

Lentil







Pulse Quality Program—Mission

The Pulse Quality Program launched in spring 2022 with a partnership between Saskatchewan Pulse Growers and the Saskatchewan Food Industry Development Centre with the mission to add in best management practices for pulses grown in Western Canada and to help the development of pulse-based ingredients/products in the food industry.

The program aims to develop a comprehensive database of composition, functionality, and nutrition for pulses that provides information to growers, agronomists, breeders, buyers, and end users to make more informed choices. This program implements a genotype by environment ($G \times E$) evaluation of quality parameters of peas, faba beans, lentils, chickpeas, and dry beans.

Phase 1 of the program analyzes up to 3000 samples annually from regional variety trials. The main focus of parameters includes seed quality (i.e., thousand kernel weight, amount of damage, seed size, and seed hardness), nutritional composition (i.e., ash, moisture, and protein content), milling, and colour. The generated data are compared across pulse varieties, locations, and years. Additional parameters will be considered in future years in Phase 2 and Phase 3.







2024 Lentil Quality

The **2024** lentil quality evaluation comprised **465** lentil samples harvested from **5** locations. There were **31** varieties, and three replicates of each variety were cultivated in each location. **Table A** provides the samples' information in detail.

Table A. Description of 2024 lentil samples tested for the Pulse Quality Program.

	Туре		Variety	Site	Number of samples
Green	Large green	CDC Greenstar	CDC Grimm		
		CDC Lima	CDC 7757		
	Small green	CDC 6964	7358-11		
		CDC Kermit	CDC 9820-1-H2-3		
		CDC Jimini			
Red	Large red	CDC Sublime	CDC Monarch		
				Clavet	
	Medium red	CDC Imu		Elrose	
	Small red	CDC 6928	7258-4	Redvers	465
		CDC 6956	7741-15br	St Brieux	
		CDC Impulse	7745-7	Swift Current	
		CDC Maxim	7785-10	Switt Current	
		CDC Nimble	Rougeaux		
		CDC Proclaim	CDC 6930		
		CDC Redmoon	CDC 7030		
		CDC Simmie	CDC 7208		
		CDC 7301-6	CDC 8587-1-H2-13-bk		
	Extra small red	CDC Imani			

Note:

- Seventeen varieties that existed in 2022, 2023, and 2024 are shown in black.
- One variety present in both 2022 and 2024 is shown in green.
- Two varieties present in both 2023 and 2024 is shown in blue.
- Eleven new varieties entered in 2024, shown in red.





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The five sampling locations for 2024 lentil trials and their corresponding crop regions (i.e., southeast, southwest, east central, and northeast) are shown in **Figure A** and **Figure B**. **Figure A** also illustrates the soil zones across the province, while **Figure B** presents the cumulative rainfall during the 2024 growing season.

According to the 2024 Crop Reports by the Ministry of Agriculture, adequate rainfall in May improved topsoil moisture conditions across the province. However, subsequent moisture and cooler temperatures delayed seeding. Seeding progress has been fastest in the southwest and southeast, while the central and northeast regions have experienced slower progress due to higher spring snowfall accumulations. Provincially, seeding of lentils is nearly complete by the end of May.

In June, cooler temperatures and excessive moisture further delayed overall crop development. By July and early August, reduced precipitation and rising temperatures depleted topsoil moisture reserves in many regions, accelerating crop advancement and maturity. The development of crops in the southern and western regions was further ahead while the central and northern regions fell behind.

Lentil harvest began in early August in southwest and southeast regions and continued throughout the province over the following two weeks. Harvest was completed by early September, reflecting variable yields across the province.

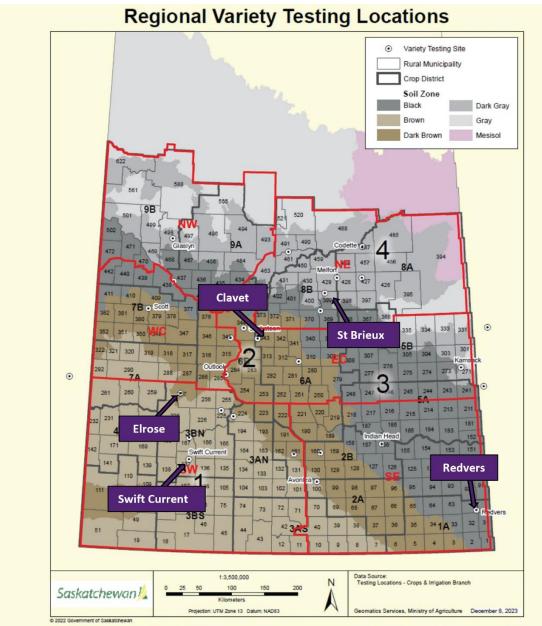
Crop yields vary across the province, with some producers reporting higher-than-expected yields, while others—particularly in areas most affected by heat and drought—are seeing below-average yields.





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in the southeastern section.



The cropland of Saskatchewan has been divided into four areas based roughly on agro-climatic conditions. Crop yields can vary from area to area. In choosing a variety, producers will want to consider the yield data in combination with marketing and agronomic factors. **Area 1:** Drought is a definite hazard and high winds are common. Sawfly outbreaks often occur in this area. Cereal rust may be a problem

Area 2: Drought and sawfly may be problems in the western and central sections of the area. Cereal rust may be a problem in the southern section.

Area 3: Sawfly can also be a problem. Drought is not as likely to be a problem in this area, particularly in the east. Cereal rust may occur in the eastern portion. The frost-free period can be fairly short in the northern section.

Area 4: Rainfall is usually adequate for crop production. However, early fall frosts and wet harvest conditions are frequent problems. Note About Dividing Lines:

The dividing lines do not represent distinct changes over a short distance. The change from one area to another is gradual.

Figure A. Locations for lentil quality testing in 2024 and the corresponding soil zones. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.





Cumulative Rainfall

from April 1 to September 16, 2024

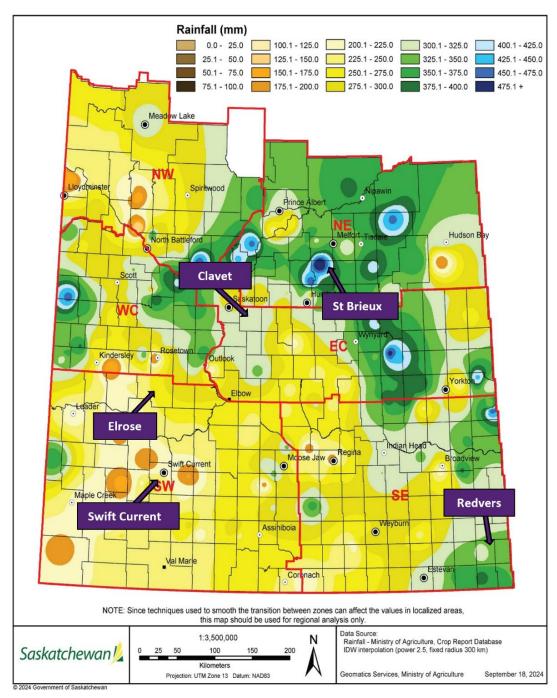


Figure B. Locations for lentil quality testing and cumulative rainfall from April 1 to September 16, 2024. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.





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This report includes ten sections for the results of the following quality parameter:

- 1. Yield
- 2. Thousand kernel weight (TKW)
- 3. Seed size distribution
- 4. Peeled + split + broken seeds
- 5. Other damage

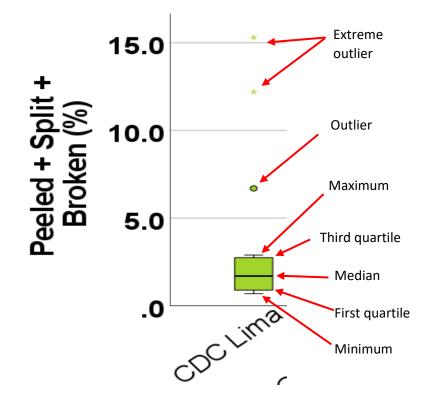
- 6. Hardness of whole seed
- 7. Ash content
- 8. Protein content
- 9. Protein productivity
- 10. Colour (*L**, *a**, and *b**)

The **method** used to evaluate each quality parameter is provided at the beginning of each subsection.

For the results, a Box and Whisker plot is first provided to show the full dataset of each variety, where the minimum, median, maximum, first quartile (the median of the lower half of the dataset), and third quartile (the median of the upper half of the dataset).

In addition, a **Bar** graph is included to provide the mean values by variety to show the variety performance and by location to show how the locations differed.

Furthermore, the effects of variety, location, and variety x location on the characteristic are given in a **table**.



For **statistics**, a one-way analysis of variance (ANOVA) along with a post-hoc Tukey test (SPSS, Chicago, IL, USA) was performed to identify the differences in the quality parameters, including yield, TKW, seed size, seed hardness, split + cracked seed coat, other damage, protein, protein productivity, ash, Hausner ratio, colour, and particle size, by location for all lentil types and by variety for small green and small red lentils. An independent T-test was conducted to identify the differences in the quality parameters by variety for large green, large red, extra small red, black, French green, and Spanish brown lentils.

A two-way analysis of variance (ANOVA) was conducted to determine the effects of variety, location, and their interaction on each parameter.





1. Yield

Method: Yield refers to how much crops are produced and how efficiently land is used to produce food or agricultural commodities. The yield of each variety from each location is provided as kilogram per hectare (kg/HA).

Results: Figure 1.1. Box and Whisker plot of 2024 lentils for yield. Results by type were reported from highest to lowest.

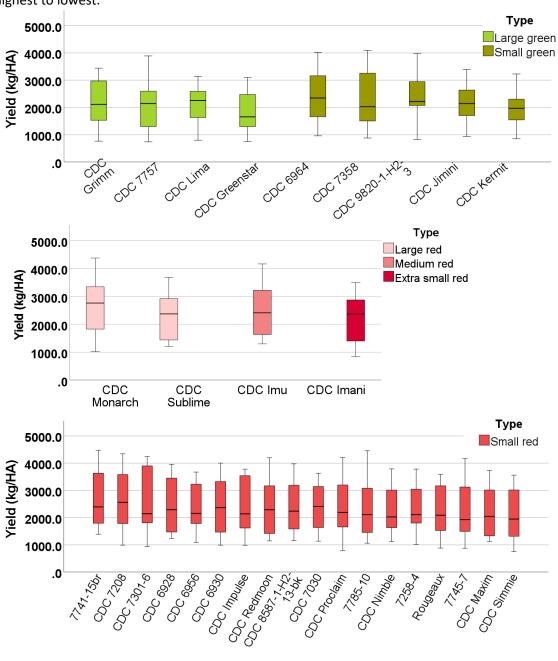
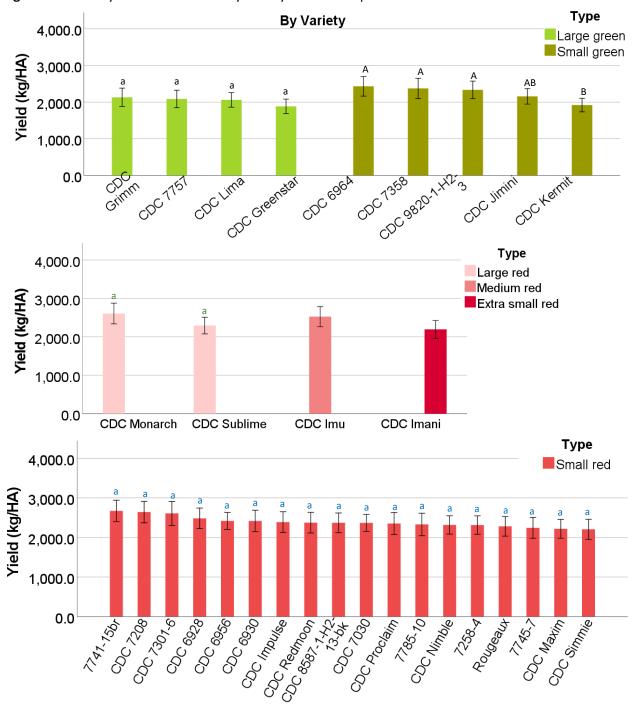






Figure 1.2. Mean yield of 2024 lentils by variety. Each bar represents mean ± one standard error.

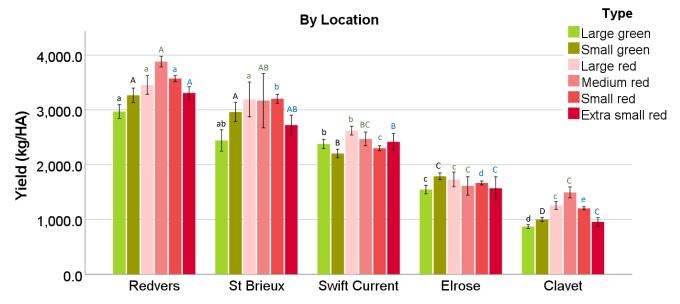


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.$





Figure 1.3. Mean yield of 2024 lentils by location. Each bar represents mean ± one standard error.



Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$

By Variety:

• **Small green:** A difference of over 500 kg/HA was observed from highest (CDC 6964) to lowest (CDC Kermit).

By Location: Yield was highest in Redvers and St Brieux, where rainfall was more abundant (Figure B). A difference of over 2000 kg/HA was observed from highest (Redvers) to lowest (Clavet) for all types.

Table 1. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	NS	**	NS	n.a.	*	n.a.
Location	***	**	***	***	***	***
Variety x Location	NS	NS	NS	n.a.	NS	n.a.





2. Thousand Kernel Weight (TKW)

Method: Seed weight is an important parameter to indicate seed size and yield production. This test was conducted by weighing 300 seeds with duplicated measurements per sample, and the thousand kernel weight (TKW) was reported.

Results: Figure 2.1. Box and Whisker plot of 2024 lentils for TKW. Results by type were reported from highest to lowest.

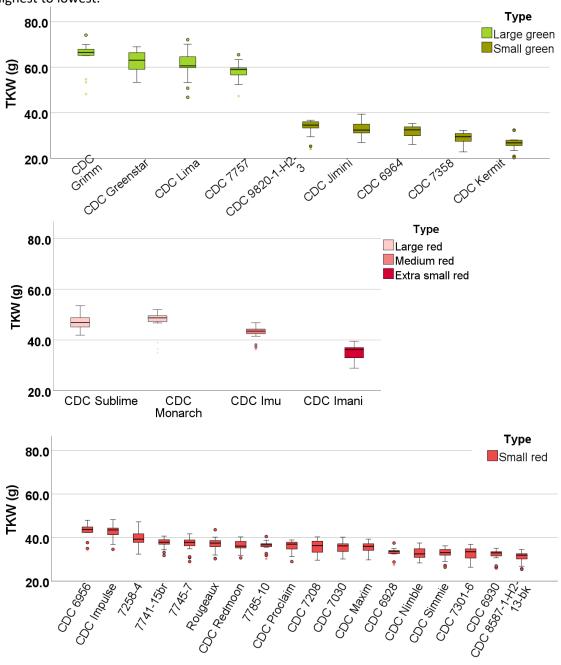
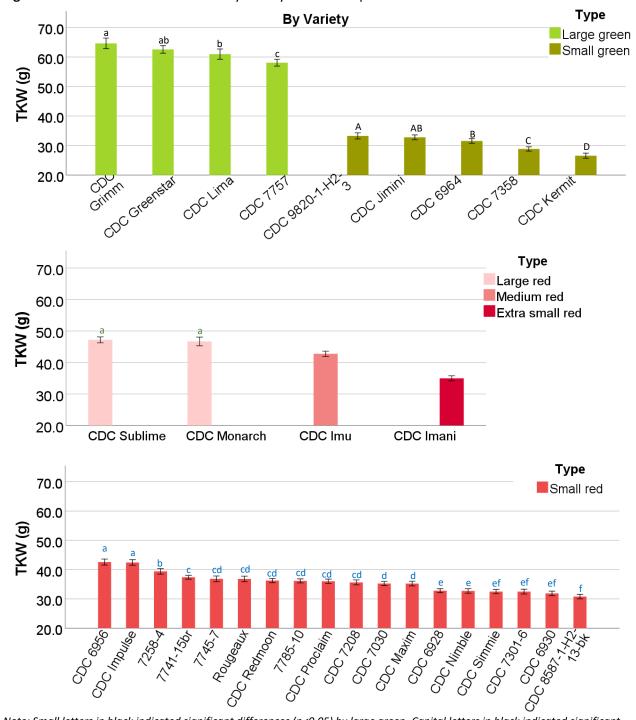






Figure 2.2. Mean TKW of 2024 lentils by variety. Each bar represents mean ± one standard error.

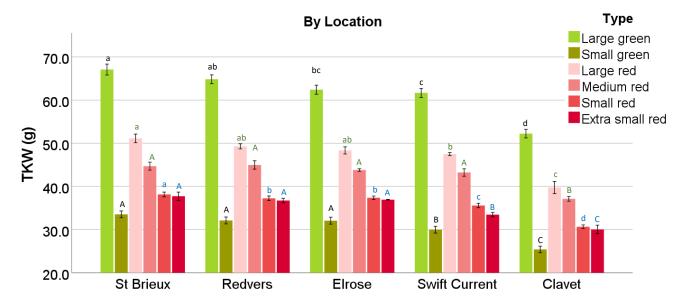


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$





Figure 2.3. Mean TKW of 2024 lentils by location. Each bar represents mean ± one standard error.



By Variety:

- CDC Grimm (large green) had the largest TKW (64.6g) among all lentil varieties.
- CDC Kermit (small green) had the smallest TKW (26.6g) among all varieties.
- Large red: No statistical difference.
- Small red: CDC 6956 and CDC Impulse were over 12 g larger than CDC 8587-1-H2-13-bk.

By Location:

- TKW was highest in St Brieux, followed by Redvers and Elrose, across all types.
- Clavet had the smallest TKW.
- A difference of 15 g, 8 g, 11 g, 8 g, 7 g, and 8 g was observed from highest to lowest for large green, small green, large red, medium red, small red, and extra small red, respectively.

A positive trend between yield and TKW was observed (r=0.129, p<0.01).

Table 2. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	***	***	NS	n.a.	***	n.a.
Location	***	***	***	***	***	***
Variety x Location	NS	NS	**	n.a.	*	n.a.





3. Seed Size Distribution

Method: 250 g of seeds were placed on a series of round-hole opening sieves. The weight of seeds retained on each sieve was determined and reported as % of seeds retained. Duplicated measurements were performed.

Sieves used for lentils:

a. #18R: 7.14 mm b. #16R: 6.35 mm c. #14R: 5.56 mm d. #12R: 4.76 mm e. #10R: 3.97 mm



Results:

Only 1% of CDC Grimm and 0.7% of CDC Greenstar were retained on the 7.14 mm sieve. No seeds from the other varieties were retained on the 7.14 mm sieve.

Table 3. Seed size distribution of each 2024 lentil variety. Data represent mean ± one standard deviation.

Туре	Variety	> 6.35 mm (%)	> 5.56 mm (%)	> 4.76 mm (%)	> 3.97 mm (%)	Below 3.97 mm (%)
Large	CDC Grimm	57.0 ± 16.8°	34.8 ± 12.3 ^d	5.3 ± 5.1 ^c	1.3 ± 1.0 ^b	1.3 ± 1.6°
green	CDC Greenstar	49.8 ± 15.1 ^b	41.4 ± 12.2 ^c	5.7 ± 5.1 ^c	1.1 ± 1.0^{ab}	1.7 ± 3.3°
	CDC Lima	26.7 ± 10.7°	61.2 ± 7.3 ^b	9.5 ± 6.4 ^b	1.2 ± 1.1 ^{ab}	1.4 ± 1.4 ^a
	CDC 7757	11.6 ± 8.5^{d}	70.1 ± 7.9^{a}	15.8 ± 8.9 ^a	1.6 ± 1.1 ^a	0.9 ± 1.5°
Small	CDC 9820-1-H2-3	0.0 ± 0.0	0.1 ± 0.1^{A}	50.0 ± 16.9 ^A	46.3 ± 12.6 ^c	$3.6 \pm 5.0^{\circ}$
green	CDC Jimini	0.0 ± 0.0	0.0 ± 0.1^{A}	29.7 ± 12.0 ^B	65.1 ± 9.3 ^B	5.2 ± 3.5 ^c
	CDC 6964	0.0 ± 0.0	0.0 ± 0.1^{A}	28.4 ± 14.5 ^B	66.7 ± 11.8 ^B	$4.8 \pm 4.1^{\circ}$
	CDC 7358	0.0 ± 0.0	0.0 ± 0.0^{A}	12.7 ± 7.1 ^c	78.1 ± 5.1 ^A	9.2 ± 5.7^{B}
	CDC Kermit	0.0 ± 0.0	0.0 ± 0.0^{A}	4.6 ± 3.0^{D}	75.5 ± 9.4 ^A	19.9 ± 11.3 ^A





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Туре	Variety	> 6.35 mm (%)	> 5.56 mm (%)	> 4.76 mm (%)	> 3.97 mm (%)	Below 3.97 mm (%)
Large	CDC Sublime	1.1 ± 0.9°	54.8 ± 12.3 ^a	40.3 ± 11.2 ^b	3.2 ± 2.5 ^a	0.7 ± 1.1 ^a
red	CDC Monarch	0.0 ± 0.1^{b}	36.9 ± 13.8 ^b	57.4 ± 9.7 ^a	4.7 ± 5.3^{a}	$0.9 \pm 0.8^{\circ}$
M red	CDC Imu	0.0 ± 0.0	8.4 ± 5.4	71.7 ± 7.3	18.6 ± 10.4	1.3 ± 1.2
	CDC Impulse	0.0 ± 0.0	25.2 ± 9.6°	65.6 ± 6.3 ^b	8.0 ± 6.1 ⁱ	1.1 ± 0.7 ^h
	7258-4	0.0 ± 0.0	17.2 ± 9.0 ^b	68.1 ± 4.5 ^b	13.5 ± 8.0 ^h	1.3 ± 0.9 ^h
	CDC 6956	0.0 ± 0.0	$5.9 \pm 3.3^{\circ}$	74.4 ± 9.6^{a}	18.2 ± 11.6 ^h	1.4 ± 1.1 ^{gh}
	7745-7	0.0 ± 0.0	1.7 ±1.5 ^d	67.8 ± 14.0 ^b	28.5 ± 13.2 ^g	2.1 ± 1.9^{efgh}
	CDC 7208	0.0 ± 0.0	1.2 ± 1.2 ^{de}	68.2 ± 12.8 ^b	28.8 ± 12.3 ^g	1.8 ± 1.6^{fgh}
Small	CDC Proclaim	0.0 ± 0.0	0.2 ± 0.3^{de}	59.0 ± 18.7°	38.9 ± 17.3 ^f	2.0 ± 2.0^{efgh}
red	CDC Maxim	0.0 ± 0.0	0.9 ± 1.3 ^{de}	55.2 ± 15.0 ^{cd}	41.7 ± 14.0 ^{ef}	2.3 ± 2.1 ^{efgh}
Teu	7741-15br	0.0 ± 0.0	0.4 ± 0.4^{de}	51.4 ± 13.9 ^d	45.3 ± 12.2 ^e	2.9 ± 2.2^{cde}
	CDC 7301-6	0.0 ± 0.0	0.4 ± 0.4^{de}	51.1 ± 15.4 ^d	45.5 ± 13.0 ^e	3.0 ± 3.1^{cde}
	7785-10	0.0 ± 0.0	0.1 ± 0.2 ^{de}	44.4 ± 16.6 ^e	52.6 ± 14.2 ^d	3.0± 2.8 ^{cde}
	CDC 7030	0.0 ± 0.0	0.0 ± 0.0^{de}	43.6 ± 14.3 ^{ef}	53.7 ± 12.7 ^d	2.7 ± 2.3 ^{cdef}
	CDC 6928	0.0 ± 0.0	0.2 ± 0.3 ^{de}	41.1 ± 13.1 ^{ef}	54.9 ± 11.0 ^d	3.8 ± 2.6 ^{bc}
	CDC Redmoon	0.0 ± 0.0	0.1 ± 0.1^{de}	39.9 ± 13.4^{efg}	56.8 ± 12.1 ^{cd}	3.3 ± 2.3^{bcd}
	CDC Simmie	0.0 ± 0.0	0.1 ± 0.1^{e}	38.4 ± 15.3^{fgh}	57.7 ± 12.5 ^{cd}	3.9 ± 3.9 ^{bc}
	CDC 6930	0.0 ± 0.0	0.1 ± 0.1 ^e	34.6 ± 13.6 ^{ghi}	61.0 ± 10.9 ^{bc}	4.3 ± 3.7^{b}
	Rougeaux	0.0 ± 0.0	0.1 ± 0.1 ^e	33.4 ± 11.6 ^{hi}	60.4 ± 9.1 ^{bc}	6.2 ± 3.2°
	CDC Nimble	0.0 ± 0.0	0.0 ± 0.0^{e}	32.0 ± 13.7^{i}	63.6 ± 11.7 ^b	4.3 ± 2.9 ^b
	CDC 8587-1-H2-13-bk	0.0 ± 0.0	0.0 ± 0.0^{e}	12.8 ± 7.3 ^j	80.8 ± 5.5°	6.5 ± 5.7°
XS red	CDC Imani	0.0 ± 0.0^{a}	0.0 ± 0.1	36.6 ± 13.9	60.3 ± 12.3	3.1 ± 2.3

Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters}\ in\ blue\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$





4. Peeled + Split + Broken

Method: 50 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Results included splits, cracks, seed coat damage, partially missing hull, and partially missing cotyledon.

Results: Figure 4.1. Box and Whisker plot of the peeled + split + broken lentils in 2024. Results by type were reported from highest to lowest.

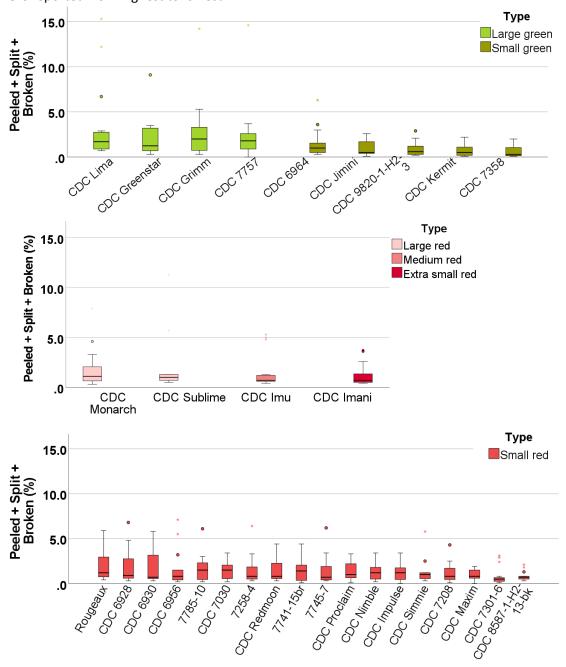
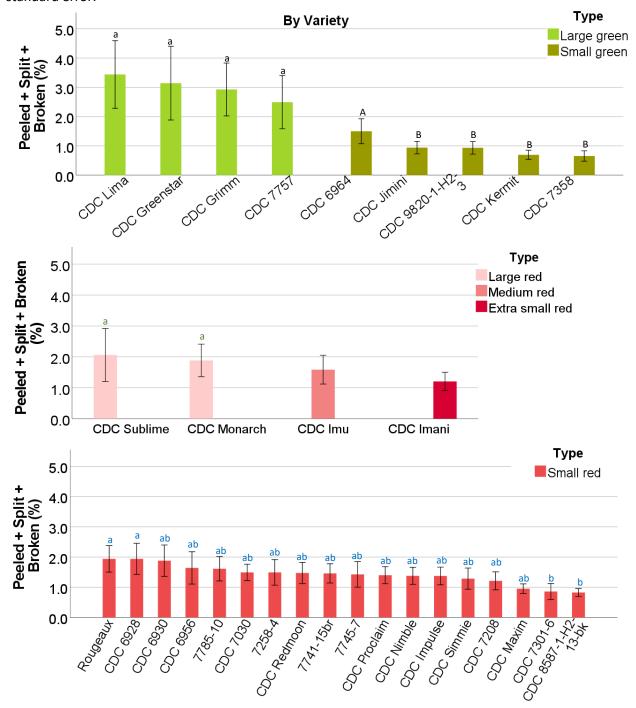






Figure 4.2. Mean peeled + split + broken (%) of 2024 lentils by variety. Each bar represents mean \pm one standard error.

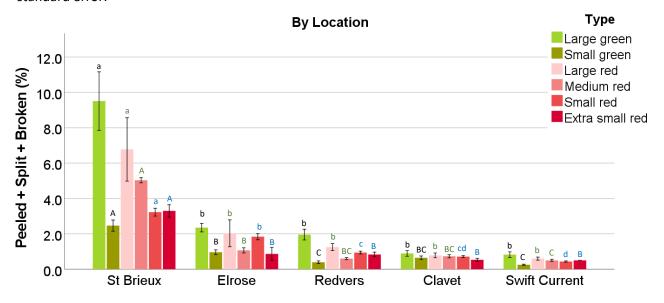


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Figure.4.3. Mean peeled + split + broken (%) of 2024 lentils by location. Each bar represents mean ± one standard error.



By Variety:

- Small green: CDC 6964 was 1% higher than CDC 7358.
- Small red: Rougeaux was 1% higher than CDC 8587-1-H2-13-bk.
- No statistical difference (p>0.05) in splits was observed within large green and large red.

By Location: The amount of peeled + split + broken lentils was extremely high in St Brieux for all types, with a 9% difference from highest to lowest observed for large green. In contrast, low damage was observed in seeds harvested from other locations, especially Swift Current and Clavet, where post-harvest processing may play a role.

A positive trend between split seeds and TKW was observed (r=0.38, p<0.01).

Table 4. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	NS	***	NS	n.a.	**	n.a.
Location	***	***	***	***	***	***
Variety x Location	NS	**	*	n.a.	***	n.a.





5. Other Damage

Method: 50 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Other damage included wrinkles, sprouting, distinct immaturity, distinct deterioration or discolouration by weather or disease, insect damage, heat damage, and any other damage that affects appearance.

Results: **Figure 5.1.** Box and Whisker plot of 2024 lentils for other damage. Results by type were reported from highest to lowest.

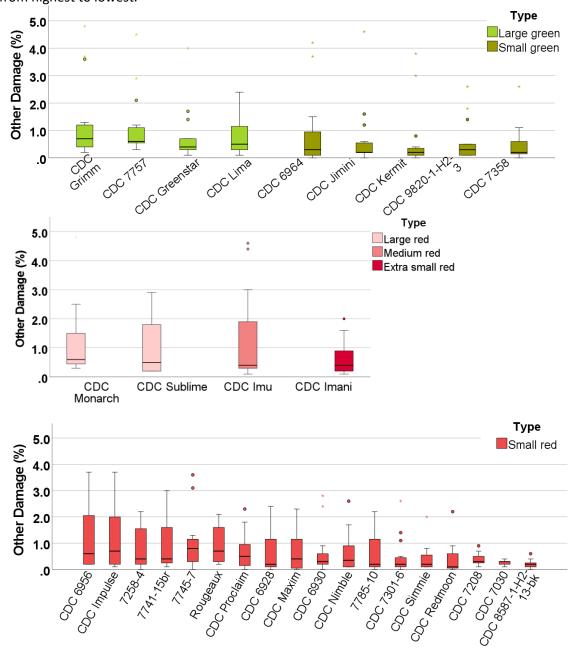
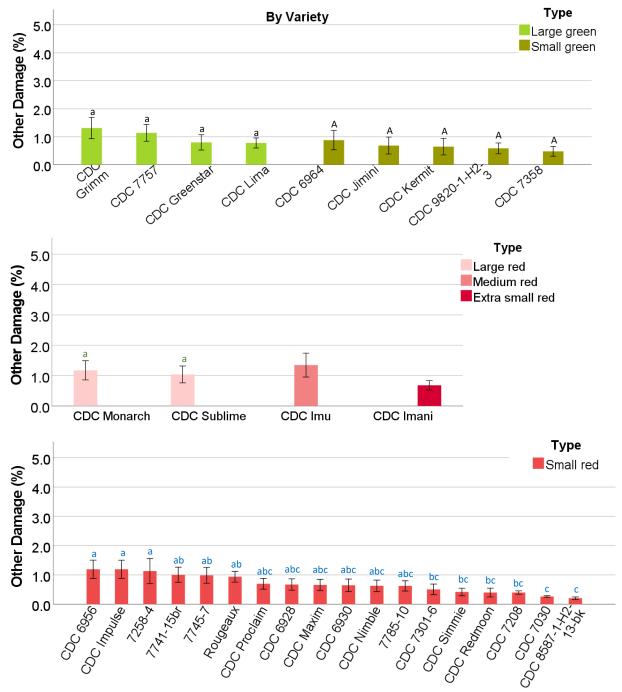






Figure 5.2. Mean other damage of 2024 lentils by variety. Each bar represents mean ± one standard error.

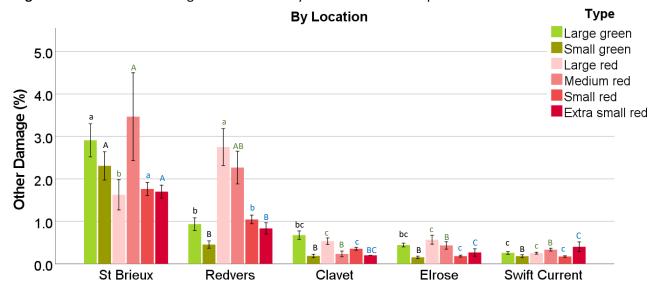


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.$





Figure 5.3. Mean other damage of 2024 lentils by location. Each bar represents mean ± one standard error.



By Variety:

- Small red: CDC 6956, Impulse, and line 7258-4 were 1% higher than CDC 8587-1-H2-13-bk.
- No statistical difference (p>0.05) in other damage was observed within large green, small green, or large red.

By Location:

• St Brieux also had a higher level of other damage, followed by Redvers. Heated and moldy seeds were observed in St Brieux, while Redvers had more wrinkled red lentils (data not shown).

Table 5. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	NS	NS	NS	n.a.	***	n.a.
Location	***	***	***	**	***	***
Variety x Location	NS	NS	NS	n.a.	***	n.a.





6. Hardness of Whole Seed

Method: Seed hardness is affected by seed size, shape, density, composition, etc. Seed hardness was determined by measuring the force of breaking a seed using a texture analyzer (TMS-Pro, Food Technology Corporation, USA). The mean peak force (N) of 10 seeds was reported.

Results: Figure 6.1. Box and Whisker plot of 2024 lentils for seed hardness. Results by type were reported from highest to lowest.

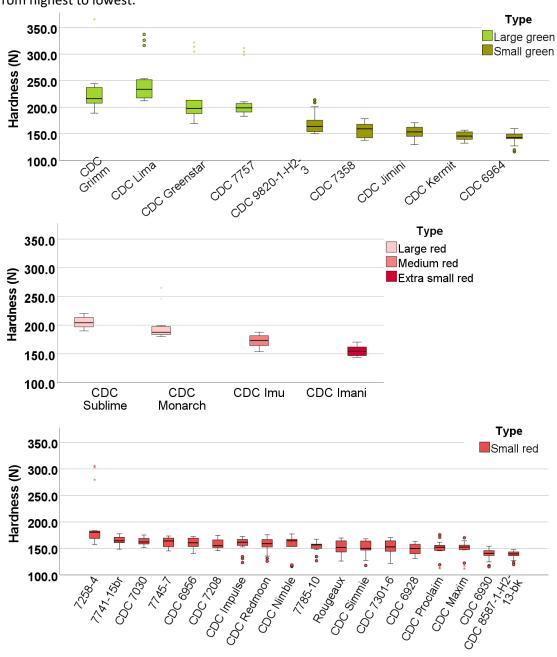
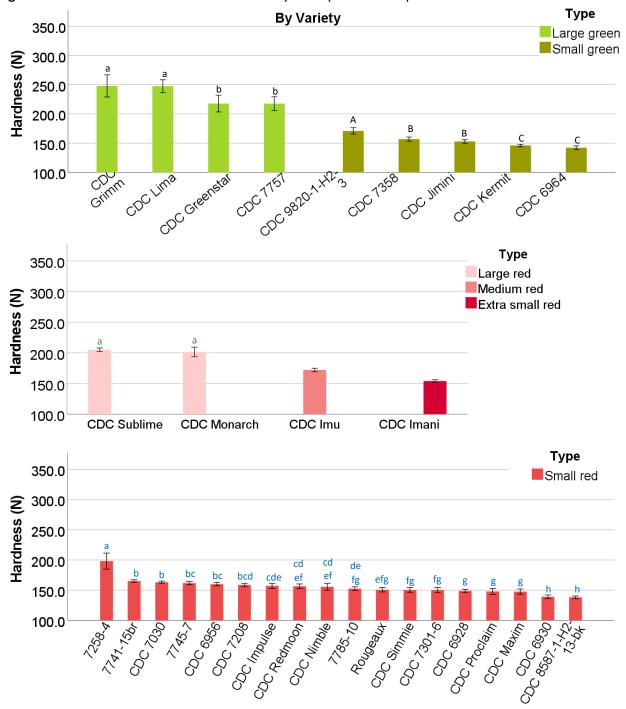






Figure 6.2. Mean seed hardness of 2024 lentils by variety. Each bar represents mean ± one standard error.

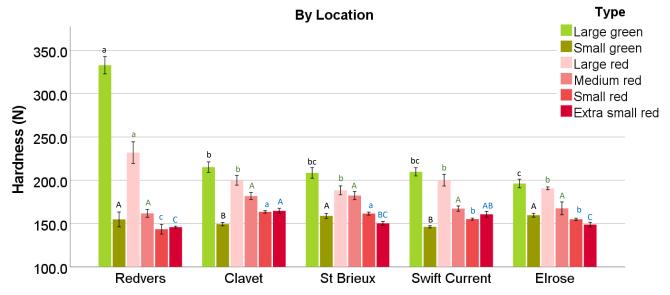


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Figure 6.3. Mean seed hardness of 2024 lentils by location. Each bar represents mean ± one standard error.



By Variety:

- Large green: CDC Grimm and CDC Lima were 30 N higher than CDC Greenstar and CDC 7757.
- Small green: CDC 9820-1-HA-3 was 30 N higher than CDC 6964.
- Large red: No statistical difference.
- Small red: Hardness of line 7258-4 was 59 N higher than CDC 6930 and CDC 8587-1-H2-13-bk.
- Means were 172 N and 154 N for large red and extra small red, respectively.

By Location: Location also impacted the hardness of red lentils.

- Large green: Redvers was 139 N higher than Elrose (lowest).
- Small green: A 14 N difference was found from highest to lowest.
- Large red: A 44 N difference was found from highest (Redvers) to lowest.
- Small red: A 20 N difference was found from highest (Clavet and St Brieux) to lowest (Redvers).
- Extra small red: A 19 N difference was found from highest (Clavet) to lowest (Redvers and Elrose).

A positive trend between hardness and TKW was observed (r=0.68, p<0.01).

Table 6. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	***	***	NS	n.a.	***	n.a.
Location	***	***	***	*	***	**
Variety x Location	***	***	***	n.a.	***	n.a.

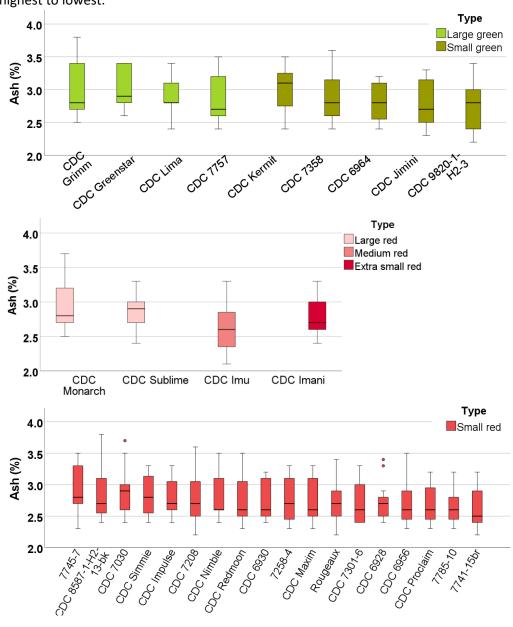




7. Ash Content

Method: Ash content (%) was determined using AACC 08-01.01¹ with modification. Samples were heated at 560°C till they turned white. Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

Results: Figure 7.1. Box and Whisker plot of 2024 lentils for ash. Results by type were reported from highest to lowest.

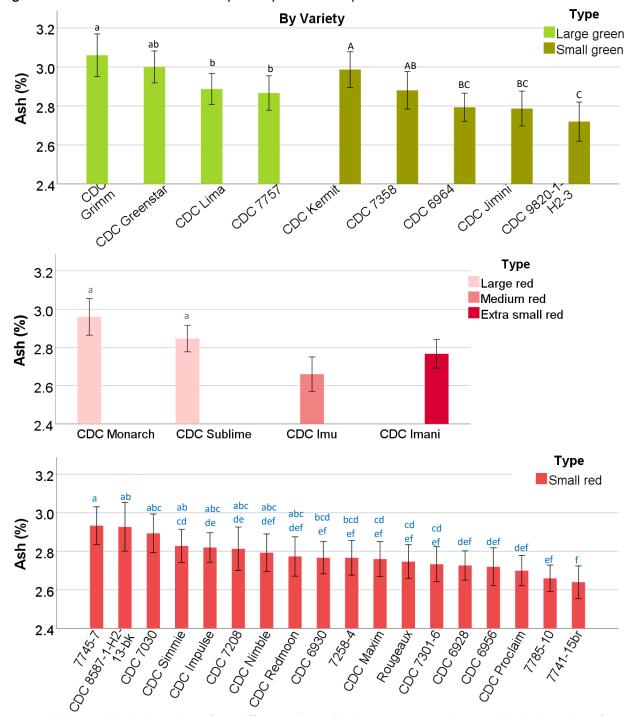


¹ AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.





Figure 7.2. Mean ash of 2024 lentils by variety. Each bar represents mean ± one standard error.

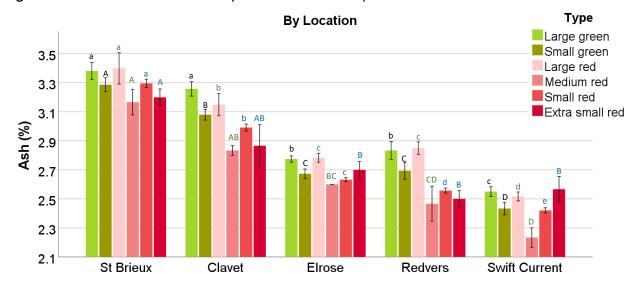


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$





Figure 7.3. Mean ash of 2024 lentils by location. Each bar represents mean \pm one standard error.



By Variety:

- Large green: An only 0.2% difference was observed from highest to lowest.
- Small green: An only 0.2% difference was observed from highest to lowest.
- Large red: No statistical difference.
- Small red: A 0.3% difference was observed from highest to lowest.

By Location: Location also impacted the hardness of red lentils. St Brieux (highest) was 0.8% higher than Swift Current (lowest) for all lentil types.

Table 7. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	***	***	NS	n.a.	***	n.a.
Location	***	***	***	***	***	**
Variety x Location	NS	NS	NS	n.a.	**	n.a.

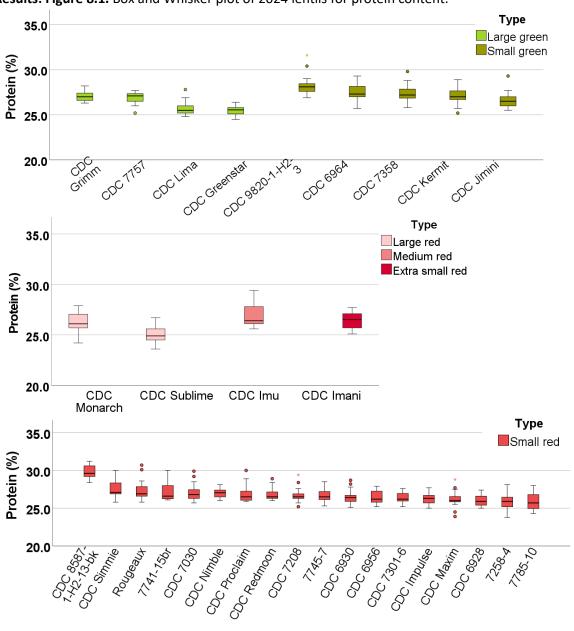




8. Protein Content

Method: The protein content (%) of each flour was determined through AACC 46-30² using the combustion method through a Rapid N Exceed (Elementar, USA). Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

Results: Figure 8.1. Box and Whisker plot of 2024 lentils for protein content.

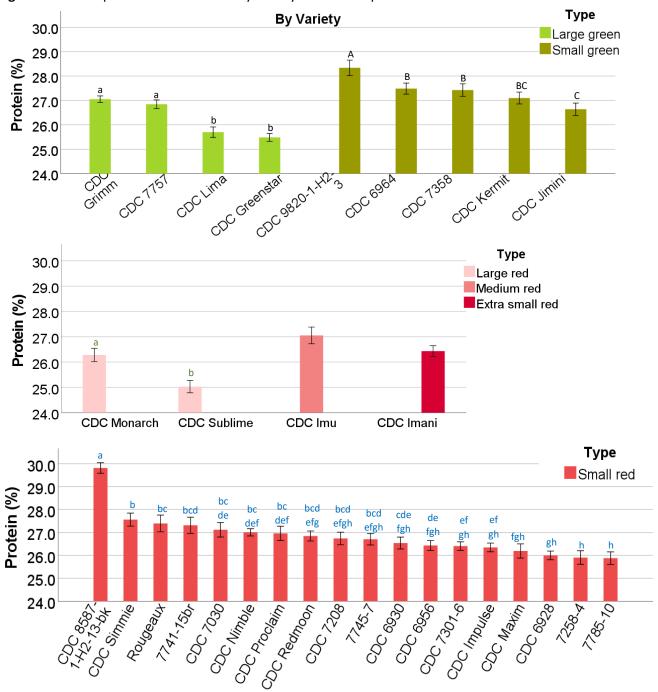


² AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.





Figure 8.2. Mean protein of 2024 lentils by variety. Each bar represents mean ± one standard error.



Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ red.\ \underline{Capital\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.$





Figure 8.3. Mean protein of 2024 lentils by location. Each bar represents mean \pm one standard error.



By Variety:

- Large green: CDC Grimm and CDC 7757 were 1% higher than CDC Greenstar and CDC Lima.
- Small green: CDC 9820-1-HA-3 was 1.7% higher than CDC Jimini.
- Large red: Monarch was 1.3% higher than Sublime.
- Small red: CDC 8587-1-H2-13-bk was 2.2% higher than CDC Simmie (second highest) and 3.8% higher than line 7785-10 (lowest).

By Location: Protein content varied significantly between locations, with Redvers being over 1% higher in protein for all types compared to other locations. Redvers is located in the black soil zone.

A positive trend between yield and protein was observed (r=0.36, p<0.01). A negative trend between TKW and protein was observed (r=-0.176, p<0.01).

Table 8. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	***	***	**	n.a.	***	n.a.
Location	***	***	***	*	***	NS
Variety x Location	NS	NS	NS	n.a.	*	n.a.





9. Protein Productivity

Method: Protein productivity (kg protein/HA), which is calculated using yield (kg/HA) multiplied by protein content (%), refers to the amount of protein produced per unit of land. It evaluates how much protein is being harvested from a given area.

Results: Figure 9.1. Box and Whisker plot of 2024 lentils for protein productivity. Results by type were reported from highest to lowest.

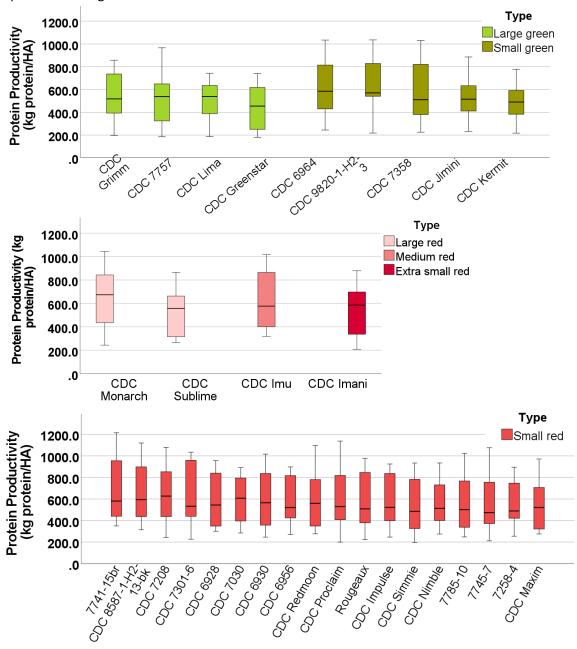
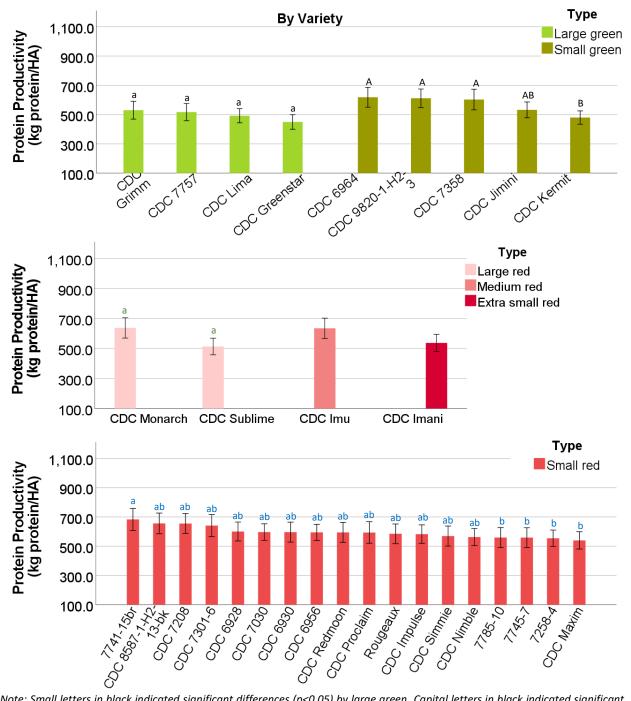






Figure 9.2. Mean protein productivity of 2024 lentils by variety. Each bar represents mean ± one standard error.

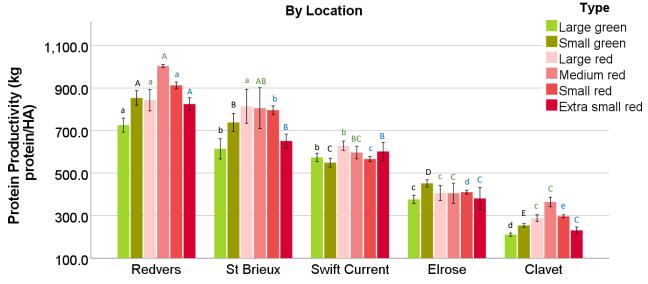


Note: <u>Small letters in black</u> indicated significant differences (p<0.05) by large green. <u>Capital letters in black</u> indicated significant differences (p<0.05) by small green. <u>Small letters in green</u> indicated significant differences (p<0.05) by large red. <u>Capital letters in green</u> indicated significant differences (p<0.05) by medium red. <u>Small letters in blue</u> indicated significant differences (p<0.05) by small red. <u>Capital letters in blue</u> indicated significant differences (p<0.05) by extra small red.





Figure 9.3. Mean protein productivity of 2024 lentils by location. Each bar represents mean ± one standard error.



By Variety:

- Small green: CDC 6964 produced 138 kg more protein per hectare than CDC Kermit.
- Small red: A difference of 143 kg protein/HA was found from highest to lowest.
- No statistical difference for large green and large red.

By Location: Protein productivity varied significantly between locations, with Redvers being the highest due to its high yield, and Clavet the lowest.

- Large green: The yield in Redvers was about 3.5 times that of Clavet.
- Small green: The yield in Redvers was about 3.6 times that of Clavet.
- Large red: The yield in Redvers was about 2.9 times that of Clavet.
- **Medium red:** The yield in Redvers was about 2.8 times that of Clavet.
- **Small red:** The yield in Redvers was about 3.0 times that of Clavet.
- Extra small red: The yield in Redvers was about 3.6 times that of Clavet.

A positive trend between yield and protein productivity was observed (r=0.993, p<0.01). A positive trend between protein and protein productivity was observed (r=0.458, p<0.01).

Table 9. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	NS	***	NS	n.a.	***	n.a.
Location	***	***	***	***	***	***
Variety x Location	NS	NS	NS	n.a.	NS	n.a.





10. Colour

Method: The absolute colour of each flour was determined using the Konica Minolta CR-400 Chroma meter, where L^* , a^* , and b^* values were reported. Three measurements were made for each sample, and the mean value was reported.

a) L* (lightness): white (100) to black (0)

Results: Figure 10.1. Box and Whisker plot of 2024 lentils for lightness. Results by type were reported from highest to lowest.

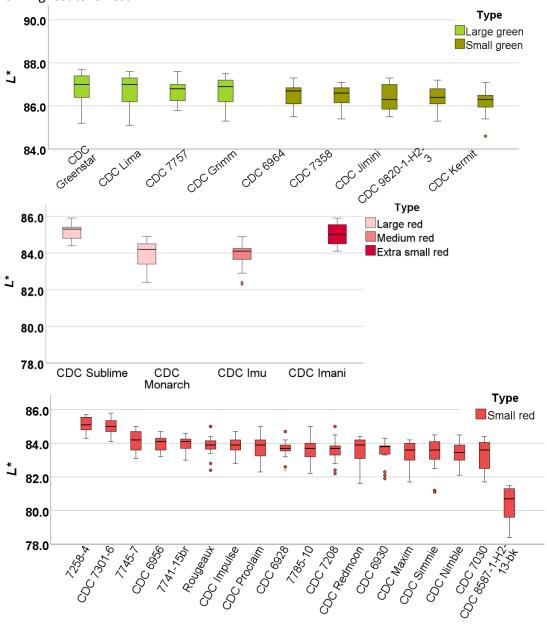
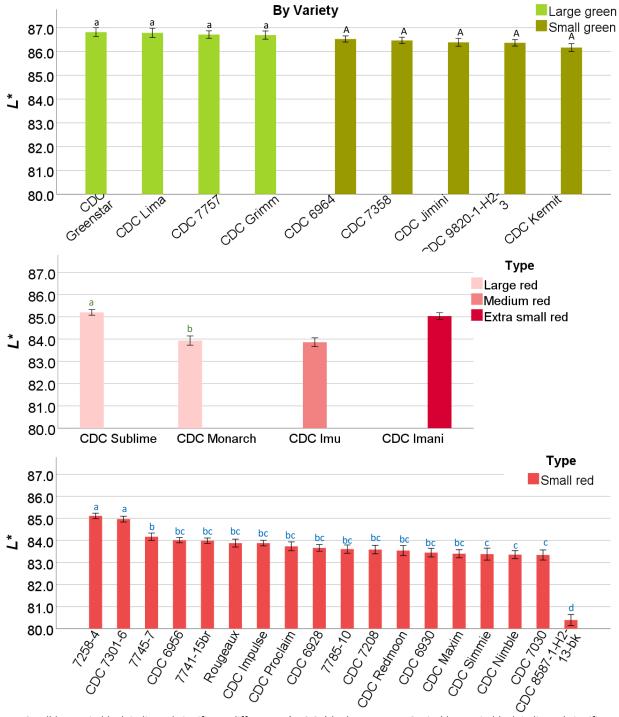






Figure 10.2. Mean lightness of 2024 lentils by variety. Each bar represents mean ± one standard error.

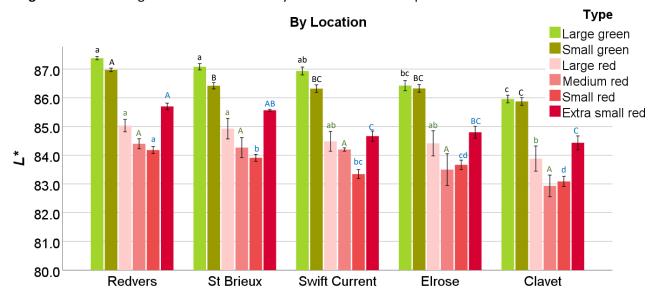


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$





Figure 10.3. Mean lightness of 2024 lentils by location. Each bar represents mean \pm one standard error.



By Variety:

- Overall, the green lentils had greater lightness. No difference was found within the large green or small green types.
- Large red: A difference of over 1 unit was observed.
- Medium red: Similar to CDC Monarch.
- **Small red:** Lines 7258-4 and CDC 7301-6 were almost 1 unit higher than line 7745-7 (second highest). CDC 8587-1-H2-13-bk was 3 units lower than the second lowest due to its black seed coat. All other varieties were statistically similar.
- Extra small red: Similar to Sublime.

By Location: L^* values varied between locations, where Clavet had the lowest lightness across all types. The difference from highest to lowest within each type was about 1 unit.

Table 10.1. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	NS	NS	***	n.a.	***	n.a.
Location	***	***	**	NS	***	**
Variety x Location	NS	NS	NS	n.a.	NS	n.a.





b) **a*:** red (+) to green (-)

Results: Figure 10.4. Box and Whisker plot of 2024 lentils for a^* values. Results by type were reported from highest to lowest.

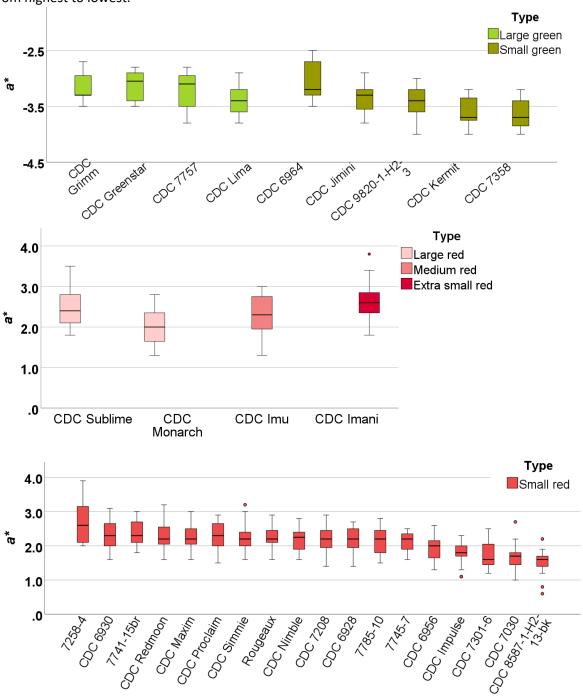
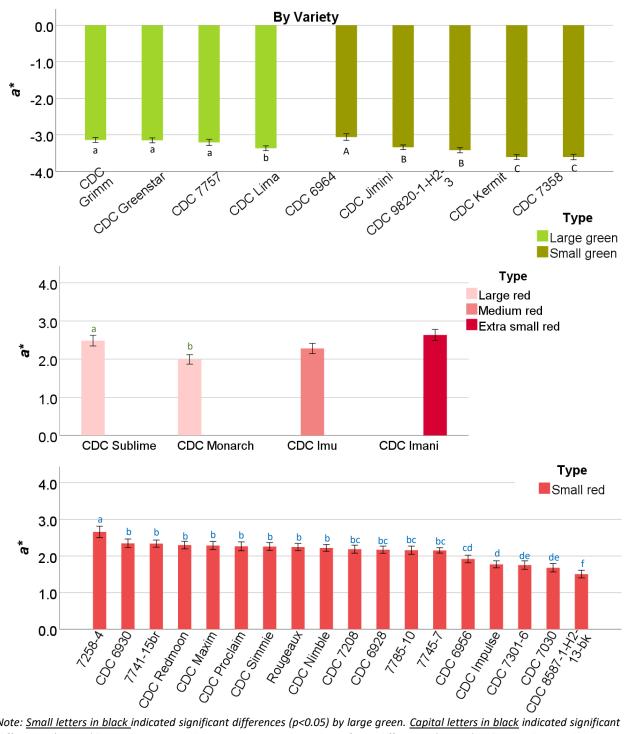






Figure 10.5. Mean a^* values of 2024 lentils by variety. Each bar represents mean \pm one standard error.

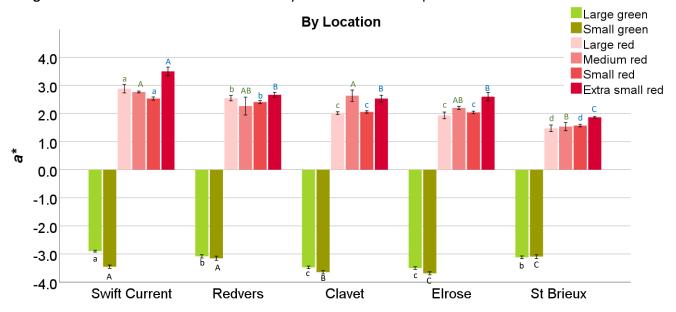


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.}\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.}\ \underline{Small\ letters\ in\ green}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ red.}\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.}\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.}$





Figure 10.6. Mean a^* values of 2024 lentils by location. Each bar represents mean \pm one standard error.



By Variety:

- CDC Kermit and CDC 7358 (both small green) had the greatest greenness.
- CDC Imani (extra small red) and line 7258-4 (small red) had the greatest redness.

By Location:

- Red lentils from Swift Current had the greatest redness, while St Brieux had the lowest redness across all types.
- Green lentils from Elrose and Clavet had the greatest greenness in both types.

Table 10.2. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	***	***	*	n.a.	***	n.a.
Location	***	***	***	**	***	***
Variety x Location	*	NS	NS	n.a.	***	n.a.





c) **b*:** yellow (+) to blue (-)

Results: Figure 10.7. Box and Whisker plot of 2024 lentils for b^* . Results by type were reported from highest to lowest.

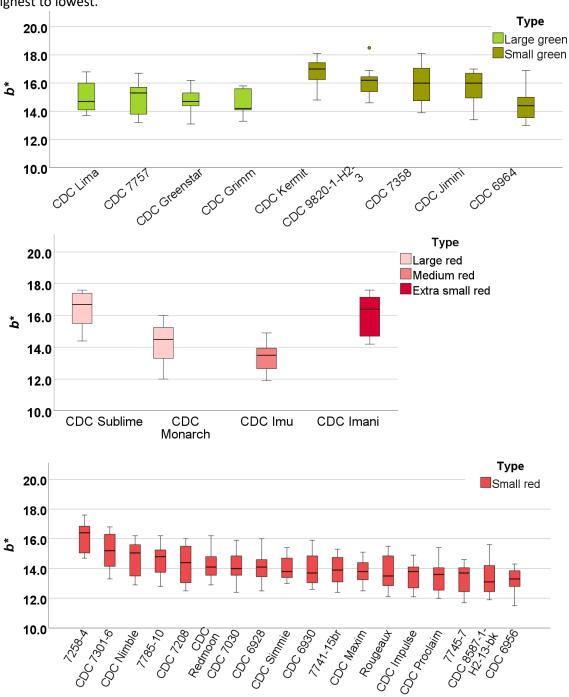
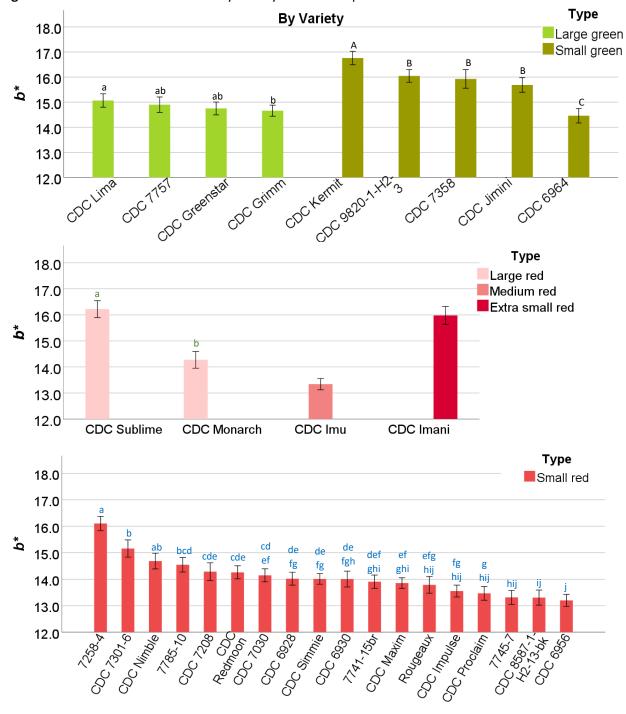






Figure 10.8. Mean b^* of 2024 lentils by variety. Each bar represents mean \pm one standard error.

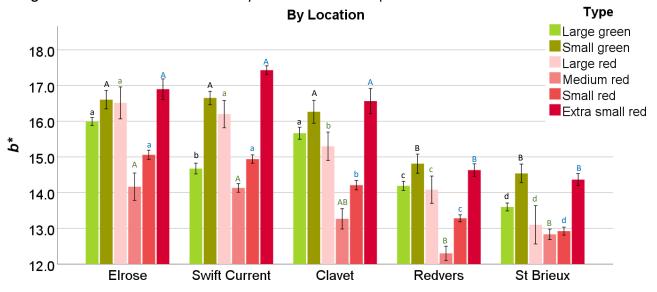


Note: $\underline{Small\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ large\ green.\ \underline{Capital\ letters\ in\ black}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ green.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ medium\ red.\ \underline{Small\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ small\ red.\ \underline{Capital\ letters\ in\ blue}\ indicated\ significant\ differences\ (p<0.05)\ by\ extra\ small\ red.$





Figure 10.9. Mean b^* of 2024 lentils by location. Each bar represents mean \pm one standard error.



By Variety:

- Large green: A 0.4-unit difference from highest to lowest.
- Small green: A 2.3-unit difference from highest to lowest.
- Large red: A 2-unit difference from highest to lowest.
- Small red: A 2.9-unit difference was observed from the highest to the lowest.

By Location: Yellowness of samples from Redvers and St Brieux was the lowest.

Table 10.3. Effects of variety and location.

	Large green	Small green	Large red	Medium red	Small red	Extra small red
Variety	*	***	***	n.a.	***	n.a.
Location	***	***	***	**	***	***
Variety x Location	**	NS	NS	n.a.	*	n.a.





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