IMPROVED MANAGEMENT OF STORED PULSES

RESEARCH UPDATE—FINAL

AUGUST 2019

Project Description

A two year study on the storage of pulses is complete. The overall objective of the project was to better define best management practices for the storage of pulses. The specific objectives were:

- To determine the effect of airflow rate on drying and cooling rates of peas and lentils
- To investigate if airflow rate has an effect on pea and lentil quality (germination)
- To verify that existing information on resistance to airflow is accurate for peas and lentils so producers can make informed decisions on fan size selection
- To verify that existing information on the equilibrium moisture content of peas and lentils is accurate so producers can make informed decisions on fan operation

Airflow Rate, Drying & Cooling

The Canadian Grain Commission has published guidelines and information on the temperature and moisture content (MC) required to minimize the risk of spoilage during storage. For peas, the target MC is 16%. For green lentils, the target MC is 14%. For all grain types, the target temperature is 15°C or lower.

Blowing air through grain is the most common method to control temperature in the bin. If the grain is tough (but not wet), then blowing ambient air through grain can also result in moisture removal. Using air for temperature control is known as aeration while using ambient air for drying is known as natural air drying (NAD). Year 2 trials were completed using green lentils and yellow peas; the effect of airflow rate on the drying and cooling rates can be seen in the following charts.

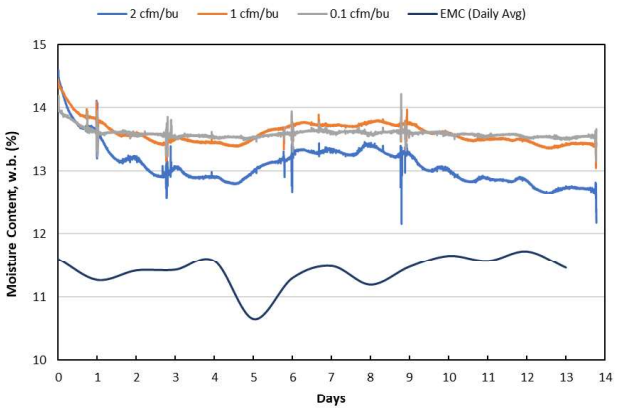


Figure 1. Average moisture content and ambient temperature throughout the green lentil drying trial (August 21 to September 4, 2018).

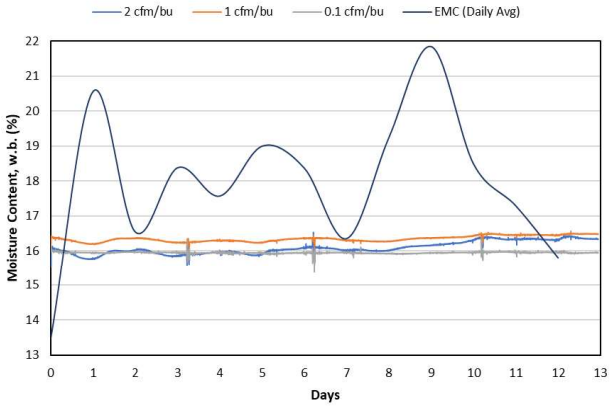


Figure 2. Average moisture content and ambient temperature throughout the pea drying trial (September 6 to 20, 2018).

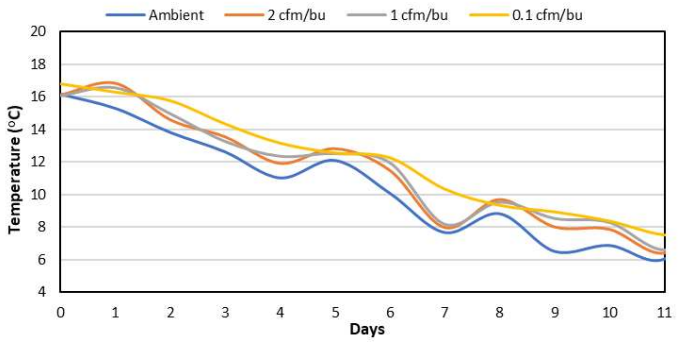
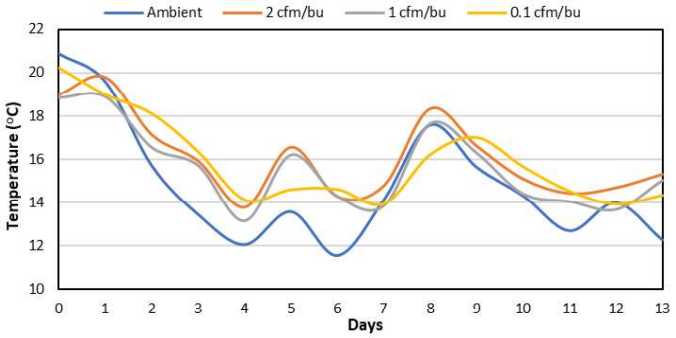


Figure 3. (left) Ambient temperature compared to average grain temperature in the bin throughout the pea drying trial (September 6 to 20, 2018).

Figure 4. (right) Ambient temperature compared to the average grain temperature in the bin throughout the green lentil drying trial (August 21 to September 4, 2018).



HOW LONG SHOULD I RUN MY FANS TO DRY LENTILS OR PEAS?

Fan run time depends on airflow rate, starting moisture content, and ambient conditions. For the green lentil trial (Figure 1), "safe to store" moisture conditions (<14%) were reached in less than one day.

For the pea trial (Figure 2), the starting moisture content was close to the "safe to store" moisture content of 16% MC; however, unusually high RH (60% to 90%) and low ambient temperatures (dropped from 18°C to 5°C over the trial) during the Year 2 (2018) pea drying trial resulted in slight rewetting (<1%) instead of drying.

Rate of drying depends heavily on ambient air conditions (moisture and RH); EMC is an indicator of potential moisture content that can be achieved over an extended period of time based on the ambient conditions.

HOW LONG SHOULD I RUN MY FANS TO COOL LENTILS OR PEAS?

As shown in Figures 3 and 4, the cooling rate is highly dependent on ambient temperature. If the goal is to cool the grain, run the fans when the average ambient temperature is cooler than the grain. To estimate the required number of fan hours to equalize grain temperature with air temperature, divide the number 15 by your airflow rate in cfm/bu. For example, with 0.5 cfm/bu. It will take 15/0.5 = 30 hours of fan operation.

To learn more about measuring airflow rate for your bins and fans, go to pami.ca/storage

Effect of Airflow Rate on Grain Quality

Germination and vigor tests were completed by a third party lab in Year 2 to provide an assessment of the effect of airflow rate on grain quality. Theoretically, high airflow rates could result in repeated shrinking and swelling cycles which could affect the seed quality.

Based on these results, airflow rate did not have an effect on germination rate or vigor, although the medium airflow rate resulted in a significantly lower germination rate for the lentils. Further, the quality of the grain did not differ between the samples collected at the plenum and from the middle of the bin. However, the minimal amount of drying observed during the two trials means that the effect of fluctuating conditioning processes exacerbated by high airflows on quality is inconclusive.

Table 1. Results from germination tests of lentils and peas after Year 2 drying trials.

Treatment		% Germinated		% Vigor	
		Green Lentil	*Yellow Pea*	*Green Lentil*	*Yellow Pea*
Control		97.0	98.5	92.5	97.3
Airflow rate	Low	96.3	98.5	92.0	98.8
	Medium	97.3	98.5	92.3	97.8
	High	97.0	99.0	92.3	98.0
Location	Plenum	97.3	98.7	92.3	98.2
	Middle	96.3	98.7	92.0	98.2

Loading peas into the 15 bu test bins at PAMI's Humboldt facility (left), Fan and transition duct used for one of the bin-scale airflow assessments with a partner producer (center), Unloading lentils from the 15 bu test bins at the end of the lentil drying trial (right).

Verification of Resistance to Airflow Information for Pulses

Predicted airflow resistance (static pressure) charts for peas and lentils were created based on Shedd's model, which accounts for the effect of grain type, grain depth, and airflow rate on static pressure. Predicted resistance to airflow is shown by the solid lines, while the individual points are those measured; bin-scale data points are shown with ●, while bench scale is represented by ■. Each point is the same color as the line it should relate closest to; airflow rates were rounded to the nearest 0.5 cfm/bu.

For lentils the actual static pressure was always higher than the predicted static pressure, particularly at high airflow rates. For peas, all of measured points were similar to the calculated lines except for the high airflow (2.6 cfm/bu) data point.

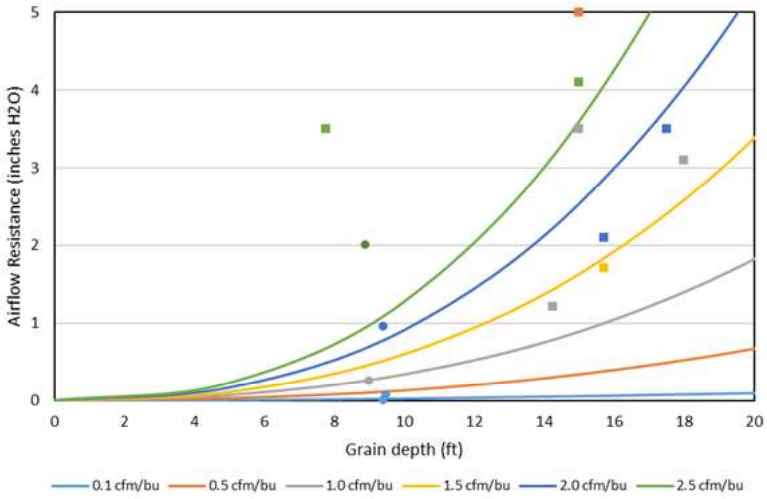


Figure 5. Pea airflow resistance at various grain depths.

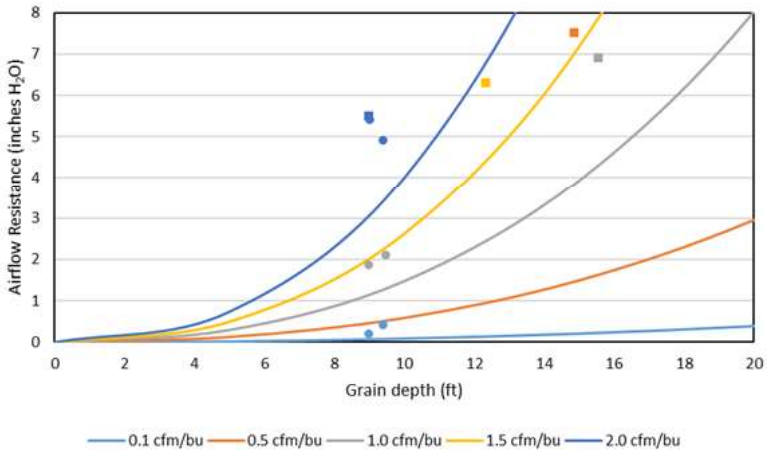


Figure 6. Lentil airflow resistance at various grain depths.

Underestimation of the static pressure by Shedd's model (particularly for lentils) is partially due to the fact that the model only accounts for the resistance of the grain and does not account for the resistance of the bin ducting. Large discrepancies observed in bin-scale measurements could also be a result of high-dockage grain, which would affect the airflow resistance through the grain bulk. Producers should account for the underestimation when using the static pressure curves to size fans.

Verification of Existing Equilibrium Moisture Content Information

Equilibrium moisture content (EMC) charts are available in literature for peas (modified Henderson model), and green lentils (modified Oswin model) as seen below. These charts predict the MC of the grain based on air temperature and humidity.

The in-grain temperature and humidity data from the Year 1 drying trials were used to calculate the moisture content of the grain using these EMC models and compared with the actual moisture content of the samples collected from those bin locations.

- The modified Oswin model was valid for predicting the actual moisture content of green lentils within 10% when the RH of the air surrounding the grain is greater than 50%.
- The modified Henderson model was validated for peas when the RH of the air surrounding the grain was less than 70%; an error of less than 10%.

Based on this data, these EMC charts may be used as a general guideline to understand when the air has a capacity to dry.

EQUILIBRIUM MOISTURE CONTENT FOR **PEAS** (Modified Henderson)

Temp	Relative Humidity (%)										
(°C)	35	40	45	50	55	60	65	70	75	80	85
-2	9.3	10.4	11.5	12.6	13.7	14.9	16.2	17.6	19.1	20.8	22.7
2	9.2	10.2	11.3	12.4	13.5	14.7	15.9	17.3	18.8	20.4	22.4
5	9.0	10.1	11.1	12.2	13.3	14.5	15.7	17.1	18.5	20.2	22.2
8	8.9	9.9	11.0	12.1	13.2	14.3	15.6	16.9	18.3	20.0	21.9
10	8.8	9.9	10.9	12.0	13.1	14.2	15.4	16.8	18.2	19.8	21.8
13	8.7	9.7	10.8	11.8	12.9	14.1	15.3	16.6	18.0	19.6	21.5
15	8.7	9.7	10.7	11.7	12.8	13.9	15.1	16.4	17.9	19.5	21.4
18	8.6	9.6	10.6	11.6	12.7	13.8	15.0	16.3	17.7	19.3	21.2
22	8.4	9.4	10.4	11.4	12.5	13.6	14.8	16.0	17.4	19.0	20.9
26	8.3	9.3	10.2	11.3	12.3	13.4	14.5	15.8	17.2	18.7	20.6
28	8.2	9.2	10.2	11.2	12.2	13.3	14.4	15.7	17.1	18.6	20.5

EQUILIBRIUM MOISTURE CONTENT FOR **LENTILS** (Modified Oswin)

Temp	Relative Humidity (%)										
(°C)	35	40	45	50	55	60	65	70	75	80	85
-2	9.3	10.3	11.2	12.3	13.4	14.6	16.0	17.6	19.5	21.9	25.0
2	9.1	10.0	11.0	12.0	13.1	14.3	15.7	17.3	19.1	21.5	24.5
5	9.0	9.9	10.8	11.8	12.9	14.1	15.4	17.0	18.8	21.1	24.2
8	8.8	9.7	10.6	11.6	12.7	13.9	15.2	16.7	18.5	20.8	23.8
10	8.7	9.6	10.5	11.5	12.5	13.7	15.0	16.5	18.3	20.6	23.6
13	8.5	9.4	10.3	11.3	12.3	13.5	14.8	16.3	18.0	20.3	23.2
15	8.4	9.3	10.2	11.1	12.2	13.3	14.6	16.1	17.8	20.1	23.0
18	8.3	9.1	10.0	10.9	12.0	13.1	14.3	15.8	17.5	19.7	22.6
22	8.1	8.9	9.7	10.7	11.7	12.8	14.0	15.4	17.1	19.3	22.1
26	7.8	8.6	9.5	10.4	11.4	12.4	13.6	15.0	16.7	18.8	21.6
28	7.7	8.5	9.4	10.3	11.2	12.3	13.5	14.9	16.5	18.6	21.4