvested canola stored between 30 and 35°C, replicate 5

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.6	5	0.114	0.103	169
		6	0.118	0.091	149
		7	0.121	0.082	135
		8	0.121	0.073	120
3	30.1	5	0.128	0.105	171
		6	0.131	0.090	147
		7	0.133	0.082	135
		8	0.133	0.077	126
6	30.5	5	0.139	0.111	181
		6	0.141	0.095	155
		7	0.141	0.084	137
		8	0.138	0.068	111
9	30.8	5	0.195	0.184	301
		6	0.202	0.165	270
		7	0.205	0.152	249
		8	0.206	0.142	233
12	31.8	5	0.169	0.154	252
		6	0.175	0.140	229
		7	0.179	0.131	214
		8	0.181	0.126	207
15	33.5	5	0.338	0.309	506
		6	0.342	0.268	439
		7	0.340	0.241	395
		8	0.337	0.230	376
20	33.7	5	0.299	0.317	519
		6	0.317	0.303	496
		7	0.330	0.292	477
		8	0.341	0.290	474
26	34	5	0.538	0.532	870
		6	0.553	0.484	791
		7	0.561	0.458	749
		8	0.565	0.440	719
32	31.9	5	0.320	0.403	660
		6	0.344	0.357	584
		7	0.360	0.332	543
		8	0.370	0.316	517
38	34.7	5	0.873	0.663	1084
		6	0.853	0.557	912
		7	0.827	0.504	824
		8	0.799	0.473	774
44	34.8	5	0.918	0.722	1182
		6	0.904	0.620	1015
		7	0.880	0.560	917
		8	0.855	0.531	869
56	33.9	6	0.438	0.850	1392
		7	0.500	0.656	1073
		8	0.542	0.593	970

Table A5. Carbon dioxide readings for 10% m.c. freshly harvested canola stored between 30 and 35°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.5	5	0.058	0.045	72
		6	0.062	0.043	68
		7	0.064	0.041	65
		8	0.066	0.038	61
3	29	5	0.067	0.046	74
		6	0.069	0.041	66
		7	0.071	0.038	61
		8	0.072	0.036	57
6	30.5	5	0.069	0.041	66
		6	0.071	0.039	62
		7	0.073	0.037	59
		8	0.074	0.034	54
9	30.3	5	0.080	0.057	91
		6	0.083	0.051	82
		7	0.083	0.039	63
		8	0.084	0.042	68
12	30.6	5	0.071	0.051	82
		6	0.073	0.043	68
		7	0.075	0.042	68
		8	0.076	0.039	63
15	30.8	5	0.085	0.058	93
		6	0.088	0.051	82
		7	0.089	0.046	73
		8	0.090	0.045	71
21	31.9	5	0.095	0.078	126
		6	0.099	0.070	112
		7	0.101	0.067	107
		8	0.103	0.064	102
27	31.8	5	0.130	0.112	179
		6	0.135	0.102	163
		7	0.138	0.091	146
		8	0.138	0.085	136
33	32.7	5	0.215	0.204	327
		6	0.220	0.173	276
		7	0.221	0.154	247
		8	0.219	0.137	219

Table A5(continued). Carbon dioxide production for freshly harvested canola at 10% m.c. stored between 30 to 35°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min/kg)	Production ((mg/min)/kg d.m.)
39	34.3	5	0.204	0.189	302
		6	0.209	0.165	263
		7	0.211	0.148	236
		8	0.209	0.134	215
45	28.5	5	0.312	0.317	507
		6	0.324	0.276	441
		7	0.327	0.239	383
		8	0.325	0.212	340
51	29.9	5	0.132	0.115	184
		6	0.137	0.103	165
		7	0.140	0.094	150
		8	0.141	0.086	138
57	30.6	5	0.232	0.222	355
		6	0.238	0.189	303
		7	0.238	0.163	261
		8	0.235	0.146	234
63	32	5	0.289	0.285	455
		6	0.296	0.243	389
		7	0.297	0.216	346
		8	0.293	0.192	308
69	34	5	0.704	0.375	600
		6	0.699	0.509	814
		7	0.656	0.299	478
		8	0.610	0.253	405
76	32.4	5	0.322	0.394	630
		6	0.340	0.327	524
		7	0.345	0.275	439
		8	0.343	0.235	376
82	33.9	5	0.420	0.407	651
		6	0.424	0.332	532
		7	0.418	0.282	452
		8	0.406	0.244	390
88	31.6	5	0.396	0.401	642
		6	0.405	0.335	536
		7	0.404	0.284	455
		8	0.396	0.250	401

Table A6. Carbon dioxide production for 10% m.c. freshly harvested canola stored between 30 and 35°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	29.3	5	0.055	0.037	59
		6	0.056	0.035	56
		7	0.057	0.032	51
		8	0.058	0.033	52
3	30.3	5	0.080	0.044	70
		6	0.081	0.042	67
		7	0.081	0.039	62
		8	0.081	0.037	59
6	30	5	0.067	0.040	64
		6	0.069	0.037	59
		7	0.070	0.032	51
		8	0.071	0.029	47
9	30.7	5	0.080	0.044	70
		6	0.083	0.041	65
		7	0.085	0.037	59
		8	0.086	0.036	58
12	30.8	5	0.074	0.043	68
		6	0.077	0.040	64
		7	0.078	0.035	55
		8	0.079	0.035	55
15	30.8	5	0.066	0.046	73
		6	0.068	0.041	65
		7	0.070	0.038	60
		8	0.071	0.034	55
21	30.9	5	0.078	0.052	82
		6	0.081	0.047	75
		7	0.083	0.045	72
		8	0.085	0.043	68
27	30.6	5	0.096	0.073	116
		6	0.101	0.068	109
		7	0.104	0.063	101
		8	0.106	0.059	94
33	30.9	5	0.177	0.168	269
		6	0.183	0.147	235
		7	0.184	0.128	206
		8	0.183	0.115	185

Table A6(continued). Carbon dioxide production for 10% m.c. freshly harvested canola stored between 30 and 35°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
39	31.3	5	0.120	0.107	172
		6	0.126	0.098	156
		7	0.130	0.092	146
		8	0.132	0.085	136
45	31.6	5	0.283	0.276	442
		6	0.290	0.236	377
		7	0.290	0.201	322
		8	0.285	0.175	279
51	32	5	0.315	0.302	483
		6	0.321	0.257	411
		7	0.319	0.220	351
		8	0.313	0.192	308
57	32.3	5	0.166	0.159	255
		6	0.171	0.138	220
		7	0.173	0.123	197
		8	0.173	0.112	180
63	32.9	5	0.340	0.325	520
		6	0.345	0.269	430
		7	0.342	0.229	366
		8	0.333	0.196	314
69	33.6	5	0.382	0.368	589
		6	0.386	0.302	484
		7	0.382	0.257	412
		8	0.371	0.225	360
76	34.2	5	0.475	0.479	766
		6	0.481	0.387	619
		7	0.476	0.334	535
		8	0.461	0.274	438
82	31.1	5	0.210	0.207	331
		6	0.216	0.175	280
		7	0.220	0.167	268
		8	0.220	0.150	239
88	31.6	5	0.451	0.454	726
		6	0.459	0.376	601
		7	0.454	0.318	509
		8	0.443	0.273	437

Table A7. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 1

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27.7	5	0.211	0.212	346
		6	0.218	0.184	300
		7	0.220	0.160	262
		8	0.219	0.145	238
3	28.2	5	0.289	0.159	260
		6	0.278	0.137	224
		7	0.265	0.120	196
		8	0.253	0.111	181
6	28.5	5	0.150	0.123	201
		6	0.152	0.104	170
		7	0.151	0.091	148
		8	0.149	0.080	131
9	29	5	0.227	0.122	200
		6	0.219	0.107	175
		7	0.209	0.095	155
		8	0.201	0.089	146
12	29.3	5	0.136	0.117	191
		6	0.140	0.103	168
		7	0.141	0.093	152
		8	0.141	0.088	144
15	28.6	5	0.331	0.195	320
		6	0.320	0.172	282
		7	0.308	0.154	252
		8	0.295	0.142	232
21	26.7	5	0.572	0.331	542
		6	0.541	0.251	411
		7	0.516	0.263	431
		8	0.486	0.207	338
26	28.4	5	0.261	0.252	413
		6	0.266	0.211	345
		7	0.265	0.186	304
		8	0.261	0.163	267
32	28.4	5	0.655	0.366	599
		6	0.622	0.308	504
		7	0.585	0.259	424
		8	0.548	0.229	375
38	28.9	5	0.388	0.375	613
		6	0.389	0.300	491
		7	0.382	0.248	406
		8	0.370	0.216	353
44	26.9	5	0.642	0.372	609
		6	0.611	0.315	516
		7	0.577	0.271	444
50	28.5	5	0.211	0.209	342
		6	0.217	0.181	296
		7	0.220	0.164	268
		8	0.220	0.149	244
56	24.6	5	0.677	0.615	1007
		6	0.650	0.369	603
		7	0.617	0.308	504
		8	0.584	0.280	458

Table A8. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 2

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28	5	0.142	0.096	157
		6	0.143	0.088	145
		7	0.144	0.089	145
		8	0.143	0.082	134
3	28.6	5	0.081	0.064	105
		6	0.084	0.059	96
		7	0.087	0.058	94
		8	0.089	0.053	87
6	28.9	5	0.164	0.088	144
		6	0.160	0.077	127
		7	0.155	0.071	116
		8	0.150	0.067	110
9	29.5	5	0.137	0.110	180
		6	0.139	0.094	154
		7	0.139	0.082	133
		8	0.137	0.074	120
12	29.7	5	0.282	0.158	258
		6	0.272	0.141	230
		7	0.260	0.123	202
		8	0.249	0.119	195
15	25.1	5	0.140	0.126	206
		6	0.145	0.109	178
		7	0.146	0.098	161
		8	0.147	0.093	152
21	25.9	5	0.284	0.275	450
		6	0.288	0.229	374
		7	0.286	0.193	315
		8	0.279	0.166	271
26	26.6	5	0.558	0.323	528
		6	0.531	0.264	432
		7	0.502	0.230	376
		8	0.474	0.206	337
32	27.9	5	0.301	0.288	471
		6	0.304	0.235	385
		7	0.302	0.204	334
		8	0.295	0.178	291
38	29.1	5	0.432	0.398	651
		6	0.432	0.322	527
		7	0.422	0.262	428
		8	0.408	0.229	375
44	26.3	5	0.355	0.349	572
		6	0.360	0.290	474
		7	0.355	0.241	394
		8	0.345	0.203	333
50	27.6	5	0.686	0.383	627
		6	0.686	0.530	867
		7	0.647	0.296	485
		8	0.607	0.261	427
56	28.9	5	0.412	0.391	640
		6	0.414	0.320	524
		7	0.407	0.270	443
		8	0.396	0.239	392

Table A9. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27.8	5	0.153	0.141	231
		6	0.158	0.125	204
		7	0.161	0.115	189
		8	0.160	0.096	157
3	28.6	5	0.146	0.082	134
		6	0.144	0.076	124
		7	0.141	0.071	117
		8	0.138	0.067	109
6	29.1	5	0.111	0.088	143
		6	0.115	0.080	131
		7	0.116	0.070	115
		8	0.116	0.067	110
9	25.4	5	0.222	0.125	205
		6	0.215	0.108	176
		7	0.207	0.099	162
		8	0.199	0.089	145
12	25.7	5	0.156	0.141	231
		6	0.160	0.119	196
		7	0.161	0.107	174
		8	0.160	0.098	160
15	27.6	5	0.512	0.264	433
		6	0.485	0.227	372
		7	0.456	0.195	320
		8	0.428	0.172	282
21	29.9	5	0.686	0.543	888
		6	0.647	0.304	497
		7	0.605	0.256	420
		8	0.563	0.225	369
26	27	5	0.106	0.095	155
		6	0.111	0.088	144
		7	0.115	0.085	138
		8	0.118	0.082	134
32	28.9	5	0.175	0.120	196
		6	0.174	0.109	179
		7	0.174	0.106	174
		8	0.173	0.103	168
38	26.1	5	0.291	0.279	456
		6	0.294	0.229	374
		7	0.291	0.193	316
		8	0.284	0.168	274
44	28	5	0.569	0.324	531
		6	0.541	0.267	437
		7	0.510	0.227	372
		8	0.480	0.202	331
50	29.1	5	0.380	0.356	583
		6	0.380	0.283	463
		7	0.372	0.237	388
		8	0.360	0.204	334
56	27.4	5	0.527	0.305	499
		6	0.504	0.261	427
		7	0.477	0.223	365
		8	0.450	0.196	320

Table A10. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 4

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27	5	0.163	0.098	160
		6	0.163	0.095	155
		7	0.161	0.089	145
		8	0.159	0.085	140
3	26.9	5	0.125	0.096	157
		6	0.127	0.082	134
		7	0.127	0.073	119
		8	0.125	0.066	108
6	26.4	5	0.140	0.067	109
		6	0.136	0.060	99
		7	0.132	0.055	90
		8	0.127	0.050	81
9	26	5	0.086	0.058	96
		6	0.087	0.048	79
		7	0.087	0.044	72
		8	0.087	0.040	66
12	26.5	5	0.105	0.047	76
		6	0.103	0.042	69
		7	0.101	0.039	64
		8	0.098	0.037	61
15	26.5	5	0.117	0.089	145
		6	0.119	0.077	126
		7	0.119	0.065	107
		8	0.117	0.060	97
21	26.5	5	0.131	0.107	175
		6	0.134	0.091	148
		7	0.134	0.081	132
		8	0.133	0.072	118
26	26.5	5	0.179	0.095	155
		6	0.174	0.087	142
		7	0.169	0.081	133
		8	0.163	0.074	121
32	26.5	5	0.145	0.120	196
		6	0.148	0.106	173
		7	0.148	0.091	148
		8	0.147	0.083	135
38	26.5	5	0.203	0.107	175
		6	0.196	0.095	156
		7	0.189	0.088	144
		8	0.182	0.081	133
44	26.5	5	0.136	0.114	187
		6	0.139	0.097	158
		7	0.139	0.088	143
		8	0.138	0.079	129
50	26.5	5	0.249	0.135	221
		6	0.240	0.117	192
		7	0.230	0.108	177
		8	0.220	0.098	160
56	26.5	5	0.106	0.085	139
		6	0.109	0.078	128
		7	0.111	0.067	109
		8	0.111	0.065	106

Table A11. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 5

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	28.2	5	0.156	0.145	237
		6	0.161	0.128	209
		7	0.163	0.113	186
		8	0.163	0.105	172
3	28.4	5	0.230	0.130	213
		6	0.223	0.116	189
		7	0.214	0.101	166
		8	0.205	0.091	149
6	28.5	5	0.137	0.109	179
		6	0.139	0.092	150
		7	0.138	0.080	131
		8	0.136	0.072	118
9	28.7	5	0.206	0.107	175
		6	0.199	0.095	155
		7	0.191	0.085	139
		8	0.183	0.081	133
12	29	5	0.115	0.093	151
		6	0.118	0.081	133
		7	0.119	0.072	118
		8	0.119	0.068	111
15	29.6	5	0.363	0.195	319
		6	0.347	0.169	276
		7	0.330	0.153	251
		8	0.313	0.136	223
21	28.8	5	0.299	0.169	277
		6	0.288	0.149	244
		7	0.276	0.132	216
		8	0.263	0.122	200
26	29.2	5	0.308	0.285	467
		6	0.310	0.232	380
		7	0.305	0.198	324
		8	0.296	0.166	272
32	26.8	5	0.216	0.127	208
		6	0.210	0.112	183
		7	0.203	0.099	162
		8	0.196	0.097	159
38	27.9	5	0.254	0.237	388
		6	0.257	0.194	318
		7	0.255	0.167	273
		8	0.249	0.146	239
44	28.9	5	0.491	0.269	441
		6	0.465	0.224	367
		7	0.438	0.194	317
		8	0.411	0.171	280
50	26.5	5	0.250	0.237	389
		6	0.254	0.198	323
		7	0.253	0.171	279
		8	0.249	0.150	246
56	27.5	5	0.433	0.249	407
		6	0.415	0.217	354
		7	0.395	0.194	317
		8	0.375	0.172	282

Table A12. Carbon dioxide production for 12% m.c. canola stored between 25 and 30°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27.9	5	0.138	0.094	153
		6	0.139	0.088	143
		7	0.140	0.084	138
		8	0.140	0.083	136
3	27.5	5	0.110	0.090	147
		6	0.113	0.081	132
		7	0.114	0.072	118
		8	0.115	0.071	116
6	27.3	5	0.130	0.067	110
		6	0.128	0.063	103
		7	0.126	0.056	92
		8	0.123	0.055	91
9	27.1	5	0.098	0.080	131
		6	0.101	0.069	113
		7	0.103	0.063	103
		8	0.103	0.060	97
12	26	5	0.192	0.110	181
		6	0.187	0.099	161
		7	0.182	0.089	145
		8	0.177	0.086	141
15	27	5	0.238	0.228	373
		6	0.241	0.186	304
		7	0.240	0.162	266
		8	0.236	0.143	234
21	27.3	5	0.177	0.166	272
		6	0.181	0.139	228
		7	0.181	0.122	200
		8	0.181	0.115	188
26	27.7	5	0.404	0.226	370
		6	0.387	0.191	313
		7	0.368	0.168	275
		8	0.349	0.150	246
32	28	5	0.166	0.156	255
		6	0.171	0.137	224
		7	0.173	0.127	207
		8	0.174	0.115	188
38	28.5	5	0.323	0.190	311
		6	0.313	0.171	280
		7	0.302	0.155	253
		8	0.290	0.142	232
44	28.9	5	0.362	0.348	569
		6	0.364	0.277	452
		7	0.358	0.237	387
		8	0.349	0.204	334
50	29.7	5	0.477	0.269	440
		6	0.457	0.234	383
		7	0.435	0.209	342
		8	0.414	0.191	313
56	26.2	5	0.405	0.411	673
		6	0.409	0.331	541
		7	0.405	0.281	460
		8	0.393	0.234	384

Table A13. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 1

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	26.7	5	0.284	0.259	434
		6	0.288	0.221	371
		7	0.287	0.195	326
		8	0.283	0.183	306
3	28.2	5	0.312	0.180	301
		6	0.302	0.166	277
		7	0.293	0.158	264
		8	0.283	0.151	253
6	27.5	5	0.283	0.164	275
		6	0.275	0.151	253
		7	0.267	0.144	242
		8	0.259	0.141	237
9	29	5	0.374	0.308	516
		6	0.371	0.256	429
		7	0.362	0.224	375
		8	0.352	0.207	347
12	27.8	5	0.395	0.203	340
		6	0.376	0.180	301
		7	0.356	0.158	265
		8	0.341	0.169	283
15	27	5	0.342	0.188	314
		6	0.328	0.170	284
		7	0.314	0.156	261
		8	0.302	0.152	254
18	28.5	5	0.418	0.220	369
		6	0.399	0.194	325
		7	0.38	0.184	309
		8	0.364	0.181	303
21	28.8	5	0.747	0.309	517
		6	0.691	0.251	421
		7	0.672	0.422	706
		8	0.62	0.214	359
27	28.6	5	0.757	0.549	920
		6	0.727	0.414	693
		7	0.685	0.321	538
		8	0.673	0.459	769
30	27.9	5	0.82	0.352	590
		6	0.762	0.291	487
		7	0.705	0.251	420
		8	0.686	0.434	727

Table A14. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 2

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27	5	0.225	0.162	272
		6	0.226	0.156	262
		7	0.226	0.153	256
		8	0.225	0.150	251
3	29	5	0.206	0.189	316
		6	0.211	0.170	285
		7	0.214	0.163	273
		8	0.218	0.165	276
6	27.2	5	0.322	0.217	363
		6	0.31	0.164	274
		7	0.295	0.137	230
		8	0.281	0.130	217
9	28.9	5	0.704	0.163	272
		6	0.669	0.342	572
		7	0.608	0.152	255
		8	0.554	0.146	245
12	27.7	5	0.461	0.311	521
		6	0.442	0.236	396
		7	0.42	0.197	329
		8	0.397	0.182	305
15	27.3	5	0.505	0.334	560
		6	0.482	0.249	417
		7	0.454	0.205	343
		8	0.427	0.181	303
18	29	5	0.569	0.376	630
		6	0.544	0.294	493
		7	0.516	0.259	433
		8	0.489	0.240	401
21	29.6	5	0.656	0.413	691
		6	0.623	0.312	523
		7	0.585	0.263	440
		8	0.552	0.254	425
27	26.1	5	0.729	0.492	823
		6	0.692	0.356	597
		7	0.683	0.487	815
		8	0.635	0.250	419
30	27.7	5	0.639	0.461	772
		6	0.615	0.353	592
		7	0.588	0.314	526
		8	0.56	0.286	478

Table A15. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mgmin)/kg)	Production ((mg/d)/kg d.m.)
0	26.9	5	0.214	0.136	228
		6	0.213	0.126	211
		7	0.212	0.124	208
		8	0.21	0.121	202
3	29	5	0.205	0.113	189
		6	0.2	0.104	174
		7	0.196	0.107	179
		8	0.193	0.107	178
6	26.1	5	0.18	0.099	166
		6	0.176	0.092	154
		7	0.173	0.090	150
		8	0.17	0.090	151
9	29	5	0.315	0.112	188
		6	0.296	0.113	189
		7	0.28	0.114	191
		8	0.266	0.116	194
12	29.6	5	0.261	0.133	223
		6	0.251	0.127	213
		7	0.243	0.127	212
		8	0.236	0.126	212
15	28.4	5	0.437	0.099	165
		6	0.396	0.085	142
		7	0.361	0.086	144
		8	0.331	0.090	151
18	29.1	5	0.493	0.107	179
		6	0.446	0.095	158
		7	0.405	0.094	158
		8	0.371	0.103	172
21	30.4	5	0.381	0.162	271
		6	0.358	0.150	251
		7	0.339	0.147	247
		8	0.324	0.159	266
27	30.5	5	0.637	0.318	533
		6	0.588	0.207	347
		7	0.537	0.154	259
		8	0.488	0.128	215
30	30	5	0.622	0.190	319
		6	0.566	0.146	244
		7	0.515	0.129	216
		8	0.472	0.129	216

Table A16. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 4

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27.1	5	0.216	0.139	233
		6	0.214	0.129	216
		7	0.211	0.125	210
		8	0.208	0.121	203
3	27	5	0.29	0.101	170
		6	0.27	0.092	154
		7	0.253	0.089	149
		8	0.239	0.089	149
6	27.2	5	0.313	0.105	177
		6	0.29	0.083	139
		7	0.272	0.097	162
		8	0.256	0.097	162
9	27.5	5	0.535	0.123	206
		6	0.485	0.109	183
		7	0.44	0.100	167
		8	0.403	0.105	176
12	27.2	5	0.611	0.154	257
		6	0.553	0.121	202
		7	0.501	0.107	180
		8	0.456	0.111	185
15	27.1	5	0.656	0.359	601
		6	0.593	0.134	224
		7	0.536	0.116	195
		8	0.487	0.122	204
18	27.3	5	0.695	0.201	336
		6	0.661	0.343	574
		7	0.601	0.161	269
		8	0.546	0.143	239
21	27.3	5	0.503	0.352	589
		6	0.484	0.276	463
		7	0.461	0.233	391
		8	0.438	0.213	357
27	27.1	5	0.705	0.451	755
		6	0.701	0.522	874
		7	0.652	0.261	437
		8	0.603	0.217	363
30	27	5	0.753	0.260	435
		6	0.69	0.209	350
		7	0.666	0.395	662
		8	0.612	0.185	310

Table A17. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 5

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	26.9	5	0.159	0.134	225
		6	0.163	0.119	199
		7	0.164	0.108	180
		8	0.165	0.105	176
3	28.1	5	0.2	0.137	229
		6	0.197	0.116	195
		7	0.192	0.104	174
		8	0.187	0.100	167
6	29.2	5	0.226	0.156	261
		6	0.223	0.133	223
		7	0.217	0.118	198
		8	0.211	0.112	188
9	27.5	5	0.485	0.087	146
		6	0.436	0.069	115
		7	0.394	0.071	119
		8	0.358	0.077	129
12	27.9	5	0.383	0.226	378
		6	0.363	0.163	272
		7	0.341	0.135	227
		8	0.32	0.124	207
15	30.3	5	0.381	0.232	388
		6	0.364	0.176	295
		7	0.345	0.157	263
		8	0.329	0.151	252
18	26.9	5	0.363	0.243	407
		6	0.349	0.181	303
		7	0.331	0.149	250
		8	0.313	0.134	225
21	28.5	5	0.384	0.258	432
		6	0.37	0.202	338
		7	0.353	0.177	296
		8	0.337	0.166	279
27	26.1	5	0.676	0.389	651
		6	0.63	0.245	411
		7	0.577	0.168	281
		8	0.526	0.130	218
30	28	5	0.479	0.326	546
		6	0.46	0.248	415
		7	0.437	0.209	349
		8	0.414	0.191	320

Table A18. Carbon dioxide production for 14% m.c. canola stored between 25 and 30°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	27	5	0.231	0.181	304
		6	0.231	0.149	250
		7	0.227	0.130	218
		8	0.222	0.123	206
3	28.8	5	0.314	0.110	184
		6	0.293	0.105	176
		7	0.275	0.104	173
		8	0.259	0.102	171
6	29	5	0.371	0.148	249
		6	0.345	0.120	201
		7	0.323	0.127	212
		8	0.306	0.131	220
9	28.3	5	0.353	0.235	394
		6	0.341	0.187	313
		7	0.325	0.155	260
		8	0.309	0.144	241
12	27.6	5	0.304	0.215	360
		6	0.295	0.166	277
		7	0.285	0.148	248
		8	0.274	0.139	232
15	30.5	5	0.472	0.150	252
		6	0.434	0.139	232
		7	0.402	0.139	233
		8	0.376	0.147	246
18	28.9	5	0.62	0.140	234
		6	0.557	0.118	198
		7	0.503	0.119	200
		8	0.456	0.113	189
21	29.3	5	0.456	0.288	482
		6	0.434	0.214	358
		7	0.411	0.185	310
		8	0.389	0.174	291
27	29.5	5	0.662	0.365	611
		6	0.616	0.254	426
		7	0.569	0.206	345
		8	0.525	0.186	312
30	28.3	5	0.714	0.213	356
		6	0.684	0.380	637
		7	0.62	0.165	276
		8	0.565	0.156	261

Table A19. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 1

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	33.8	5	0.177	0.154	252
		6	0.181	0.136	223
		7	0.181	0.120	197
		8	0.18	0.110	180
3	31.6	5	0.199	0.107	175
		6	0.192	0.093	153
		7	0.185	0.086	141
		8	0.179	0.081	133
6	32.2	5	0.134	0.113	184
		6	0.136	0.089	146
		7	0.135	0.078	127
		8	0.134	0.075	123
9	32.8	5	0.272	0.135	220
		6	0.26	0.117	192
		7	0.246	0.099	162
		8	0.234	0.094	154
12	33.6	5	0.179	0.152	249
		6	0.182	0.135	221
		7	0.182	0.118	194
		8	0.18	0.108	177
18	30.9	5	0.363	0.333	545
		6	0.364	0.266	435
		7	0.358	0.221	361
		8	0.346	0.186	305
24	35.2	5	0.306	0.282	461
		6	0.31	0.242	396
		7	0.308	0.212	347
		8	0.304	0.195	319
30	34.8	5	0.709	0.352	576
		6	0.667	0.298	487
		7	0.657	0.456	746
		8	0.614	0.247	404
36	34.3	5	0.322	0.297	485
		6	0.324	0.245	401
		7	0.32	0.213	349
		8	0.313	0.189	310
42	32.4	5	0.712	0.376	616
		6	0.672	0.319	522
		7	0.662	0.460	753
		8	0.619	0.261	428

Table A20. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 2

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	33.8	5	0.155	0.102	167
		6	0.156	0.096	157
		7	0.155	0.094	154
		8	0.155	0.090	147
3	30.7	5	0.111	0.089	146
		6	0.113	0.075	123
		7	0.114	0.070	115
		8	0.114	0.062	102
6	30.8	5	0.136	0.071	117
		6	0.134	0.066	108
		7	0.131	0.060	99
		8	0.128	0.056	92
9	30.8	5	0.105	0.086	141
		6	0.109	0.082	134
		7	0.112	0.076	124
		8	0.114	0.073	119
12	31	5	0.181	0.105	171
		6	0.177	0.097	158
		7	0.174	0.092	150
		8	0.17	0.087	142
18	33	5	0.421	0.382	625
		6	0.42	0.307	502
		7	0.411	0.259	423
		8	0.398	0.230	376
24	34.6	5	0.509	0.277	453
		6	0.483	0.234	383
		7	0.458	0.217	355
		8	0.436	0.212	347
30	33	5	0.439	0.397	650
		6	0.438	0.319	521
		7	0.427	0.263	430
		8	0.412	0.227	371
36	35	5	0.568	0.478	782
		6	0.559	0.379	620
		7	0.54	0.315	516
		8	0.519	0.283	463
42	33.4	5	0.574	0.510	835
		6	0.569	0.410	670
		7	0.554	0.344	563
		8	0.532	0.300	491

Table A21. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	35	5	0.151	0.130	213
		6	0.154	0.111	181
		7	0.155	0.101	165
		8	0.154	0.090	147
3	29.2	5	0.093	0.050	81
		6	0.094	0.048	79
		7	0.094	0.043	70
		8	0.094	0.044	72
6	29.4	5	0.125	0.098	160
		6	0.126	0.082	134
		7	0.127	0.074	121
		8	0.125	0.066	108
9	29.8	5	0.242	0.130	214
		6	0.234	0.116	190
		7	0.225	0.107	176
		8	0.216	0.098	160
12	30.4	5	0.146	0.128	210
		6	0.15	0.112	183
		7	0.152	0.103	168
		8	0.152	0.095	155
18	33	5	0.613	0.312	510
		6	0.576	0.253	413
		7	0.54	0.232	380
		8	0.504	0.201	329
24	31.8	5	0.166	0.154	251
		6	0.171	0.137	225
		7	0.174	0.128	210
		8	0.176	0.121	198
30	33.4	5	0.473	0.407	666
		6	0.468	0.320	524
		7	0.455	0.267	436
		8	0.438	0.234	383
36	32.8	5	0.449	0.399	652
		6	0.446	0.318	520
		7	0.434	0.266	436
		8	0.418	0.232	380
42	30.1	5	0.557	0.523	856
		6	0.555	0.408	667
		7	0.541	0.334	546
		8	0.52	0.279	456

Table A22. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 4

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34	5	0.18	0.106	173
		6	0.179	0.103	169
		7	0.176	0.096	157
		8	0.173	0.092	150
3	29.9	5	0.13	0.092	150
		6	0.13	0.079	130
		7	0.128	0.067	109
		8	0.125	0.060	98
6	30.3	5	0.167	0.074	122
		6	0.161	0.067	109
		7	0.154	0.061	100
		8	0.148	0.057	93
9	30.2	5	0.109	0.073	119
		6	0.11	0.060	99
		7	0.108	0.053	86
		8	0.107	0.049	79
12	30	5	0.144	0.067	110
		6	0.139	0.060	98
		7	0.134	0.055	90
		8	0.128	0.049	80
18	32.2	5	0.185	0.144	236
		6	0.185	0.120	196
		7	0.182	0.104	170
		8	0.178	0.092	151
24	31.1	5	0.235	0.121	198
		6	0.226	0.108	177
		7	0.217	0.101	165
		8	0.207	0.091	148
30	32.5	5	0.21	0.177	290
		6	0.211	0.148	243
		7	0.209	0.127	207
		8	0.204	0.112	184
36	31.4	5	0.311	0.154	253
		6	0.297	0.140	229
		7	0.281	0.122	200
		8	0.266	0.113	184
42	30.4	5	0.162	0.137	224
		6	0.165	0.117	192
		7	0.165	0.103	169
		8	0.162	0.091	149

Table A23. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 5

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	33.5	5	0.18	0.153	250
		6	0.182	0.132	215
		7	0.182	0.119	195
		8	0.18	0.108	176
3	34.3	5	0.193	0.104	170
		6	0.187	0.093	151
		7	0.181	0.086	141
		8	0.175	0.085	140
6	34.6	5	0.186	0.144	236
		6	0.186	0.123	201
		7	0.183	0.107	175
		8	0.179	0.097	159
9	34.8	5	0.396	0.197	322
		6	0.376	0.176	287
		7	0.354	0.154	252
		8	0.334	0.146	239
12	31.6	5	0.216	0.194	317
		6	0.219	0.162	265
		7	0.218	0.143	233
		8	0.215	0.128	210
18	33	5	0.633	0.340	557
		6	0.597	0.277	453
		7	0.56	0.242	397
		8	0.523	0.216	354
24	34.1	5	0.213	0.187	306
		6	0.217	0.166	272
		7	0.217	0.145	237
		8	0.215	0.134	219
30	32.7	5	0.599	0.301	493
		6	0.564	0.255	417
		7	0.528	0.215	352
		8	0.493	0.190	310
36	35	5	0.403	0.355	581
		6	0.401	0.282	461
		7	0.389	0.231	378
		8	0.375	0.205	335
42	33.8	5	0.721	0.368	602
		6	0.677	0.307	502
		7	0.666	0.452	740
		8	0.62	0.251	411

Table A24. Carbon dioxide production for 12% m.c. canola stored between 30 and 35°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34.5	5	0.174	0.112	183
		6	0.172	0.100	164
		7	0.171	0.095	155
		8	0.168	0.091	149
3	30	5	0.121	0.100	164
		6	0.123	0.083	136
		7	0.124	0.076	125
		8	0.124	0.070	115
6	30.5	5	0.175	0.094	153
		6	0.17	0.084	137
		7	0.166	0.078	127
		8	0.161	0.076	124
9	31	5	0.211	0.126	206
		6	0.207	0.118	192
		7	0.202	0.108	177
		8	0.197	0.105	172
12	31.5	5	0.409	0.215	352
		6	0.39	0.187	306
		7	0.371	0.166	272
		8	0.352	0.155	253
18	33.6	5	0.389	0.341	559
		6	0.386	0.270	442
		7	0.377	0.228	373
		8	0.364	0.202	330
24	32.7	5	0.545	0.277	453
		6	0.517	0.238	389
		7	0.487	0.208	341
		8	0.459	0.189	310
30	33.4	5	0.446	0.389	636
		6	0.442	0.311	509
		7	0.431	0.261	427
		8	0.415	0.226	369
36	32.4	5	0.678	0.344	563
		6	0.676	0.503	824
		7	0.636	0.269	440
		8	0.595	0.238	389
42	34.9	5	0.439	0.392	642
		6	0.439	0.326	533
		7	0.433	0.289	473
		8	0.423	0.265	434

Table A25. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 1

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34.8	5	0.357	0.208	349
		6	0.349	0.210	351
		7	0.343	0.211	353
		8	0.338	0.212	356
3	32.8	5	0.383	0.256	428
		6	0.373	0.223	373
		7	0.362	0.213	356
		8	0.353	0.211	353
6	34.1	5	0.616	0.395	661
		6	0.596	0.357	597
		7	0.577	0.345	577
		8	0.561	0.346	579
9	34.5	5	0.574	0.470	788
		6	0.576	0.434	727
		7	0.576	0.421	706
		8	0.576	0.422	707
12	34.9	5	0.693	0.591	990
		6	0.697	0.559	937
		7	0.696	0.530	888
		8	0.695	0.536	898
15	35.0	5	0.710	0.558	935
		6	0.701	0.497	832
		7	0.691	0.478	801
		8	0.682	0.478	800

Table A26. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 2

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	35.9	5	0.370	0.291	488
		6	0.369	0.263	440
		7	0.364	0.240	402
		8	0.357	0.231	386
3	34.9	5	0.676	0.380	636
		6	0.626	0.236	395
		7	0.583	0.234	391
		8	0.550	0.257	430
6	30.8	5	0.476	0.321	538
		6	0.458	0.256	428
		7	0.437	0.223	373
		8	0.417	0.213	357
9	35.2	5	0.709	0.578	967
		6	0.710	0.554	927
		7	0.708	0.535	896
		8	0.706	0.533	893
12	35.6	5	0.772	0.677	1134
		6	0.782	0.650	1088
		7	0.787	0.633	1060
		8	0.792	0.632	1058
15	33.8	5	0.759	0.658	1103
		6	0.762	0.599	1004
		7	0.762	0.587	983
		8	0.761	0.586	980

Table A27. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 3

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34.5	5	0.418	0.280	468
		6	0.413	0.278	466
		7	0.405	0.256	428
		8	0.399	0.263	441
3	33.6	5	0.510	0.360	603
		6	0.500	0.325	545
		7	0.489	0.317	531
		8	0.479	0.312	523
6	32.2	5	0.621	0.410	687
		6	0.600	0.355	595
		7	0.579	0.339	568
		8	0.561	0.335	561
9	30.3	5	0.620	0.418	700
		6	0.599	0.354	593
		7	0.575	0.318	532
		8	0.553	0.309	518
12	35.1	5	0.780	0.758	1269
		6	0.803	0.724	1211
		7	0.819	0.705	1181
		8	0.833	0.710	1189
15	33.5	5	0.689	0.524	878
		6	0.686	0.520	871
		7	0.684	0.515	862
		8	0.683	0.526	880

Table A28. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 4

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	36.0	5	0.371	0.363	608
		6	0.336	0.060	100
		7	0.381	0.510	854
		8	0.386	0.310	518
3	32.2	5	0.385	0.429	718
		6	0.397	0.351	588
		7	0.399	0.306	512
		8	0.399	0.292	489
6	35.5	5	0.724	0.639	1069
		6	0.728	0.584	977
		7	0.727	0.559	935
		8	0.721	0.532	892
9	33.1	5	0.733	0.602	1007
		6	0.725	0.519	870
		7	0.709	0.470	787
		8	0.692	0.447	748
12	32.2	5	0.655	0.607	1016
		6	0.662	0.539	902
		7	0.659	0.494	827
		8	0.656	0.484	810
15	34.5	5	0.688	0.483	809
		6	0.697	0.580	971
		7	0.700	0.556	931
		8	0.700	0.541	906

Table A29. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 5

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34.1	5	0.363	0.191	320
		6	0.349	0.181	303
		7	0.336	0.177	296
		8	0.324	0.177	296
3	34.2	5	0.374	0.299	501
		6	0.374	0.273	457
		7	0.372	0.262	439
		8	0.370	0.257	431
6	30.4	5	0.548	0.319	534
		6	0.518	0.243	407
		7	0.488	0.213	357
		8	0.460	0.207	347
9	32.0	5	0.664	0.458	767
		6	0.648	0.414	693
		7	0.666	0.589	987
		8	0.650	0.416	696
12	34.9	5	0.755	0.669	1120
		6	0.763	0.629	1054
		7	0.766	0.613	1026
		8	0.768	0.606	1014
15	33.0	5	0.726	0.610	1022
		6	0.724	0.553	927
		7	0.720	0.536	898
		8	0.716	0.532	891

Table A30. Carbon dioxide production for 14% m.c. canola stored between 30 and 35°C, replicate 6

Day	Box Temp (°C)	Reading	CO2 (%)	Production ((mg/min)/kg)	Production ((mg/d)/kg d.m.)
0	34.9	5	0.441	0.361	605
		6	0.444	0.346	579
		7	0.443	0.323	541
		8	0.440	0.310	519
3	34.0	5	0.552	0.382	640
		6	0.539	0.344	576
		7	0.526	0.331	555
		8	0.514	0.328	549
6	32.3	5	0.576	0.391	655
		6	0.556	0.325	544
		7	0.541	0.338	565
		8	0.525	0.320	536
9	30.8	5	0.589	0.413	692
		6	0.570	0.346	579
		7	0.549	0.310	519
		8	0.527	0.296	495
12	35.8	5	0.798	0.772	1292
		6	0.820	0.737	1235
		7	0.836	0.730	1223
		8	0.851	0.733	1227
15	34.3	5	0.636	0.644	1079
		6	0.660	0.622	1042
		7	0.677	0.602	1008
		8	0.691	0.595	996

APPENDIX B: Germination Data

Table B1. Germination (%) of 14% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Plate	Storage Day 0	3	6	9	12	15	18	21	24	27	30	33 (sample)	33 (temp)	33 (resp)
1	a	100	98	98	98	96	90	88	96	64	52	36	36	50	28
	b	98	98	98	100	94	82	96	90	72	36	34	40	44	30
4	a	98	96	96	98	100	96	92	72	50	66	66	46	26	40
	b	100	98	98	98	94	92	94	88	52	74	54	50	38	58

Table B2. Germination (%) of 12% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Plate	Storage Day 0	3	6	9	12	15	20	26	32	38	44	56 (sample)	56 (temp)	56 (resp)
2	a	98	98	100	100	94	92	98	88	92	76	66	38	42	66
	b	100	100	98	94	96	98	96	88	88	82	64	26	34	72
5	a	100	96	96	98	94	98	98	88	90	78	34	32	22	2
	b	100	100	100	100	92	96	92	92	84	56	36	12	28	0

Table B3. Germination (%) of 10% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Plate	Storage Day 0	3	6	9	12	15	21	27	33	39	45	51	57	63	69	76	82	88 (sample)	88 (temp)	88 (resp)
3	a	94	98	100	100	98	96	96	94	98	92	100	96	98	96	82	82	60	80	84	24
	b	98	100	100	100	98	98	98	94	98	96	96	90	94	86	92	88	88	60	76	14
6	a	94	96	100	100	100	100	98	100	100	94	98	100	94	92	80	84	84	66	88	30
	b	96	100	100	96	100	100	98	98	96	90	96	94	90	88	88	90	70	70	80	40

First visible sign of mould
sample = sample flask
temp = temperature flask
resp = respiration flask

Table B4. Germination (%) of 12% m.c. canola stored between 25 and 30°C

Replicate	Plate	Storage Day 0	3	6	9	12	15	21	26	32	38	44	50	56 (sample)	56 (temp)	56 (resp)
1	a	98	100	100	100	96	96	94	94	90	86	84	58	52	66	66
	b	100	98	94	96	94	96	98	96	82	86	72	78	56	54	74
2	a	96	98	98	96	96	94	94	96	96	92	88	84	78	70	70
	b	98	98	98	96	92	100	94	98	94	88	90	76	81	78	72
3	a	92	98	96	94	100	94	98	94	88	90	82	84	84	80	64
	b	100	98	98	96	90	98	92	94	84	86	90	84	84	68	70
4	a	100	100	96	98	98	98	94	96	81	92	84	90	80	no data	96
	b	94	96	100	98	98	100	92	92	92	88	86	92	90	no data	84
5	a	100	98	96	96	92	96	92	96	96	94	76	92	62	50	86
	b	100	96	96	98	100	98	88	92	90	94	86	74	76	82	72
6	a	100	100	98	94	94	96	92	98	92	98	94	84	84	70	72
	b	bad	98	100	98	94	94	96	94	98	86	90	72	78	86	74

First visible sign of mould

sample = sample flask
temp = temperature flask
resp = respiration flask

Table B5. Germination (%) of 14% m.c. canola stored between 25 and 30°C

Replicate	Plate	Storage Day 0	3	6	9	12	15	18	21	27	30 (sample)	30 (temp)	30 (resp)
1	a	98	96	94	98	100	98	90	90	76	50	48	72
	b	96	98	100	96	96	90	96	86	82	40	50	78
2	a	98	100	96	94	92	88	94	82	92	58	48	66
	b	96	98	98	100	90	92	86	94	84	62	44	72
3	a	100	96	96	98	96	98	98	84	82	76	66	54
	b	98	98	98	98	96	92	90	90	88	72	58	56
4	a	96	96	96	98	96	94	94	92	82	66	none	62
	b	100	98	98	96	94	98	90	88	82	48	none	60
5	a	92	94	98	98	94	96	92	94	84	78	72	90
	b	98	98	94	88	92	92	96	84	78	72	81	76
6	a	98	96	96	98	96	92	94	88	62	90	82	80
	b	98	96	98	96	98	90	96	90	90	82	60	84

First visible sign of mould
sample = sample flask
temp = temperature flask
resp = respiration flask

Table B6. Germination (%) of 12% m.c. canola stored between 30 and 35°C

Replicate	Plate	Storage Day											
		0	3	6	9	12	18	24	30	36	42 (sample)	42 (temp)	42 (resp)
1	a	98	100	100	96	94	96	86	70	38	48	62	80
	b	96	96	96	94	92	88	84	72	48	64	64	82
2	a	96	100	96	96	92	96	80	82	68	40	50	22
	b	98	98	96	98	92	88	94	82	66	28	44	40
3	a	98	98	100	96	92	94	86	88	74	70	74	*
	b	98	100	96	98	96	92	96	82	80	74	74	36
4	a	100	98	98	96	98	90	90	90	86	32	20	42
	b	98	98	98	96	94	94	96	86	74	36	34	40
5	a	98	98	96	96	96	72	92	76	48	54	70	50
	b	96	100	100	96	94	94	80	74	54	48	48	34
6	a	98	94	96	92	100	94	94	86	80	76	60	52
	b	96	98	98	98	94	94	90	82	72	66	64	40

First visible sign of mould

* Plate was spoiled

sample = sample flask

temp = temperature flask

resp = respiration flask

Table B7. Germination (%) of 14% m.c. canola stored between 30 and 35°C

Replicate	Plate	Storage Day							
		0	3	6	9	12	15 (sample)	15 (temp)	15 (resp)
1	a	98	94	96	80	80	58	*	52
	b	96	92	90	*	68	40	44	72
2	a	98	96	90	60	70	70	62	70
	b	92	90	90	78	74	62	42	74
3	a	100	90	98	84	58	76	*	62
	b	96	94	90	84	72	70	78	86
4	a	92	96	90	94	58	60	44	84
	b	96	96	94	88	76	34	50	44
5	a	96	94	94	86	*	80	68	78
	b	96	98	94	88	74	60	62	68
6	a	98	98	86	92	60	76	90	54
	b	96	96	92	94	66	74	74	44

First visible sign of mould
* Plate was spoiled
sample = sample flask
temp = temperature flask
resp = respiration flask

Table B8. Germination (%) of 10% m.c. canola stored between 30 and 35°C

Replicate	Plate	Storage Day												
		0	6	12	18	24	30	36	42	48	54	60	66	72 (sample)
1	a	98	94	96	98	98	95	96	86	84	94	70	96	80
	b	100	96	96	100	100	96	96	96	78	86	88	84	78
2	a	98	96	98	98	96	94	94	94	88	94	76	72	78
	b	100	98	*	94	90	84	94	94	96	88	90	76	76
3	a	100	96	96	96	94	92	92	96	90	94	82	66	80
	b	100	98	98	98	98	96	96	94	96	92	80	82	72
4	a	100	94	98	96	94	96	90	96	92	84	90	84	88
	b	98	98	96	98	94	96	96	*	90	92	90	88	76
5	a	98	100	96	100	94	94	96	94	88	84	84	70	84
	b	*	96	96	96	100	94	98	96	92	92	60	72	62
6	a	94	100	98	92	90	94	98	92	94	84	92	88	80
	b	98	96	98	96	96	96	96	92	88	96	82	84	*

first visible sign of mould
* Plate was spoiled
sample = sample flask

APPENDIX C: Ergosterol Data

Table C1. Ergosterol levels of 12 and 14% m.c. canola stored between 30 and 35°C

Moisture Content	Time (d)	Replicate	Ergosterol Test Date	Total Ergosterol (ppm)
12%	0	1	22/01/02	1.45
12%	0	2	31/01/02	1.42
12%	0	3	07/02/02	1.50
12%	0	5	14/02/02	1.84
12%	0	6	21/02/02	1.66
12%	24	1	22/01/02	1.87
12%	24	2	31/01/02	2.98
12%	24	3	07/02/02	2.04
12%	24	5	14/02/02	2.27
12%	24	6	21/02/02	1.96
12%	42	1	22/01/02	3.30
12%	42	2	31/01/02	3.09
12%	42	3	07/02/02	3.33
12%	42	5	14/02/02	2.46
12%	42	6	21/02/02	3.19
14%	0	1	24/01/02	1.55
14%	0	2	05/02/02	1.26
14%	0	3	12/02/02	1.48
14%	0	5	19/02/02	1.30
14%	0	6	26/02/02	1.69
14%	9	1	24/01/02	2.54
14%	9	2	05/02/02	2.08
14%	9	3	12/02/02	2.18
14%	9	5	19/02/02	2.43
14%	9	6	26/02/02	2.50
14%	15	1	24/01/02	3.20
14%	15	2	05/02/02	2.83
14%	15	3	12/02/02	3.12
14%	15	5	19/02/02	3.28
14%	15	6	26/02/02	3.16

APPENDIX D: Microflora Data

Table D1. Microfloral infection of 14% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Time	Plate	Microfloral Infection (%of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	78	30	4		4
		b	76	42		4	4
		c	58	40		4	
1 (sample)	final	a			8	96	98
		b			2	86	96
		c			4	88	98
1 (temp)	final	a			44	98	48
		b			50	100	54
		c			48	100	56
1 (resp)	final	a				52	98
		b				46	100
		c				28	100
4	initial	a	84	34	2	4	2
		b	80	36	6		4
		c	70	34		2	
4 (sample)	final	a			52	100	44
		b			64	98	46
		c			74	98	40
4 (temp)	final	a			86	99	28
		b			74	92	32
		c			76	92	40
4 (resp)	final	a			2	26	98
		b				12	98
		c				12	100

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D2. Microfloral infection of 12% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
2	initial	a	61	28	4	24	4
		b	70	26	4	30	2
		c	50	32	6	34	2
2 (sample)	final	a			18	92	84
		b			44	88	72
		c	2		38	99	80
2 (temp)	final	a			90	100	4
		b	2		88	100	8
		c			84	99	14
2 (resp)	final	a	6		72	58	34
		b			62	80	26
		c			72	80	30
5	initial	a	54	44	6	41	2
		b	61	20	2	26	
		c	32	18	12	24	
5 (sample)	final	a			30	100	28
		b			32	100	20
		c			32	100	34
5 (temp)	final	a			68	98	36
		b	2		78	100	30
		c			62	100	36
5 (resp)	final	a			2	90	88
		b				94	92
		c			8	82	80

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D3. Microfloral infection of 10% m.c. freshly harvested canola stored between 30 and 35°C

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	60	10	6	10	4
		b	56	24	6	20	2
		c	48	26	4	24	8
3 (sample)	final	a			100	20	
		b			98	30	2
		c			92	10	6
3 (temp)	final	a			98	10	6
		b			96	10	4
		c			94	8	4
3 (resp)	final	a			94	80	20
		b			90	72	19
		c			98	81	19
6	initial	a	**Samples were lost for replicate 6**				
		b					
		c					
6 (sample)	final	a			100	44	
		b			100	36	
		c			100	26	
6 (temp)	final	a			98	12	14
		b			100	20	16
		c			92	8	2
6 (resp)	final	a			100	88	16
		b			100	90	14
		c			96	88	20

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D4. Microfloral infection of 12% m.c. canola stored between 25 and 30°C replicates 1 and 2

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	62	22	6	2	
		b	66	28			2
		c	56	24	4	4	2
1	60%	a	2		72	98	
		b	6		70	94	4
		c	2		76	98	4
1 (sample)	final	a			86	80	14
		b			94	90	10
		c			98	80	16
1 (temp)	final	a	6		94	20	46
		b			100	44	46
		c			100	32	44
1 (resp)	final	a			98	56	10
		b			96	54	12
		c			96	70	6
2	initial	a	50	24			8
		b	42	28	6	2	8
		c	60	12			4
2	60%	a	14		96		52
		b	6		96	16	74
		c	4		98	10	56
2 (sample)	final	a			94	56	26
		b	2		92	68	28
		c			94	72	34
2 (temp)	final	a	2		100	12	16
		b	6		98	12	32
		c			100	14	24
2 (resp)	final	a	2		98	100	6
		b	2		92	96	10
		c	2		84	100	

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D5. Microfloral infection of 12% m.c. canola stored between 25 and 30°C replicates 3 and 4

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	44	32	8	2	
		b	42	30	6	6	4
		c	44	22	10	8	4
3	60%	a	12		94	34	40
		b	16		86	30	48
		c	16		90	44	58
3 (sample)	final	a	2		94	58	34
		b	2		96	58	28
		c	2		92	54	34
3 (temp)	final	a			94	22	26
		b	8		98	16	34
		c	8		98	14	28
3 (resp)	final	a			98	64	24
		b			100	78	8
		c			98	74	16
4	initial	a	46	26	6		
		b	42	28			
		c	**Plate dried out**				
4	60%	a	**No sample taken for replicate 4**				
		b					
		c					
4 (sample)	final	a	4		94	40	30
		b	2		98	40	26
		c	4		94	54	24
4 (temp)	final	a	**For this replicate experiment there was no temperature flask**				
		b					
		c					
4 (resp)	final	a	**Respiration flask dried out for this replicate**				
		b					
		c					

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D6. Microfloral infection of 12% m.c. canola stored between 25 and 30°C replicates 5 and 6

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
5	initial	a	62	30		2	
		b	62	30	8	2	
		c	66	22			4
5	60%	a	12		92	26	40
		b	6		100	20	58
		c	6		98	20	38
5 (sample)	final	a			96	72	14
		b			100	62	18
		c			98	88	18
5 (temp)	final	a	2		98	6	44
		b	2		98	14	44
		c	2		100	2	66
5 (resp)	final	a	4		98	24	26
		b			98	10	38
		c	2		96	18	36
6	initial	a	54	28	2	2	6
		b	52	28	6		2
		c	46	40	2	4	2
6	60%	a	12		90	10	62
		b	18		92	8	34
		c	12		96	10	56
6 (sample)	final	a	2		98	52	10
		b	2		100	46	16
		c	4		90	66	12
6 (temp)	final	a	2		98	22	26
		b	4		92	28	26
		c	6		98	16	30
6 (resp)	final	a			94	100	2
		b	2		90	96	10
		c	2		88	98	10

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D7. Microfloral infection of 14% m.c. canola stored between 25 and 30°C replicates 1 and 2

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	64	20	4	4	4
		b	68	20			4
		c	42	18		2	4
1	60%	a	4		94	66	
		b	2		98	80	2
		c	2		98	74	
1 (sample)	final	a	2		48	100	10
		b	4		38	98	4
		c	4		40	100	6
1 (temp)	final	a	2		98	80	18
		b			94	72	4
		c	2		94	72	2
1 (resp)	final	a	6		34	100	2
		b	4		32	94	
		c	6		28	98	2
2	initial	a	54	24	2	4	2
		b	56	24	2	2	
		c	66	20	2	8	
2	60%	a	6		98	52	4
		b	4		96	38	10
		c	6		94	44	8
2 (sample)	final	a	8		58	98	12
		b	2		36	98	10
		c			36	100	12
2 (temp)	final	a			100	90	4
		b			94	82	
		c	4		98	90	2
2 (resp)	final	a	4		62	98	2
		b	2		52	100	
		c			46	96	4

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D8. Microfloral infection of 14% m.c. canola stored between 25 and 30°C replicates 3 and 4

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	72	12	12	4	
		b	78	20	8	6	
		c	66	16	4	4	
3	60%	a	4		92	86	
		b	10		86	90	
		c	6		94	86	2
3 (sample)	final	a	6		90	84	12
		b	2		56	98	10
		c	2		56	96	6
3 (temp)	final	a	2		24	98	46
		b			10	100	36
		c	4		10	100	20
3 (resp)	final	a	4		12	84	90
		b	8		16	90	68
		c	2		2	88	76
4	initial	a	66	26		12	
		b	64	18	4	4	
		c	66	24		8	
4	60%	a	**No sample taken for replicate 4**				
		b					
		c					
4 (sample)	final	a	2		20	100	54
		b	4		8	98	46
		c	2		4	100	58
4 (temp)	final	a	**For this replicate experiment there was no temperature flask**				
		b					
		c					
4 (resp)	final	a	2		24	100	92
		b	2		16	100	84
		c			12	94	80

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D9. Microfloral infection of 14% m.c. canola stored between 25 and 30°C replicates 5 and 6

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
5	initial	a	60	26	6		2
		b	50	16	6	2	2
		c	54	22	10	8	8
5	60%	a	6		100	70	
		b			100	56	
		c	8		94	56	
5 (sample)	final	a	4		70	92	60
		b	6		60	100	52
		c	6		70	98	32
5 (temp)	final	a	6		94	80	20
		b	4		86	86	10
		c	4		96	80	2
5 (resp)	final	a	2		40	100	10
		b	6		60	98	14
		c	4		38	98	18
6	initial	a	50	16	20	6	
		b	58	22	22	6	
		c	56	6	32	4	2
6	60%	a	6		96	74	
		b	2		94	80	
		c	4		92	80	
6 (sample)	final	a	6		66	98	12
		b			36	94	8
		c	10		30	98	4
6 (temp)	final	a	6		100	46	8
		b	4		96	58	12
		c	2		84	80	10
6 (resp)	final	a	4		40	98	4
		b	2		40	98	14
		c	6		41	98	26

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D10. Microfloral infection of 12% m.c. canola stored between 30 and 35°C replicates 1 and 2

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	56	34	2		2
		b	62	16	4	4	
		c	44	40		6	8
1 (sample)	final	a			100	24	62
		b			92	16	58
		c			98	16	44
1 (temp)	final	a			86	42	44
		b			96	38	42
		c			96	20	44
1 (resp)	final	a			94	16	30
		b			86	22	44
		c			92	18	46
2	initial	a	54	30	2	4	2
		b	62	22		2	4
		c	46	24		2	4
2	60%	a	4		100	4	
		b	2		100	8	
		c	4		100	10	
2 (sample)	final	a			100	26	12
		b	2		100	24	6
		c			98	18	10
2 (temp)	final	a	2		98	20	32
		b			100	22	44
		c			100	20	46
2 (resp)	final	a			80	24	86
		b			92	24	90
		c			82	30	90

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D11. Microfloral infection of 12% m.c. canola stored between 30 and 35°C replicates 3 and 4

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	64	28		4	6
		b	50	36	2	8	2
		c	58	28	2	2	4
3	60%	a	2		98	4	
		b	8		96	2	
		c	12		98	16	
3 (sample)	final	a			100	14	
		b			100	8	4
		c	2		100	24	
3 (temp)	final	a	4		98	4	24
		b	2		100	4	20
		c			100	2	20
3 (resp)	final	a			100	10	72
		b			94	18	64
		c			96	2	62
4	initial	a	58	28		2	
		b	66	30	2	2	
		c	48	46	4	2	4
4	60%	a	**No sample taken for replicate 4**				
		b					
		c					
4 (sample)	final	a			88	64	40
		b			96	48	24
		c	6		94	28	20
4 (temp)	final	a	4		80	36	44
		b			76	54	50
		c			74	48	46
4 (resp)	final	a	**Respiration flask dried out for this replicate**				
		b					
		c					

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D12. Microfloral infection of 12% m.c. canola stored between 30 and 35°C replicates 5 and 6

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
5	initial	a	34	16	8	2	4
		b	48	24	2	8	4
		c	50	20	4	4	10
5	60%	a	2		100		
		b	4		100	2	
		c	2		98		
5 (sample)	final	a			100	6	24
		b			100	20	26
		c			98	6	22
5 (temp)	final	a			96	12	28
		b			98	12	56
		c			96	12	36
5 (resp)	final	a			98	12	38
		b			98	12	36
		c			98	4	32
6	initial	a	66	32	2	4	
		b	70	16	2	4	4
		c	72	32			2
6	60%	a	6		98	10	
		b	2		96	16	
		c	6		96	10	
6 (sample)	final	a			100	8	2
		b	2		100	8	
		c	4		98	16	
6 (temp)	final	a	4		100	2	14
		b			96	4	14
		c	4		100	4	8
6 (resp)	final	a	2		100	16	86
		b			100	18	96
		c	4		94	8	86

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D13. Microfloral infection of 14% m.c. canola stored between 30 and 35°C replicates 1 and 2

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	74	14	6	20	2
		b	52	18	20	22	8
		c	46	20	14	22	12
1	60%	a	6		94	94	6
		b	2		90	90	4
		c	2		96	84	4
1 (sample)	final	a			90	100	98
		b	2		82	96	100
		c			74	98	96
1 (temp)	final	a			100	76	12
		b	4		94	96	10
		c			98	96	16
1 (resp)	final	a	2			68	100
		b	2		2	74	100
		c	4		6	74	100
2	initial	a	46	8	8	26	12
		b	54	16	14	22	8
		c	44	8	2	26	6
2	60%	a	6		94	80	
		b			100	88	8
		c	4		98	82	4
2 (sample)	final	a			100	82	16
		b	2		94	96	36
		c	4		96	86	24
2 (temp)	final	a	6		92	70	6
		b			94	76	8
		c	2		88	74	10
2 (resp)	final	a	2			76	100
		b	2		10	68	100
		c	4		6	76	98

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D14. Microfloral infection of 14% m.c. canola stored between 30 and 35°C replicates 3 and 4

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	58	18	2	8	2
		b	54	20	6	14	10
		c	50	18	6	2	6
3	60%	a	10		76	60	6
		b	8		74	64	2
		c	18		74	62	2
3 (sample)	final	a	2		88	90	80
		b	6		92	84	78
		c	4		96	90	84
3 (temp)	final	a	4		78	82	92
		b			94	70	90
		c			92	64	86
3 (resp)	final	a	2			80	100
		b	4		8	84	98
		c	2		2	82	98
4	initial	a	66	24	4	8	8
		b	46	28	10	14	10
		c	58	12	10	14	14
4	60%	a	**No sample taken for replicate 4**				
		b					
		c					
4 (sample)	final	a			88	96	92
		b			78	100	94
		c			78	100	96
4 (temp)	final	a			94	94	22
		b			98	98	41
		c			90	96	64
4 (resp)	final	a	6		2	66	100
		b	8		6	64	96
		c	4		2	66	100

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D15. Microfloral infection of 14% m.c. canola stored between 30 and 35°C replicates 5 and 6

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
5	initial	a	46	18	6	26	
		b	32	10	6	22	
		c	52	14	4	32	6
5	60%	a	4		96	82	6
		b			96	76	4
		c			98	86	6
5 (sample)	final	a			92	98	82
		b			82	92	90
		c			92	98	88
5 (temp)	final	a	2		98	78	16
		b			94	62	4
		c	2		100	78	14
5 (resp)	final	a	4		4	94	100
		b	2			78	98
		c	2			86	100
6	initial	a	58	14	4	16	2
		b	70	14	2	22	6
		c	66	16	2	16	4
6	60%	a	4		96	96	14
		b	4		96	90	26
		c	14		92	90	30
6 (sample)	final	a	6		66	46	94
		b	4		74	46	96
		c			66	64	98
6 (temp)	final	a	2		94	32	62
		b			78	42	68
		c			96	14	32
6 (resp)	final	a				54	98
		b	6			50	96
		c				32	100

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D16. Microfloral infection of 10% m.c. canola stored between 30 and 35°C, replicates 1 and 2

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
1	initial	a	58	10	6	2	2
		b	40	24	16		6
		c	48	26	10	4	8
1 (sample)	final	a	2		100	4	
		b			100	6	4
		c	6		100	8	
1 (temp)	final	a			100	2	
		b	4		100		2
		c			100		2
1 (resp)	final	a	4		100	2	
		b	6		98	2	8
		c	8		100	2	10
2	initial	a	48	10	4	8	4
		b	47	20	2		2
		c	50	14	2	2	8
2 (sample)	final	a			100	2	6
		b			100	2	6
		c	2		100	6	
2 (temp)	final	a			100		
		b			100	6	2
		c	2		100	2	
2 (resp)	final	a	4		100	2	
		b			100		
		c	4		100		

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D17. Microfloral infection of 10% m.c. canola stored between 30 and 35°C, replicates 3 and 4

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
3	initial	a	34	8	2	2	2
		b	44	12	6		2
		c	30	18	2	2	4
3 (sample)	final	a			100	2	2
		b	2		98	6	2
		c			98	4	2
3 (temp)	final	a			100	6	4
		b			100	4	
		c			100	4	6
3 (resp)	final	a	4		100		
		b	2		100	2	
		c			100		
4	initial	a	36	10	2		
		b	46	12	2		2
		c	48	16	2	4	8
4 (sample)	final	a			98	6	2
		b	2		100	12	4
		c			100	2	
4 (temp)	final	a	2		100	14	2
		b	2		100	2	6
		c			100	8	2
4 (resp)	final	a			100	2	10
		b	4		100		4
		c			100		4

sample = sample flask
temp = temperature flask
resp = respiration flask

Table D18. Microfloral infection of 10% m.c. canola stored between 30 and 35°C, replicates 5 and 6

Replicate	Time	Plate	Microfloral Infection (% of seeds)				
			Alternaria	*Cladosporium*	*A. Glaucus*	*A. Candidus*	*Penicillium*
5	initial	a	50	8	12	8	16
		b	54	18		2	4
		c	54	16	6	4	8
5 (sample)	final	a	2		100	2	2
		b	2		100		2
		c	2		100		2
5 (temp)	final	a			98	12	4
		b			96	8	4
		c			100	2	8
5 (resp)	final	a			100		2
		b			100		
		c			100		
6	initial	a	38	8	14	6	2
		b	44	12	6	2	2
		c	42	10	8	2	8
6 (sample)	final	a			100	14	2
		b	4		100	8	4
		c	6		100	4	
6 (temp)	final	a			100	8	4
		b	2		100	6	
		c			100	2	2
6 (resp)	final	a			100	16	8
		b			100	8	2
		c			100	2	2

sample = sample flask
temp = temperature flask
resp = respiration flask

APPENDIX E: Moisture Data

Table E1. Moisture content of freshly harvested canola stored between 30 and 35°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	14	13.9	14.1	13.9	15.7
	b	14	13.9	14.0	13.9	17.1
	c	14	13.9	14.1	13.8	15.9
2	a	12	11.6	12.1	12.2	11.0
	b	12	11.7	12.2	12.1	11.0
	c	12	11.8	12.2	12.1	10.9
3	a	10	10.0	10.1	10.1	11.5
	b	10	10.0	10.3	10.0	11.7
	c	10	10.1	10.3	10.1	11.6
4	a	14	13.7	14.6	14.5	16.1
	b	14	13.6	14.6	14.4	16.6
	c	14	13.6	14.7	14.4	17.6
5	a	12	11.4	12.5	12.3	14.0
	b	12	11.5	12.5	12.3	13.9
	c	12	11.4	12.5	12.3	13.9
6	a	10	9.9	10.4	10.0	11.6
	b	10	9.9	10.4	9.9	11.6
	c	10	9.8	10.4	10.0	11.6

Table E2. Moisture content of 12% m.c. canola stored between 25 and 30°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	12	12.8	12.5	12.1	12.5
	b	12	12.8	12.6	12.0	12.6
	c	12	12.7	12.6	11.9	12.6
2	a	12	11.9	12.1	12.2	12.7
	b	12	11.9	12.1	12.3	12.7
	c	12	11.9	12.1	12.3	12.7
3	a	12	12.0	12.1	12.3	12.4
	b	12	12.0	12.0	12.3	12.5
	c	12	12.0	12.2	12.2	12.5
4	a	12	12.1	12.0	no flask	10.8
	b	12	12.2	12.1	no flask	10.8
	c	12	12.1	12.3	no flask	10.8
5	a	12	12.0	12.3	12.2	12.2
	b	12	12.0	12.2	12.1	12.2
	c	12	11.9	12.2	12.2	12.2
6	a	12	12.1	12.0	12.1	12.8
	b	12	12.1	12.1	12.3	12.9
	c	12	12.0	12.1	12.2	12.2

Table E3. Moisture content for 14% m.c. canola stored between 25 and 30°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	14	14.0	14.1	13.8	13.2
	b	14	14.1	14.0	13.8	13.3
	c	14	13.9	14.1	13.8	13.3
2	a	14	14.5	13.6	14.1	13.9
	b	14	14.6	13.8	14.1	14.0
	c	14	14.2	13.8	14.1	14.1
3	a	14	14.8	13.5	14.0	13.5
	b	14	14.9	13.6	14.0	13.5
	c	14	14.6	13.6	14.1	13.4
4	a	14	14.2	14.0	no flask	13.8
	b	14	14.0	14.1	no flask	13.7
	c	14	14.0	14.1	no flask	13.7
5	a	14	13.9	14.1	14.1	13.7
	b	14	14.0	14.1	13.9	13.8
	c	14	13.8	14.2	13.9	13.8
6	a	14	13.7	13.9	14.0	14.5
	b	14	13.8	14.0	13.9	14.2
	c	14	13.8	14.0	13.9	14.2

Table E4. Moisture content for 12% m.c. canola stored between 30 and 35°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	12	11.8	12.2	12.1	11.6
	b	12	11.8	12.3	12.2	11.7
	c	12	11.9	12.3	12.1	11.7
2	a	12	11.9	12.4	12.2	12.4
	b	12	11.9	12.3	12.3	12.4
	c	12	11.9	12.4	12.2	12.6
3	a	12	11.8	12.3	12.3	12.4
	b	12	11.9	12.1	12.4	12.3
	c	12	11.9	12.4	12.3	12.3
4	a	12	11.9	12.1	11.5	10.5
	b	12	12.0	12.0	11.4	10.7
	c	12	12.0	12.0	11.4	10.7
5	a	12	11.9	11.9	12.0	11.9
	b	12	11.8	12.0	11.9	11.9
	c	12	11.9	12.1	11.9	12.0
6	a	12	11.7	12.1	11.8	12.7
	b	12	11.7	12.2	12.1	12.8
	c	12	11.8	12.2	12.1	12.7

Table E5. Moisture content for 14% m.c. canola stored between 30 and 35°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	14	14.4	14.2	14.4	14.3
	b	14	14.4	14.2	14.2	14.4
	c	14	14.3	14.4	14.3	14.2
2	a	14	14.4	14.4	14.5	14.5
	b	14	14.5	14.4	14.5	14.6
	c	14	14.3	14.5	14.6	14.2
3	a	14	13.8	14.2	13.8	14.0
	b	14	13.9	14.3	13.8	14.2
	c	14	14.0	14.4	13.9	14.0
4	a	14	14.1	14.4	14.3	13.5
	b	14	14.1	14.6	14.2	13.4
	c	14	14.1	14.7	14.2	13.3
5	a	14	14.3	14.4	14.3	14.6
	b	14	14.3	14.3	14.4	14.4
	c	14	14.3	14.3	14.4	14.4
6	a	14	14.1	14.0	13.8	14.5
	b	14	14.1	13.9	13.9	14.7
	c	14	14.1	13.8	13.9	14.4

Table E6. Moisture content for 10% m.c. canola stored between 30 and 35°C

Replicate	Dish	Goal (%)	Moisture Content (%)			
			Initial	Final		
				(sample flask)	(temperature flask)	(respiration flask)
1	a	10	9.9	10.1	9.8	8.3
	b	10	9.9	10.0	10.0	8.2
	c	10	9.9	10.0	10.0	8.2
2	a	10	10.0	9.9	10.2	8.0
	b	10	9.9	9.9	10.1	8.0
	c	10	10.0	10.0	10.1	8.0
3	a	10	9.8	9.7	9.9	8.0
	b	10	9.8	9.7	10.1	8.0
	c	10	9.8	9.6	10.2	8.0
4	a	10	9.8	10.1	10.1	7.0
	b	10	9.8	10.2	10.0	6.8
	c	10	9.8	10.2	10.1	6.9
5	a	10	9.8	10.0	9.9	8.3
	b	10	9.9	10.0	9.9	8.4
	c	10	9.9	10.0	9.9	8.3
6	a	10	10.0	9.9	10.0	8.3
	b	10	10.1	9.9	10.0	8.3
	c	10	10.1	9.8	10.0	8.3

APPENDIX F: Fat Acidity Data

Table F1. Fat acidity value for freshly harvested canola stored between 30 and 35°C

Replicate	Sample	FAV (mg KOH/100 g ground seed)					
		Initial	30%[a]	60%[b]	Final[c]		
					(sample flask)	(temperature flask)	(respiration flask)
1	a	13.1	26.2	63.2	100.2	47.9	122.0
	b	13.1	26.1	61.0	100.3	56.6	91.6
	c	13.1	26.1	58.9	93.7	58.8	115.6
2	a	17.2	30.7	*	81.1	66.4	50.4
	b	14.8	30.7	49.2	76.3	66.4	50.4
	c	17.2	32.0	46.7	78.7	61.5	50.4
3	a	14.1	22.8	19.1	44.9	41.2	64.6
	b	14.1	20.3	24.0	42.5	41.2	64.6
	c	12.9	19.1	40.0	42.4	*	*
4	a	17.4	28.3	79.5	74.1	54.5	96.0
	b	13.0	28.3	77.4	87.0	52.3	93.6
	c	13.0	30.5	81.7	80.6	54.4	78.5
5	a	12.3	28.2	51.7	70.1	78.7	107.0
	b	12.3	28.3	49.2	67.6	78.7	109.4
	c	11.0	23.4	49.2	70.1	75.1	109.4
6	a	13.5	24.6	20.9	44.3	41.8	60.3
	b	13.5	24.6	27.1	44.3	41.8	56.6
	c	12.3	24.6	40.6	43.1	*	*

* Sample spoiled

[a] Day 12, replicates 1 and 4; Day 20, replicates 2 and 5; Day 33, replicates 3 and 6

[b] Day 21, replicates 1 and 4; Day 38, replicates 2 and 5; Day 57, replicates 3 and 6

[c] Day 33, replicates 1 and 4; Day 56, replicates 2 and 5; Day 88, replicates 3 and 6

Table F2. Fat acidity value for 12% m.c. canola stored between 25 and 30°C

Replicate	Sample	FAV (mg KOH/100g ground seed)					
		Initial	Day 15	Day 38	Final (Day 56)		
					(sample flask)	(temperature flask)	(respiration flask)
1	a	16.0	24.6	41.8	51.6	38.1	50.4
	b	13.5	24.6	38.1	50.4	44.3	47.9
	c	14.8	24.6	38.1	51.6	43.0	48.0
2	a	12.9	21.5	31.3	39.9	42.4	47.3
	b	12.9	21.5	31.7	*	42.4	47.3
	c	12.9	22.7	30.1	41.2	43.7	46.1
3	a	17.2	23.4	38.1	45.5	45.5	45.5
	b	13.5	25.8	34.4	45.5	45.5	46.7
	c	13.5	23.4	36.9	43.1	43.0	45.5
4	a	14.2	22.8	29.5	40.6	no flask	flask dried
	b	14.1	21.5	30.7	40.6	no flask	flask dried
	c	15.4	21.5	29.5	43.1	no flask	flask dried
5	a	13.5	23.4	35.6	41.8	43.0	41.8
	b	12.3	20.9	32.0	39.4	40.6	39.4
	c	11.1	20.9	30.7	41.8	38.1	40.6
6	a	15.4	21.5	32.6	41.2	41.2	47.3
	b	14.1	21.5	32.6	*	42.4	47.4
	c	14.1	22.7	32.6	*	42.4	46.1

* Sample spoiled

Table F3. Fat acidity value for 14% m.c. canola stored between 25 and 30°C

Replicate	Sample	FAV (mg KOH/100g ground seed)					
		Initial	Day 9	Day 21	Final (Day 30)		
					(sample flask)	(temperature flask)	(respiration flask)
1	a	19.7	25.8	*	40.6	36.9	45.5
	b	19.7	27.0	20.9	40.6	34.4	47.9
	c	19.7	22.1	25.8	38.1	*	*
2	a	22.7	27.7	28.9	51.1	33.8	48.6
	b	21.5	30.1	26.4	51.1	33.8	46.1
	c	19.1	28.9	28.9	48.5	31.3	48.5
3	a	23.4	28.3	29.5	45.5	62.7	50.4
	b	20.9	25.8	30.8	45.5	62.7	52.9
	c	18.4	24.6	30.7	43.0	*	*
4	a	20.9	22.1	*	45.5	no flask	55.3
	b	20.9	22.1	*	45.5	no flask	57.8
	c	19.7	*	*	45.5	no flask	*
5	a	20.3	24.0	25.2	32.6	35.0	48.6
	b	19.0	24.0	25.2	33.8	32.6	48.6
	c	19.0	22.8	25.2	33.8	32.6	48.6
6	a	17.8	21.5	30.1	35.0	42.4	37.5
	b	17.8	20.3	28.9	35.1	38.7	38.7
	c	17.8	22.8	28.9	35.0	38.7	33.8

* Sample spoiled

Table F4. Fat acidity value for 12% m.c. canola stored between 30 and 35°C

Replicate	Sample	FAV (mg KOH/100 g ground seed)					
		Initial	Day 12	Day 24	Final (Day 42)		
					(sample flask)	(temperature flask)	(respiration flask)
1	a	11.8	25.3	36.4	54.8	51.2	45.0
	b	16.7	37.6	36.4	57.3	51.1	49.9
	c	13.0	13.0	35.2	54.8	51.2	45.0
2	a	14.5	23.5	36.6	52.6	53.1	55.5
	b	14.8	23.8	36.1	53.6	51.6	56.5
	c	14.5	24.0	36.6	53.1	51.8	56.2
3	a	22.3	32.5	54.1	67.6	66.6	64.0
	b	22.0	30.5	50.9	70.8	67.2	65.2
	c	21.3	30.8	51.6	65.7	65.7	66.6
4	a	18.4	25.8	38.1	50.4	no flask	flask dried
	b	18.5	25.8	40.6	50.4	no flask	flask dried
	c	17.2	*	*	50.4	no flask	flask dried
5	a	15.7	27.8	44.5	*	52.0	53.4
	b	16.0	28.0	41.3	52.1	51.4	51.9
	c	15.5	27.3	41.3	52.6	50.9	51.6
6	a	18.5	31.3	45.1	60.6	54.6	68.4
	b	19.4	31.5	43.4	61.5	60.1	70.1
	c	20.3	31.5	43.6	59.6	60.9	69.1

* Sample spoiled

Table F5. Fat acidity value for 14% m.c. canola stored between 30 and 35°C

Replicate	Sample	FAV (mg KOH/100 g ground seed)					
		Initial	Day 6	Day 9	Final (Day 15)		
					(sample flask)	(temperature flask)	(respiration flask)
1	a	10.9	28.4	47.9	50.0	39.2	74.1
	b	37.0	28.3	37.0	47.9	41.4	78.5
	c	28.4	26.2	37.0	47.9	37.0	78.5
2	a	30.5	30.5	27.2	32.6	30.5	100.3
	b	26.2	30.5	27.2	32.7	32.6	93.6
	c	30.5	28.3	29.5	32.7	30.5	91.4
3	a	27.3	36.0	27.2	52.3	34.9	84.9
	b	22.9	31.6	29.4	50.1	32.7	82.9
	c	22.9	33.8	29.4	52.2	32.7	85.0
4	a	22.9	29.0	27.2	45.7	30.5	94.4
	b	9.8	29.5	27.2	41.4	32.7	92.2
	c	38.2	*	27.2	39.2	30.5	94.7
5	a	25.1	28.3	32.7	45.7	39.9	96.8
	b	29.4	28.3	30.5	43.6	44.3	98.8
	c	27.3	30.5	30.5	45.8	37.7	98.8
6	a	21.8	30.5	37.0	51.3	37.7	77.4
	b	21.8	24.0	39.2	55.7	35.6	79.5
	c	19.6	26.1	37.1	55.6	37.9	75.3

* Sample spoiled

Table F6. Fat acidity value for 10% m.c. canola stored between 30 and 35°C

Replicate	Sample	FAV (mg KOH/100 g ground seed)			
		Initial	Day 15	Day 38	Final (Day 56) (sample flask)
1	a	19.7	29.5	39.4	43.0
	b	19.7	27.1	38.1	35.7
	c	22.1	*	*	33.2
2	a	18.5	29.5	35.7	47.9
	b	18.4	28.3	38.1	49.2
	c	19.7	25.8	*	46.8
3	a	16.0	25.8	36.9	43.1
	b	17.2	24.6	35.7	*
	c	17.2	25.8	*	*
4	a	18.5	25.8	30.7	43.0
	b	17.2	25.8	30.8	40.6
	c	18.4	25.8	*	40.6
5	a	20.3	26.4	42.5	44.9
	b	20.3	30.1	43.6	41.2
	c	17.8	*	*	37.5
6	a	17.2	22.2	39.3	43.0
	b	18.4	20.9	36.9	43.1
	c	14.8	*	*	45.5

* Sample spoiled

APPENDIX G: Temperature Data

Table G1. Temperature data for 12% m.c. canola stored between 25 and 30°C

Date	Time	Replicate	Flask Temp (°C)
1/11/02	10:30:17	1	27.8
1/12/02	14:32:08	1	28.0
1/16/02	23:04:24	1	28.5
1/20/02	16:44:00	1	29.0
1/24/02	12:24:40	1	29.5
1/25/02	16:51:37	1	27.7
1/26/02	6:15:28	1	28.0
1/28/02	22:18:48	1	28.5
1/30/02	16:16:40	1	29.0
1/31/02	18:08:48	1	29.5
2/1/02	16:26:24	1	30.0
2/3/02	12:10:17	1	26.1
2/3/02	22:20:32	1	26.5
2/4/02	16:00:08	1	27.0
2/7/02	15:43:36	1	27.5
2/9/02	9:07:36	1	28.0
2/11/02	6:52:40	1	28.5
2/12/02	19:15:36	1	29.0
2/14/02	5:29:44	1	29.5
2/15/02	16:14:09	1	28.1
2/16/02	21:16:32	1	28.5
2/18/02	5:25:28	1	29.0
2/19/02	12:48:00	1	29.5
2/20/02	15:28:48	1	30.0
2/21/02	17:40:32	1	28.6
2/23/02	0:57:20	1	29.0
2/23/02	18:45:12	1	29.5
2/25/02	3:26:48	1	30.0
2/26/02	9:55:28	1	26.2
2/27/02	3:18:32	1	26.5
3/1/02	0:30:40	1	27.0
3/2/02	22:22:32	1	27.5
3/4/02	16:17:52	1	28.0
3/6/02	2:54:24	1	28.5
3/7/02	13:37:20	1	29.0
3/8/02	22:16:00	1	29.5
3/10/02	1:54:56	1	30.0
3/11/02	14:11:12	1	24.4
1/9/02	11:06:09	5	18.0
1/12/02	1:54:48	5	28.5
1/21/02	22:34:24	5	29.0
2/6/02	9:10:56	5	29.5
2/6/02	15:10:49	5	28.9
2/9/02	16:03:20	5	29.5
2/10/02	11:37:52	5	26.1
2/12/02	2:15:36	5	26.5
2/16/02	17:25:28	5	27.0
2/19/02	6:16:24	5	27.5
2/21/02	11:45:44	5	28.0
2/23/02	18:43:44	5	28.5
2/28/02	1:50:56	5	29.0
3/1/02	10:28:17	5	25.9
3/5/02	2:47:28	5	26.5
3/8/02	15:35:52	5	27.0
3/10/02	22:34:48	5	27.5
3/11/02	14:11:04	5	27.8
1/9/02	11:06:09	2	18.0
1/10/02	12:14:00	2	28.0
1/12/02	6:50:24	2	28.5
1/16/02	20:12:16	2	29.0
1/19/02	8:01:20	2	29.5
1/22/02	23:55:44	2	30.0
1/24/02	10:11:53	2	24.7
1/25/02	19:48:16	2	25.0
1/28/02	0:22:48	2	25.5
2/28/02	13:28:16	2	26.5
3/3/02	2:24:48	2	27.0
3/5/02	2:48:08	2	27.5
3/11/02	2:03:28	2	29.0
3/11/02	2:13:12	2	28.5
1/9/02	11:06:09	3	17.9
1/9/02	11:14:56	3	25.4
1/9/02	11:52:40	3	27.5
1/11/02	19:52:56	3	28.0
1/12/02	0:49:52	3	28.5
1/14/02	23:51:44	3	29.0
1/17/02	13:06:01	3	25.3
1/19/02	7:58:40	3	25.5
1/20/02	18:50:16	3	26.0
1/22/02	23:54:24	3	26.5
1/24/02	23:08:48	3	27.0
1/26/02	17:56:16	3	27.5
1/29/02	2:52:24	3	28.0
1/29/02	18:27:36	3	28.5
1/31/02	4:17:28	3	29.0
2/2/02	17:11:04	3	29.5
2/3/02	12:10:08	3	25.7
2/11/02	22:12:08	3	28.0
2/13/02	9:44:24	3	28.5
2/14/02	14:19:04	3	29.0
2/16/02	12:57:36	3	25.3
2/18/02	1:51:28	3	25.5
2/19/02	19:00:56	3	26.0
2/26/02	14:37:04	3	28.0
2/27/02	22:45:28	3	28.5
3/1/02	0:28:08	3	29.0
3/1/02	16:54:57	3	28.2
3/3/02	4:05:52	3	28.5
3/4/02	1:01:44	3	29.0
3/5/02	10:06:42	3	25.7
3/10/02	15:19:20	3	27.0
1/9/02	11:06:09	6	18.0
1/9/02	11:40:08	6	27.6
1/9/02	11:58:00	6	28.0
1/9/02	14:21:44	6	27.5
1/18/02	8:32:48	6	27.0
2/5/02	17:45:36	6	27.5
2/14/02	14:18:24	6	28.0
2/20/02	12:58:24	6	28.5
2/25/02	6:13:04	6	28.5
2/27/02	0:06:24	6	29.0
3/3/02	13:34:48	6	29.5
3/5/02	10:06:48	6	25.8
3/8/02	16:27:12	6	26.0
3/10/02	1:51:20	6	26.0

Table G2. Temperature data for 14% m.c. canola stored between 25 and 30°C

Date	Time	Replicate	Flask Temp (°C)	Date	Time	Replicate	Flask Temp (°C)
3/23/02	10:50:40	1	25.3	3/22/02	15:18:16	2	27.0
3/23/02	11:07:04	1	26.5	3/23/02	14:38:08	2	27.0
3/24/02	1:59:44	1	27.0	3/24/02	4:49:36	2	27.5
3/24/02	20:22:08	1	27.5	3/24/02	18:26:56	2	28.0
3/25/02	19:43:04	1	28.0	3/25/02	10:51:36	2	28.5
3/27/02	5:12:00	1	28.5	3/26/02	17:01:52	2	29.0
3/27/02	19:37:20	1	29.0	3/26/02	23:04:56	2	27.8
3/28/02	19:27:12	1	27.2	3/27/02	3:07:12	2	28.0
3/29/02	13:11:52	1	27.5	3/27/02	13:59:52	2	28.5
3/30/02	9:17:28	1	28.0	3/28/02	5:02:16	2	29.0
3/31/02	1:41:04	1	28.5	3/28/02	19:27:12	2	26.9
4/1/02	10:18:08	1	29.0	3/28/02	22:15:44	2	27.0
4/3/02	19:28:16	1	27.2	3/30/02	4:08:56	2	27.5
4/4/02	3:49:20	1	27.5	3/30/02	15:34:48	2	28.0
4/4/02	15:28:40	1	28.0	3/31/02	6:33:44	2	28.5
4/5/02	7:10:24	1	28.5	4/1/02	15:45:52	2	29.0
4/5/02	19:17:04	1	29.0	4/3/02	19:28:25	2	27.1
4/6/02	18:15:52	1	26.9	4/4/02	4:00:56	2	27.5
4/7/02	2:19:20	1	27.0	4/4/02	20:21:04	2	28.0
4/8/02	4:58:16	1	27.5	4/5/02	5:47:04	2	28.5
4/8/02	18:30:24	1	28.0	4/5/02	14:28:32	2	29.0
4/10/02	14:43:52	1	28.5	4/6/02	8:58:40	2	29.5
4/11/02	4:40:48	1	29.0	4/6/02	18:15:53	2	27.0
4/11/02	15:20:56	1	29.5	4/7/02	22:50:16	2	27.5
4/12/02	18:13:44	1	27.7	4/8/02	9:48:32	2	28.0
4/13/02	0:28:08	1	28.0	4/8/02	19:18:56	2	28.5
4/13/02	11:10:24	1	28.5	4/10/02	9:17:20	2	29.0
4/13/02	22:24:16	1	29.0	4/10/02	23:52:40	2	29.5
4/14/02	13:34:18	1	28.3	4/11/02	8:21:44	2	30.0
4/14/02	19:30:48	1	28.5	4/11/02	16:45:36	2	30.5
4/15/02	5:52:00	1	29.0	4/12/02	18:13:52	2	28.2
4/15/02	16:37:20	1	29.5	4/12/02	21:25:44	2	28.5
4/18/02	19:10:32	1	27.8	4/13/02	4:23:52	2	29.0
4/18/02	23:14:48	1	28.0	4/13/02	12:42:08	2	29.5
4/19/02	8:58:00	1	28.5	4/14/02	3:08:16	2	30.0
4/19/02	21:29:44	1	29.0	4/14/02	13:34:18	2	29.0
4/20/02	8:15:44	1	29.5	4/18/02	9:35:36	2	25.5
4/20/02	19:25:36	1	30.0	4/19/02	6:04:40	2	26.0
4/21/02	18:12:40	1	27.7	4/19/02	19:12:16	2	26.5
				4/20/02	6:44:16	2	27.0
				4/20/02	18:00:40	2	27.5

Table G2(continued). Temperature data for 14% m.c. canola stored between 25 and 30°C

Date	Time	Replicate	Flask Temp (°C)
3/22/02	10:36:09	3	20.3
3/22/02	11:32:56	3	26.6
3/22/02	19:54:56	3	27.0
3/23/02	13:50:16	3	27.5
3/24/02	6:45:44	3	28.0
3/24/02	23:55:20	3	28.5
3/25/02	16:51:12	3	29.0
3/26/02	14:00:48	3	25.0
3/27/02	15:08:48	3	25.5
3/28/02	11:43:44	3	26.0
3/29/02	4:24:32	3	26.5
3/29/02	17:55:28	3	27.0
3/30/02	7:06:32	3	27.5
3/30/02	18:59:44	3	28.0
3/31/02	5:31:20	3	28.5
3/31/02	15:30:24	3	29.0
4/1/02	0:58:32	3	29.5
4/1/02	19:12:32	3	27.6
4/2/02	6:24:40	3	28.0
4/2/02	17:16:08	3	28.5
4/3/02	3:50:00	3	29.0
4/3/02	17:08:48	3	29.5
4/4/02	9:07:28	3	26.5
4/5/02	5:11:36	3	27.0
4/5/02	18:33:52	3	27.5
4/6/02	7:41:20	3	28.0
4/6/02	19:15:12	3	28.5
4/7/02	6:08:24	3	29.0
4/7/02	18:23:44	3	27.0
4/8/02	6:44:16	3	27.5
4/8/02	17:50:08	3	28.0
4/9/02	4:15:28	3	28.5
4/9/02	14:00:24	3	29.0
4/9/02	23:17:20	3	29.5
4/10/02	7:20:08	3	30.0
4/10/02	17:50:08	3	27.9
4/10/02	18:03:52	3	27.5
4/10/02	22:44:16	3	28.0
4/11/02	6:41:04	3	28.5
4/11/02	14:49:12	3	29.0
4/11/02	22:49:36	3	29.5
4/12/02	6:28:32	3	30.0
4/12/02	15:37:44	3	30.5
4/13/02	9:03:52	3	26.9
4/13/02	13:02:08	3	27.0
4/13/02	19:58:08	3	27.5
4/14/02	3:15:44	3	28.0
4/14/02	13:34:25	3	27.5
4/14/02	15:30:40	3	27.5
4/14/02	22:32:16	3	28.0
4/15/02	5:40:40	3	28.5
4/15/02	12:30:56	3	29.0
4/15/02	18:50:24	3	29.5
4/16/02	1:02:40	3	30.0
4/16/02	7:01:12	3	30.5
4/16/02	12:50:16	3	31.0
4/16/02	18:12:48	3	31.5
4/16/02	23:21:20	3	32.0
4/17/02	4:18:40	3	32.5
4/17/02	9:07:12	3	33.0
4/17/02	13:45:04	3	33.5
4/17/02	18:05:36	3	34.0
4/17/02	22:19:52	3	34.5
4/18/02	2:21:36	3	35.0
4/18/02	6:20:48	3	35.5
4/19/02	9:00:00	3	28.0
4/19/02	17:08:16	3	28.5
4/19/02	21:47:52	3	29.0
4/20/02	2:52:24	3	29.5
4/20/02	7:56:48	3	30.0
4/20/02	12:42:16	3	30.5
4/20/02	17:27:20	3	31.0
4/20/02	22:12:56	3	31.5
4/21/02	2:32:56	3	32.0
4/21/02	6:59:04	3	32.5

Table G2(continued). Temperature data for 14% m.c. canola stored between 25 and 30°C

Date	Time	Replicate	Flask Temp (°C)
3/22/02	10:36:09	5	20.1
3/22/02	18:19:28	5	26.8
3/22/02	23:44:32	5	27.0
3/23/02	21:07:04	5	27.5
3/24/02	23:25:04	5	28.0
3/27/02	4:07:52	5	28.5
3/27/02	22:44:32	5	29.0
3/29/02	9:49:29	5	26.1
3/29/02	20:29:52	5	26.5
3/30/02	15:32:00	5	27.0
3/31/02	11:49:12	5	27.5
4/3/02	11:56:48	5	28.0
4/4/02	2:17:04	5	28.5
4/4/02	15:14:16	5	29.0
4/5/02	2:37:28	5	29.5
4/5/02	13:05:04	5	30.0
4/7/02	8:54:00	5	25.4
4/7/02	11:18:24	5	25.5
4/8/02	3:12:40	5	26.0
4/8/02	19:44:40	5	26.5
4/9/02	17:33:28	5	27.0
4/11/02	2:49:44	5	27.5
4/11/02	17:17:20	5	28.0
4/12/02	8:54:08	5	28.5
4/13/02	2:53:36	5	29.0
4/13/02	14:23:44	5	29.5
4/14/02	13:34:25	5	28.4
4/14/02	13:35:44	5	26.0
4/19/02	6:04:48	5	26.5
4/19/02	23:45:28	5	27.0
4/20/02	15:41:44	5	27.5
4/21/02	8:26:48	5	28.0

Date	Time	Replicate	Flask Temp (°C)
3/22/02	10:36:09	6	25.9
3/22/02	10:38:56	6	26.4
3/22/02	16:47:52	6	26.9
3/23/02	10:10:48	6	27.4
3/24/02	5:21:28	6	27.9
3/25/02	1:24:24	6	28.4
3/25/02	23:32:40	6	28.9
3/26/02	23:05:05	6	27.5
3/27/02	2:16:08	6	27.5
3/27/02	14:00:48	6	28.0
3/28/02	3:28:56	6	28.5
3/28/02	18:32:00	6	29.0
3/29/02	9:49:29	6	26.4
3/29/02	14:31:12	6	26.5
3/30/02	2:59:28	6	27.0
3/30/02	14:40:40	6	27.5
3/31/02	2:37:36	6	28.0
3/31/02	16:49:28	6	28.5
4/1/02	19:12:41	6	26.5
4/2/02	17:13:20	6	27.0
4/3/02	15:30:56	6	27.5
4/4/02	2:09:20	6	28.0
4/4/02	12:35:36	6	28.5
4/4/02	22:15:28	6	29.0
4/5/02	7:24:48	6	29.5
4/5/02	17:19:36	6	30.0
4/6/02	8:58:40	6	30.5
4/7/02	8:54:00	6	26.8
4/7/02	18:36:48	6	27.0
4/8/02	5:20:48	6	27.5
4/8/02	16:53:44	6	28.0
4/9/02	5:01:04	6	28.5
4/9/02	22:20:08	6	29.0
4/10/02	17:50:09	6	27.2
4/10/02	23:08:24	6	27.5
4/11/02	9:50:48	6	28.0
4/11/02	21:24:48	6	28.5
4/12/02	10:16:32	6	29.0
4/13/02	9:03:46	6	26.7
4/13/02	16:38:16	6	27.0
4/14/02	6:24:16	6	27.5
4/14/02	13:34:25	6	26.7
4/14/02	21:14:32	6	27.0
4/15/02	10:33:36	6	27.5
4/15/02	23:43:52	6	28.0
4/16/02	15:09:20	6	28.5
4/17/02	15:54:08	6	29.0
4/19/02	9:00:00	6	26.2
4/19/02	15:46:40	6	26.5
4/20/02	4:02:08	6	27.0
4/20/02	17:04:40	6	27.5
4/21/02	6:28:24	6	28.0

Table G3. Temperature data for 12% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
10/26/01	9:44:32	1	24.8
10/28/01	13:08:32	1	34.0
10/29/01	10:10:10	1	30.8
10/29/01	15:14:40	1	31.0
10/31/01	6:01:28	1	31.5
11/2/01	18:25:12	1	32.0
11/5/01	3:04:08	1	32.5
11/7/01	6:17:44	1	33.0
11/9/01	0:59:52	1	33.5
11/10/01	13:04:16	1	34.0
11/11/01	19:11:52	1	34.5
11/12/01	20:18:16	1	35.0
11/14/01	10:11:21	1	30.3
11/14/01	16:04:40	1	30.5
11/15/01	16:58:40	1	31.0
11/16/01	18:40:32	1	31.5
11/17/01	13:17:36	1	32.0
11/18/01	7:28:40	1	32.5
11/19/01	0:18:08	1	33.0
11/19/01	14:40:48	1	33.5
11/20/01	5:04:08	1	34.0
11/20/01	18:56:24	1	34.5
11/21/01	7:05:20	1	35.0
11/22/01	10:19:20	1	31.1
11/22/01	19:01:04	1	31.5
11/23/01	13:40:24	1	32.0
11/24/01	10:54:32	1	32.5
11/25/01	5:52:00	1	33.0
11/25/01	23:27:12	1	33.5
11/26/01	14:52:56	1	34.0
11/27/01	5:15:12	1	34.5
11/28/01	11:43:53	1	30.9
11/28/01	14:09:12	1	31.0
11/29/01	3:29:04	1	31.5
11/30/01	1:30:32	1	32.0
11/30/01	23:50:16	1	32.5
12/1/01	19:44:40	1	33.0
12/2/01	12:40:56	1	33.5
12/3/01	4:51:04	1	34.0
12/3/01	19:01:20	1	34.5
12/4/01	9:10:00	1	35.0
12/4/01	23:39:28	1	35.5
12/6/01	9:34:17	1	30.6
12/6/01	15:52:16	1	31.0
12/7/01	11:43:20	1	31.5
12/8/01	12:44:56	1	32.0
12/9/01	15:23:36	1	33.0

Date	Time	Replicate	Flask Temp (°C)
10/26/01	9:44:33	2	24.8
10/27/01	12:41:44	2	32.0
10/27/01	12:50:40	2	34.4
10/29/01	10:10:17	2	30.8
11/8/01	14:01:28	2	31.0
11/10/01	14:28:00	2	31.5
11/12/01	2:18:24	2	32.0
11/13/01	7:18:32	2	32.5
11/14/01	7:18:40	2	33.0
11/15/01	2:20:32	2	33.5
11/15/01	19:52:40	2	34.0
11/16/01	15:07:04	2	32.8
11/17/01	8:43:52	2	33.0
11/18/01	13:13:36	2	33.5
11/19/01	14:04:08	2	34.0
11/20/01	10:20:32	2	34.5
11/21/01	10:18:25	2	30.4
11/21/01	19:37:12	2	30.5
11/23/01	8:25:52	2	31.0
11/24/01	23:12:48	2	31.5
11/26/01	8:48:24	2	32.0
11/27/01	9:59:04	2	32.5
11/28/01	15:31:36	2	33.0
11/29/01	15:41:52	2	33.5
11/30/01	20:59:28	2	34.0
12/1/01	17:03:04	2	34.5
12/2/01	16:12:08	2	35.0
12/3/01	10:29:52	2	31.2
12/4/01	3:40:56	2	31.5
12/5/01	7:52:16	2	32.0
12/6/01	7:57:20	2	32.5
12/7/01	13:22:48	2	33.0

Table G3(continued). Temperature data for 12% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
10/26/01	9:44:33	3	35.8
10/26/01	13:10:32	3	34.4
10/27/01	11:50:56	3	29.1
11/2/01	15:41:04	3	29.5
11/6/01	0:32:48	3	30.0
11/7/01	14:50:56	3	30.5
11/9/01	5:11:36	3	31.0
11/10/01	8:11:52	3	31.5
11/11/01	12:13:12	3	32.0
11/12/01	15:14:32	3	32.5
11/13/01	14:55:36	3	33.0
11/14/01	14:33:36	3	33.5
11/15/01	10:25:52	3	34.0
11/16/01	10:05:20	3	30.8
11/16/01	18:38:00	3	30.5
11/17/01	13:40:32	3	31.0
11/18/01	22:00:16	3	31.5
11/19/01	15:29:44	3	32.0
11/20/01	14:35:44	3	32.5
11/21/01	14:44:00	3	33.0
11/22/01	8:18:32	3	33.5
11/23/01	8:25:28	3	34.0
11/23/01	15:50:40	3	32.7
11/24/01	18:04:48	3	33.0
11/25/01	16:38:08	3	33.5
11/26/01	7:32:56	3	34.0
11/27/01	10:24:24	3	30.7
11/28/01	4:03:20	3	31.0
11/29/01	5:21:12	3	31.5
11/30/01	1:30:08	3	32.0
12/1/01	6:04:16	3	32.5
12/1/01	22:07:44	3	33.0
12/2/01	16:10:08	3	33.5
12/3/01	5:31:44	3	34.0
12/3/01	21:42:32	3	34.5
12/4/01	18:09:20	3	35.0
12/5/01	3:35:36	3	35.5
12/6/01	9:34:17	3	29.6
12/6/01	20:16:24	3	30.0
12/7/01	11:18:16	3	30.5

Date	Time	Replicate	Flask Temp (°C)
10/26/01	9:44:33	5	25.0
10/27/01	12:35:04	5	34.0
11/1/01	10:41:20	5	34.5
11/6/01	9:37:36	5	31.6
11/11/01	20:26:48	5	32.0
11/13/01	8:22:32	5	32.5
11/14/01	23:52:56	5	33.0
11/16/01	3:56:40	5	33.5
11/16/01	15:07:04	5	32.4
11/16/01	18:40:48	5	32.5
11/17/01	14:35:12	5	33.0
11/18/01	18:10:56	5	33.5
11/19/01	14:42:16	5	34.0
11/21/01	10:18:17	5	31.2
11/22/01	4:27:44	5	31.5
11/23/01	17:55:52	5	32.0
11/25/01	8:19:52	5	32.5
11/27/01	6:02:32	5	33.0
11/28/01	18:33:52	5	33.5
11/29/01	22:10:24	5	34.0
12/1/01	7:52:24	5	34.5
12/2/01	12:37:44	5	35.0
12/3/01	10:29:52	5	32.0
12/3/01	14:58:40	5	32.0
12/4/01	19:27:20	5	32.5
12/6/01	3:45:28	5	33.0
12/7/01	13:42:32	5	33.5
12/8/01	16:02:33	5	34.0

Table G3(continued). Temperature data for 12% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
10/26/01	9:44:33	6	24.8
10/26/01	13:10:51	6	34.5
10/27/01	11:51:05	6	29.7
10/29/01	15:55:36	6	30.0
11/1/01	19:46:16	6	30.5
11/5/01	4:27:44	6	31.0
11/7/01	14:43:36	6	31.5
11/9/01	13:45:52	6	32.0
11/10/01	23:21:36	6	32.5
11/12/01	3:39:20	6	33.0
11/13/01	7:32:32	6	33.5
11/14/01	6:49:12	6	34.0
11/15/01	10:25:04	6	31.2
11/16/01	9:11:36	6	31.5
11/17/01	18:29:12	6	32.0
11/19/01	11:43:04	6	32.5
11/20/01	14:03:44	6	33.0
11/21/01	20:00:56	6	33.5
11/23/01	0:06:40	6	34.0
11/23/01	15:50:40	6	33.0
11/23/01	16:05:04	6	33.0
11/23/01	18:43:12	6	32.5
11/24/01	12:11:20	6	33.0
11/25/01	14:01:44	6	33.5
11/27/01	10:24:33	6	31.0
11/27/01	10:51:44	6	31.0
11/29/01	5:22:00	6	31.5
11/30/01	23:08:56	6	32.0
12/2/01	3:15:04	6	32.5
12/3/01	5:31:28	6	33.0
12/4/01	8:03:36	6	33.5
12/5/01	11:27:12	6	34.0
12/6/01	15:50:32	6	34.5
12/7/01	11:18:16	6	35.0

Table G4. Temperature data for 14% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:08	1	24.8
6/20/01	9:57:28	1	34.4
6/20/01	10:02:32	1	34.5
6/20/01	14:39:12	1	35.0
6/20/01	19:58:08	1	35.5
6/21/01	4:35:12	1	36.0
6/22/01	9:22:00	1	31.2
6/22/01	16:35:28	1	31.5
6/22/01	21:42:24	1	32.0
6/23/01	4:32:40	1	32.5
6/23/01	14:07:44	1	33.0
6/23/01	18:10:32	1	33.5
6/23/01	22:56:24	1	34.0
6/24/01	6:11:44	1	34.5
6/25/01	10:17:13	1	32.1
6/25/01	17:12:56	1	32.5
6/25/01	20:53:04	1	33.0
6/26/01	1:29:44	1	33.5
6/26/01	12:16:16	1	34.0
6/27/01	10:04:32	1	31.6
6/27/01	15:31:36	1	32.0
6/27/01	19:05:12	1	32.5
6/27/01	22:48:08	1	33.0
6/28/01	8:36:24	1	33.5
6/29/01	2:02:48	1	34.0
6/29/01	13:13:44	1	34.5
6/30/01	10:33:12	1	31.6
6/30/01	17:16:40	1	32.0
6/30/01	21:00:56	1	32.5
7/1/01	1:13:52	1	33.0
7/1/01	17:08:08	1	33.5
7/1/01	20:42:32	1	34.0
7/2/01	0:15:04	1	34.5
7/3/01	9:35:20	1	31.7
7/3/01	17:29:44	1	32.0
7/3/01	21:01:04	1	32.5
7/4/01	1:00:48	1	33.0
7/4/01	15:37:28	1	33.5
7/4/01	19:02:56	1	34.0
7/4/01	22:38:16	1	34.5

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:08	2	24.6
6/21/01	10:23:12	2	37.5
6/22/01	9:22:08	2	31.4
6/22/01	13:07:52	2	31.5
6/22/01	18:32:00	2	32.0
6/22/01	23:33:12	2	32.5
6/23/01	6:36:16	2	33.0
6/23/01	15:38:40	2	33.5
6/23/01	20:39:12	2	34.0
6/24/01	4:10:48	2	34.5
6/24/01	14:22:40	2	35.0
6/25/01	10:17:20	2	32.1
6/25/01	17:35:04	2	32.5
6/25/01	21:23:52	2	33.0
6/26/01	2:11:44	2	33.5
6/26/01	12:36:32	2	34.0
6/27/01	10:04:32	2	30.8
6/27/01	13:39:20	2	31.0
6/27/01	17:28:48	2	31.5
6/27/01	21:06:48	2	32.0
6/28/01	1:39:36	2	32.5
6/28/01	18:05:20	2	33.0
6/29/01	12:32:56	2	33.5
6/29/01	16:04:48	2	34.0
6/29/01	19:54:08	2	34.5
6/30/01	5:56:16	2	35.0
7/1/01	9:53:04	2	31.8
7/1/01	16:17:20	2	32.0
7/1/01	19:36:00	2	32.5
7/1/01	22:56:56	2	33.0
7/2/01	2:44:56	2	33.5
7/2/01	16:45:20	2	34.0
7/2/01	19:42:40	2	34.5
7/2/01	23:08:40	2	35.0
7/3/01	13:21:20	2	35.5
7/3/01	18:49:28	2	36.0
7/3/01	21:41:04	2	36.5
7/4/01	4:09:44	2	37.0
7/5/01	9:42:17	2	31.8
7/5/01	16:06:56	2	32.0
7/5/01	19:32:08	2	32.5
7/5/01	22:54:24	2	33.0
7/6/01	3:17:52	2	33.5

Table G4(continued). Temperature data for 14% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:09	3	24.6
6/22/01	11:31:12	3	34.5
6/23/01	8:35:13	3	31.1
6/23/01	19:12:16	3	31.5
6/24/01	4:14:56	3	32.0
6/24/01	15:22:08	3	32.5
6/25/01	0:06:32	3	33.0
6/25/01	8:51:36	3	33.5
6/25/01	18:05:12	3	34.0
6/26/01	0:47:44	3	34.5
6/26/01	8:46:40	3	35.0
6/27/01	10:04:32	3	30.5
6/27/01	19:37:36	3	31.0
6/28/01	1:54:56	3	31.5
6/28/01	9:37:20	3	32.0
6/29/01	6:35:12	3	32.5
6/29/01	16:08:24	3	33.0
6/29/01	21:46:40	3	33.5
6/30/01	4:29:20	3	34.0
7/1/01	9:52:57	3	30.3
7/1/01	16:17:20	3	30.5
7/2/01	0:17:20	3	31.0
7/2/01	6:14:00	3	31.5
7/2/01	15:27:28	3	32.0
7/2/01	21:00:56	3	32.5
7/3/01	2:47:04	3	33.0
7/3/01	14:09:12	3	33.5
7/3/01	20:49:44	3	34.0
7/4/01	1:22:08	3	34.5
7/4/01	10:47:12	3	35.0
7/5/01	9:42:24	3	31.7
7/5/01	19:36:48	3	32.0
7/6/01	0:42:48	3	32.5
7/6/01	6:36:00	3	33.0
7/7/01	10:00:40	3	33.5

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:09	4	35.8
6/20/01	15:39:47	4	35.7
6/22/01	9:22:00	4	31.2
6/22/01	20:50:48	4	31.5
6/23/01	6:17:52	4	32.0
6/23/01	17:35:28	4	32.5
6/24/01	0:31:20	4	33.0
6/24/01	17:34:56	4	33.5
6/24/01	22:56:16	4	34.0
6/25/01	16:28:40	4	34.5
6/25/01	21:04:00	4	35.0
6/27/01	10:04:41	4	32.0
6/27/01	14:57:28	4	32.0
6/27/01	19:15:28	4	32.5
6/28/01	0:21:52	4	33.0
6/29/01	15:09:44	4	33.5
6/29/01	19:56:32	4	34.0
7/1/01	9:52:57	4	31.0
7/1/01	16:30:00	4	31.0
7/1/01	21:56:48	4	31.5
7/2/01	3:00:24	4	32.0
7/2/01	18:15:44	4	32.5
7/2/01	22:50:08	4	33.0
7/3/01	17:52:16	4	33.5
7/3/01	22:15:28	4	34.0
7/4/01	15:34:24	4	33.5
7/4/01	20:26:56	4	34.0

Table G4(continued). Temperature data for 14% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:09	5	24.8
6/21/01	10:53:52	5	35.2
6/21/01	16:29:36	5	33.7
6/21/01	22:25:36	5	34.0
6/22/01	4:47:12	5	34.5
6/22/01	12:19:44	5	35.0
6/23/01	8:35:28	5	31.9
6/23/01	11:58:08	5	32.0
6/23/01	18:01:52	5	32.5
6/24/01	0:01:44	5	33.0
6/24/01	5:50:56	5	33.5
6/24/01	11:24:48	5	34.0
6/25/01	10:17:28	5	32.0
6/25/01	16:27:04	5	32.5
6/25/01	19:52:24	5	33.0
6/25/01	23:32:48	5	33.5
6/26/01	3:27:20	5	34.0
6/26/01	7:26:08	5	34.5
6/27/01	10:04:41	5	30.3
6/27/01	16:36:00	5	30.5
6/27/01	21:27:28	5	31.0
6/29/01	16:19:12	5	31.5
6/29/01	22:55:44	5	32.0
6/30/01	19:46:24	5	32.5
7/1/01	1:41:12	5	33.0
7/1/01	21:37:44	5	33.5
7/2/01	3:26:24	5	34.0
7/2/01	21:22:16	5	34.5
7/4/01	9:11:21	5	31.0
7/4/01	20:46:00	5	31.5
7/5/01	2:53:36	5	32.0
7/5/01	21:11:28	5	32.5
7/6/01	3:07:52	5	33.0

Date	Time	Replicate	Flask Temp (°C)
6/20/01	9:28:09	6	24.8
6/22/01	9:44:40	6	34.7
6/22/01	9:59:36	6	35.0
6/23/01	8:35:28	6	31.5
6/23/01	13:36:16	6	31.5
6/24/01	0:01:36	6	32.0
6/24/01	10:39:28	6	32.5
6/24/01	21:22:48	6	33.0
6/25/01	6:23:04	6	33.5
6/25/01	15:15:28	6	34.0
6/25/01	23:05:04	6	34.5
6/26/01	6:29:28	6	35.0
6/27/01	10:04:41	6	30.7
6/27/01	18:14:56	6	31.0
6/28/01	0:35:52	6	31.5
6/28/01	7:43:36	6	32.0
6/28/01	20:58:08	6	32.5
6/29/01	11:33:04	6	33.0
6/29/01	17:44:08	6	33.5
6/29/01	23:18:08	6	34.0
6/30/01	6:15:20	6	34.5
7/1/01	9:52:48	6	30.7
7/1/01	19:29:20	6	31.0
7/2/01	1:45:36	6	31.5
7/2/01	8:18:32	6	32.0
7/2/01	15:18:40	6	32.5
7/2/01	21:58:32	6	33.0
7/3/01	3:11:36	6	33.5
7/3/01	11:16:56	6	34.0
7/3/01	19:58:08	6	34.5
7/4/01	0:47:20	6	35.0
7/4/01	6:07:36	6	35.5
7/5/01	9:42:33	6	31.7
7/5/01	19:34:24	6	32.0
7/6/01	1:13:52	6	32.5
7/6/01	6:59:52	6	33.0
7/6/01	17:17:12	6	33.5
7/7/01	8:22:00	6	34.0
7/7/01	13:01:20	6	34.2
7/7/01	13:01:28	6	34.1

Table G5. Temperature data for freshly harvested 10% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
8/30/00			
8/31/00	11:38:33	3	28.5
9/1/00	11:56:16	3	29.0
9/3/00	10:45:04	3	33.0
9/3/00	16:52:32	3	29.7
9/8/00	10:40:56	3	30.5
9/14/00	11:58:00	3	31.0
9/17/00	14:10:48	3	31.5
9/20/00	9:46:00	3	32.0
9/29/00	1:18:16	3	32.4
9/30/00	18:28:40	3	32.9
10/3/00	5:58:08	3	33.4
10/6/00	4:46:24	3	33.9
10/8/00	11:06:08	3	34.4
10/14/00	12:08:48	3	28.2
10/14/00	15:18:16	3	28.4
10/16/00	14:23:29	3	29.4
10/18/00	9:10:48	3	29.9
10/23/00	10:22:16	3	30.4
10/26/00	12:48:08	3	30.9
10/29/00	4:54:24	3	31.4
10/30/00	22:16:16	3	31.9
11/1/00	23:26:08	3	32.4
11/4/00	1:07:52	3	32.9
11/5/00	16:10:08	3	33.4
11/6/00	23:42:00	3	33.9
11/10/00	7:35:12	3	31.9
11/14/00	12:00:00	3	32.4
11/16/00	9:03:20	3	32.9
11/17/00	17:13:04	3	33.4
11/19/00	10:39:28	3	33.9
11/21/00	11:48:48	3	29.4
11/23/00	18:02:08	3	29.9

Date	Time	Replicate	Flask Temp (°C)
8/31/00	11:38:33	6	29.2
9/1/00	14:53:20	6	29.7
9/2/00	15:36:40	6	30.2
9/10/00	19:27:52	6	30.7
9/30/00	18:29:04	6	31.1
10/14/00	9:40:32	6	31.6
10/18/00	23:14:00	6	32.1
10/27/00	17:53:36	6	32.6
11/2/00	9:15:36	6	33.1
11/7/00	7:28:00	6	33.6
11/11/00	14:50:40	6	34.1
11/16/00	11:58:32	6	34.6
11/17/00	9:18:00	6	31.0
11/25/00	9:21:52	6	31.6

Table G6. Temperature data for freshly harvested 12% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
9/1/00	9:18:08	2	28.9
9/2/00	15:32:16	2	27.1
9/3/00	16:52:32	2	29.2
9/7/00	10:43:52	2	29.9
9/11/00	13:00:16	2	30.4
9/13/00	16:12:32	2	30.9
9/15/00	9:49:44	2	31.4
9/16/00	20:03:44	2	31.9
9/18/00	2:35:52	2	32.4
9/19/00	3:07:28	2	32.9
9/20/00	1:44:56	2	33.4
9/20/00	19:34:08	2	33.9
9/21/00	15:02:24	2	33.4
9/21/00	21:04:56	2	32.7
9/22/00	18:41:44	2	33.2
9/23/00	12:01:20	2	33.7
9/24/00	7:31:20	2	34.2
9/25/00	8:15:37	2	30.8
9/26/00	4:25:12	2	31.2
9/27/00	1:04:16	2	31.7
9/27/00	20:01:44	2	32.2
9/28/00	13:14:24	2	32.7
9/29/00	5:02:24	2	33.2
9/29/00	16:33:52	2	33.7
9/30/00	6:22:32	2	34.2
9/30/00	23:03:52	2	34.7
10/2/00	7:11:04	2	35.2
10/3/00	8:34:56	2	30.7
10/4/00	9:49:44	2	31.2
10/5/00	3:20:24	2	31.7
10/6/00	1:35:20	2	32.2
10/6/00	19:42:00	2	32.7
10/7/00	12:11:28	2	33.2
10/8/00	4:23:12	2	33.7
10/8/00	19:50:56	2	34.2
10/9/00	9:42:56	2	34.7
10/9/00	23:45:20	2	35.2
10/10/00	14:34:56	2	35.7
10/11/00	8:10:56	2	32.7
10/12/00	1:09:12	2	33.2
10/12/00	15:12:56	2	33.7
10/13/00	5:30:24	2	34.2
10/14/00	1:47:28	2	34.7
10/14/00	18:17:13	2	34.3
10/15/00	7:56:16	2	34.7
10/15/00	22:02:32	2	35.2
10/16/00	11:19:36	2	35.7
10/17/00	8:24:00	2	31.8
10/17/00	22:49:12	2	32.2
10/18/00	23:13:12	2	32.7
10/19/00	19:16:40	2	33.2
10/20/00	16:58:48	2	33.7

Date	Time	Replicate	Flask Temp (°C)
9/1/00	9:06:48	5	28.6
9/1/00	16:05:44	5	29.1
9/1/00	19:33:52	5	29.6
9/2/00	15:22:40	5	27.9
9/2/00	15:30:08	5	28.3
9/2/00	18:04:40	5	28.6
9/2/00	20:51:36	5	29.1
9/3/00	10:44:25	5	33.0
9/3/00	16:52:40	5	30.0
9/8/00	10:30:32	5	30.6
9/11/00	4:02:56	5	31.1
9/13/00	7:02:08	5	31.6
9/14/00	11:47:36	5	32.2
9/15/00	17:40:24	5	32.6
9/16/00	18:37:04	5	33.1
9/17/00	14:02:24	5	33.6
9/18/00	14:27:44	5	32.9
9/19/00	3:18:24	5	33.1
9/19/00	22:11:12	5	33.6
9/20/00	15:48:24	5	34.1
9/23/00	6:44:08	5	34.3
9/23/00	23:13:20	5	34.8
9/25/00	8:15:44	5	31.7
9/25/00	13:27:44	5	31.8
9/26/00	6:44:32	5	32.3
9/26/00	23:17:52	5	32.8
9/27/00	15:28:00	5	33.3
9/28/00	6:16:16	5	33.8
9/29/00	7:34:24	5	31.9
9/29/00	17:05:44	5	32.3
9/30/00	9:36:16	5	32.8
10/1/00	7:12:40	5	33.3
10/3/00	1:03:44	5	33.8
10/3/00	16:48:48	5	34.3
10/4/00	8:10:40	5	31.8
10/4/00	12:19:52	5	31.8
10/5/00	2:47:52	5	32.3
10/5/00	20:13:36	5	32.8
10/6/00	12:32:56	5	33.3
10/7/00	1:42:40	5	33.8
10/7/00	15:23:20	5	34.3
10/8/00	5:56:32	5	34.8
10/8/00	15:56:26	5	33.4
10/9/00	4:28:16	5	33.8
10/9/00	18:44:32	5	34.3
10/10/00	15:40:48	5	34.8
10/11/00	8:11:04	5	32.4
10/11/00	21:24:00	5	32.8
10/12/00	12:47:28	5	33.3
10/13/00	4:46:00	5	33.8
10/14/00	18:17:13	5	33.5
10/15/00	4:15:04	5	33.8
10/15/00	19:21:20	5	34.3
10/16/00	11:20:08	5	34.8
10/17/00	8:24:00	5	31.7
10/17/00	13:30:40	5	31.8
10/18/00	2:56:08	5	32.3
10/18/00	20:52:40	5	32.8
10/19/00	13:43:12	5	33.3
10/20/00	5:29:12	5	33.8

Table G7. Temperature data for freshly harvested 14% m.c. canola stored between 30 and 35°C

Date	Time	Replicate	Flask Temp (°C)
8/31/00	11:38:33	1	28.7
9/1/00	4:55:12	1	29.2
9/1/00	17:16:08	1	29.7
9/2/00	6:04:16	1	30.2
9/2/00	19:37:44	1	30.7
9/3/00	11:55:52	1	31.2
9/3/00	22:28:16	1	31.7
9/4/00	8:21:12	1	32.2
9/4/00	18:09:20	1	32.7
9/5/00	2:10:00	1	33.2
9/5/00	9:59:04	1	33.7
9/5/00	17:17:12	1	34.2
9/5/00	23:34:32	1	34.7
9/6/00	6:31:44	1	35.2
9/7/00	8:36:33	1	30.9
9/7/00	15:10:56	1	31.2
9/7/00	22:32:00	1	31.7
9/8/00	7:00:24	1	32.2
9/8/00	14:58:00	1	32.7
9/8/00	21:16:40	1	33.2
9/9/00	4:46:32	1	33.7
9/10/00	10:12:16	1	30.9
9/10/00	15:58:48	1	31.2
9/10/00	22:58:24	1	31.7
9/11/00	6:20:32	1	32.2
9/11/00	14:32:40	1	32.7
9/11/00	21:37:28	1	33.2
9/12/00	3:27:04	1	33.7
9/12/00	16:06:24	1	34.2
9/13/00	8:09:28	1	31.7
9/13/00	14:34:08	1	32.2
9/13/00	20:45:36	1	32.7
9/14/00	3:39:20	1	33.2
9/14/00	14:31:36	1	33.7
9/14/00	20:16:56	1	34.2
9/15/00	2:23:04	1	34.7
9/15/00	12:11:04	1	35.2
9/17/00	10:35:12	1	27.6
9/18/00	1:50:48	1	28.2
9/18/00	13:24:00	1	28.7
9/18/00	23:44:32	1	29.2
9/19/00	10:08:08	1	29.7
9/19/00	19:21:20	1	30.2
9/20/00	3:58:32	1	30.7
9/20/00	12:32:00	1	31.2
9/20/00	19:55:52	1	31.7
9/21/00	3:08:56	1	32.2
9/21/00	12:06:00	1	32.7
9/21/00	21:04:56	1	32.6
9/22/00	5:03:52	1	33.1
9/22/00	13:47:36	1	33.6
9/22/00	19:27:28	1	34.1
9/23/00	1:36:24	1	34.6
9/23/00	23:09:12	1	35.1
9/24/00	15:03:04	1	35.6
9/25/00	8:15:36	1	32.3
9/25/00	15:00:16	1	32.6
9/25/00	20:26:56	1	33.1
9/26/00	2:25:20	1	33.6
9/26/00	13:31:28	1	34.1
9/26/00	18:48:24	1	34.6
9/26/00	23:57:44	1	35.1
9/27/00	11:37:44	1	35.6
9/28/00	9:35:52	1	31.4
9/28/00	14:18:56	1	31.6
9/28/00	20:10:08	1	32.1
9/29/00	1:52:56	1	32.6
9/29/00	12:05:36	1	33.1
10/2/00	11:05:20	1	32.6
10/2/00	17:53:44	1	33.1
8/31/00	11:38:33	4	28.2
9/1/00	4:23:20	4	28.7
9/1/00	11:54:00	4	29.2
9/1/00	16:14:56	4	29.7
9/2/00	5:50:56	4	30.2
9/2/00	15:11:52	4	28.2
9/2/00	19:27:12	4	29.2
9/2/00	22:30:48	4	29.7
9/3/00	11:55:52	4	30.2
9/3/00	23:57:52	4	30.7
9/4/00	15:44:40	4	31.2
9/5/00	2:34:32	4	31.7
9/5/00	14:45:20	4	32.2
9/5/00	22:46:48	4	32.7
9/6/00	12:16:40	4	33.2
9/7/00	16:19:04	4	33.7
9/8/00	0:08:24	4	34.2
9/9/00	10:15:44	4	31.0
9/9/00	20:37:20	4	31.2
9/10/00	4:12:48	4	31.7
9/10/00	16:07:20	4	32.2
9/10/00	22:20:24	4	32.7
9/11/00	14:34:40	4	33.2
9/11/00	20:34:16	4	33.7
9/12/00	8:32:56	4	34.2
9/13/00	8:09:36	4	32.7
9/13/00	15:46:08	4	33.2
9/13/00	21:03:36	4	33.7
9/14/00	16:02:48	4	34.2
9/14/00	21:58:08	4	34.7
9/15/00	13:32:40	4	35.2
9/17/00	10:35:12	4	28.7
9/17/00	22:01:28	4	29.2
9/18/00	7:07:44	4	29.7
9/18/00	15:50:00	4	30.2
9/19/00	0:14:40	4	30.7
9/19/00	15:15:44	4	31.2
9/19/00	22:47:28	4	31.7
9/20/00	12:09:04	4	32.2
9/20/00	18:56:08	4	32.7
9/21/00	11:15:20	4	33.2
9/21/00	21:04:56	4	33.4
9/22/00	13:52:00	4	33.9
9/22/00	20:11:12	4	34.4
9/25/00	8:15:44	4	31.9
9/25/00	13:04:08	4	31.9
9/25/00	19:03:36	4	32.4
9/26/00	11:22:24	4	32.9
9/26/00	17:26:32	4	33.4
9/26/00	23:46:08	4	33.9
9/28/00	9:36:00	4	31.6
9/28/00	17:02:48	4	32.0
9/28/00	23:28:08	4	32.4
9/29/00	12:12:24	4	32.9
10/2/00	23:59:04	4	33.4