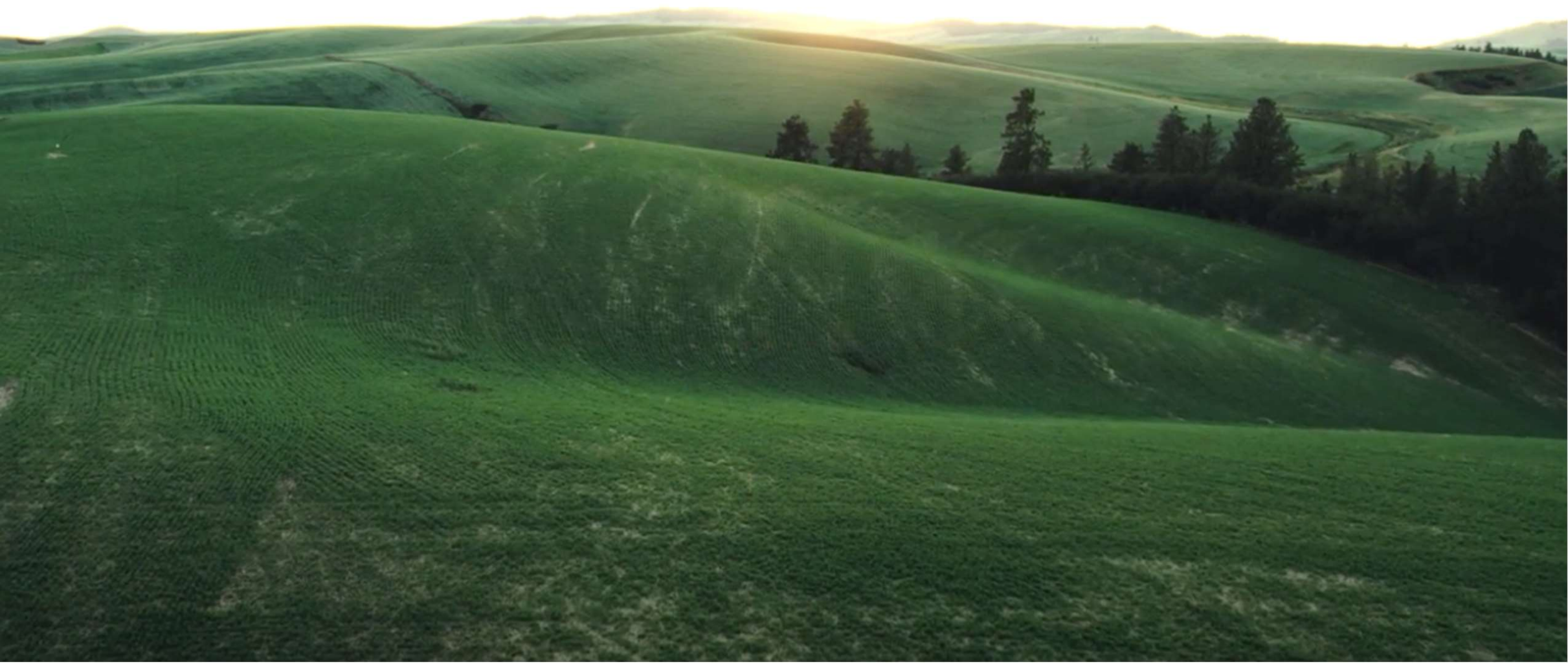
2024 U.S. Pulse Quality Survey



Northern Pulse Growers Association

USA Dry Pea & Lentil Council

Contents

2024 Overview and Author's Comments

Summary Points

1. The 2024 pulse quality report represents the 17th variation of a pulse quality evaluation started by the Northern Crops Institute in 2008. The data in this report includes both 5- and 10-year mean values where available. The 10-year mean represents a long-term assessment of quality.
2. Data from 278 samples received from major US pulse growing regions were evaluated. Mixed growing conditions (i.e., both dry and wet) were experienced by growers in 2024.
3. Six functionality tests and an RVA gel firmness value were reported for the third time in 2024.
4. Higher mean protein contents were observed in peas, lentils, and chickpeas compared to the 5- and 10-year mean protein contents. All pulse types had lower fat content in 2024 compared to pulses from previous years.
5. Chickpea from 2024 had higher 1000-seed weights and percentage retention on a 22/64-inch sieve than chickpea in 2023. However, these values tended to be lower than the 5- and 10-year mean 1000-seed weights and percentage retention. Due in part to the evaluation of more small-seeded chickpea cultivars in 2024.
6. Cold paste viscosity was lower for all pulses compared to previous years and may have contributed to the lower gel firmness in 2024 compared to 2023.
7. Rehydration of peas and chickpea during canning matched their respective 5-year mean values. However, canned peas tended to be less firm than the 5-year mean firmness. In contrast, chickpea firmness matched the 5-year mean firmness value.

This report provides a summary of the 2024 pulse crop quality for dry pea, lentil, and chickpea grown commercially in the USA. In 2024, a total of 278 pulse samples were collected from the major US pulse growing regions. The seeds evaluated included 127 dry pea, 97 lentils, and 54 chickpea samples, which were acquired from pulse growers and industry representatives in pulse-growing areas in Idaho, Montana, Nebraska, North Dakota, Oregon, and Washington.

According to the USDA National Agricultural Statistics Service and U.S. Dry Pea and Lentil Council, pulse harvested acres and estimated total production for 2024 were 2.4 million acres and approximately 1.6 million metric tons, respectively. Pulse harvested acres were higher in 2024 compared to 2020-2023, while pulse production was higher in 2024 compared to 2020-2023. The exception was the higher production of peas in 2020.

The quality is grouped into three main categories, which include proximate composition, physical parameters, and functional characteristics. The canning quality was also a separate category. Proximate quality parameters include ash, fat, moisture, protein, and total starch content. Water hydration capacity, percentage unhydrated seeds, swelling capacity, cooked firmness, test weight, 1000 seed weight, size distribution, and color represent the physical parameters evaluated. The pasting characteristics represent the functional characteristics of the pulses. In addition, six functionality tests were completed for the third time in 2024. These included emulsion activity and stability, foaming capacity and stability, water holding capacity, and oil holding capacity.

Results from the proximate (e.g., moisture, protein) composition analyses indicated that results were mixed and did not follow closely the results from any one previous year. However, some results were comparable to 5- and 10-year mean data.

In general, peas, lentils, and chickpeas from 2024 had the same or higher moisture contents compared to pulses from previous crop years. Lentils and chickpeas had moisture contents higher than the 5-year mean moisture values. However, the moisture contents of the pulses from 2024 tended to be higher than the 10-year mean moisture contents of their respective pulse crop. In contrast, pea moisture content in 2024 was slightly lower than the 5- and 10-year mean values. Collectively, the data suggests that the mean long-term moisture is a good guide to predicting the moisture content of pulses. The total starch contents of pea and chickpea from 2024 were comparable to their respective 5- and 10-year mean starch content. The mean total starch percentage in lentils from 2024 was comparable to the 5-year mean starch content. Total starch in peas grown in 2024 was lower than that of peas from only the 2020 harvest. The chickpeas from 2024 had a mean total starch content that was similar to that of chickpeas from 2020 and 2021. The winter pea class had total starch that was lower than winter peas from previous production years, except winter peas from 2022. The red lentil class had lower mean total starch contents in 2024 compared to the 5- and 10-year mean values. The green and Spanish Brown lentil classes had mean starch contents comparable to the 5-year mean starch content. The mean protein content in peas from 2024 was higher than the 5- and 10-year mean protein contents. The protein content of green peas was comparable to that of the samples from 2021, 2022, and the 5-year mean protein content. In contrast, the protein content in yellow peas from 2024 was comparable to that of the yellow peas from 2022 and was higher than the 5- and 10-year mean values. Winter peas from 2024 closely matched winter peas from 2023. Lentils from 2024 had protein contents similar to lentils from 2020 and 2022. The red and Spanish Brown lentils had protein contents that were most like samples from 2020, while the green lentils were most similar to the 5-year mean protein content. The protein content in the 2024 chickpeas was higher than both the 5- and 10-year mean values. Collectively, the protein data from recent years supports higher protein compared to the long-term mean value, with only a few exceptions. The fat contents of the pulses evaluated were within the range reported in the literature. The mean fat contents of peas, lentils, and chickpeas from 2024 were lower than their respective crops from previous years, including the 5-year mean fat content.

The mean test weight, water holding capacity, and swelling capacity of peas either matched or were higher than the 5- and 10-year mean values. The mean 1000 seed weight and cooked firmness values were lower than the long-term mean. The values of the physical parameters of lentils were the same or higher compared to their 5- or 10-year mean values. Only the cooked firmness of lentils was less than the 5- and 10-year mean. In general, physical parameter values were slightly less than the 5- or 10-year mean values for chickpeas, except for the hydration capacity and swelling capacity. The large chickpea, such as Nash had 1000 seed weights of 591, 526, and 530 in 2024, 2023, and 2020, respectively. This suggests that only minor differences in seed size existed for the same cultivar over different years and that the considerable number of small chickpea samples that were included in the 2024 survey likely contributed to the lower 1000 seed weight. A size distribution analysis of chickpeas indicated a slightly smaller seed size for chickpeas from 2024 compared to the 5-year seed size. The Nash and Quinn chickpea cultivars had the highest percentage (93.6 and 92.0%, respectively) of seeds retained on a 22/64-inch sieve in 2024. Overall, the chickpea from 2023 had a lower percentage of seeds being retained on the 22/64- and 20/64-inch sieves compared to other years, except 2023. However, the results were impacted by the Marvel cultivar, as only 2% of their seeds were retained on the 22/64-inch sieve. The physical parameter values of winter peas were similar to values obtained in peas from 2023. However, the green and yellow peas tended not to be like previous crop years except for test weight and swelling capacity, which were similar to the 5- and 10-year mean value and peas from 2023. Unlike red lentil, green and Spanish brown lentils from 2024 had similar physical parameter values as lentils used to determine the 5- and 10-year mean values for their respective color classes. The appearance of the green and yellow peas in 2024 was either the same (green) or slightly darker (yellow) than peas that made up the 5- and 10-year mean lightness (L*). The color difference values of dry peas vs. soaked peas from 2024 were higher than those of peas from other harvest years. The increased yellowness was the main reason for the higher color differences in both the green and yellow peas from previous years. The color tended to be lighter for all lentil classes than lentils from previous years. The 2024 chickpea crop had slightly higher lightness values compared to the 5- and 10-year mean L* values. Overall, the color difference between dry and soaked chickpeas was higher than the 5-year mean value.

The starch pasting properties for the 2024 peas, lentils, and chickpeas were significantly lower compared to the 5- and 10-mean values. The pastes that resulted from samples were less viscous than the pastes of samples from other crop years. The RVA gel firmness test indicated that peas, regardless of class, from 2024 had gel firmness values that were lower than those of samples from 2022 and 2023. Regardless of market class, lentils from 2024 had significantly lower gel firmness values compared to lentils from 2022 and 2023. However, the green and red lentils did have the same or higher peak and hot paste viscosities compared to the 5- and 10-mean values. In contrast, Spanish Brown lentils had peak, hot paste, and cold paste viscosities that were lower than those of samples from previous years. Chickpea followed the same trend as the Spanish brown lentils. Functionality tests showed that emulsion activity and stability did not differ significantly among the pulse samples from different years. The foaming capacity was lower in 2024 for pea, lentils, and chickpeas compared to samples from 2022 and 2023. However, foam stability was either greater than or the same for all pulses from 2024 compared to pulses from 2022 and 2023. The oil holding capacities of all pulses were higher in 2024 compared to values from pulses grown in 2023. Water holding capacity was higher in samples from 2024 compared to pulses from 2022 and 2023, regardless of pulse type.

Overall, the canning quality data of peas from 2024 supports more rehydration of the peas and less canned firmness. The water hydration capacity of canned peas in 2024 was comparable to the 5-year mean values. Canning firmness was significantly lower (i.e., less firm) in 2024 compared to peas from 2021 and 2023 and the 5-year mean value. Chickpeas from 2024 had hydration capacity and swelling capacity greater than canned chickpeas from other years, except 2023. The mean canned firmness of chickpea from 2024 was 6.7 N/g, which is the same as the 5-year mean canned firmness value.

The focus of the pulse program is the quality evaluation and utilization of pulses as food and food ingredients. The mission of the Pulse Quality Program is to provide industry, academic, and government personnel with readily accessible data on pulse quality and to provide science-based evidence for the utilization of pulses as whole food and as ingredients in food products. Thus, I welcome any thoughts, comments, and suggestions regarding the report. If a quality trait is of interest to you, please reach out to me. I would like to thank the USA pulse producers for their support of this survey.

Sincerely,

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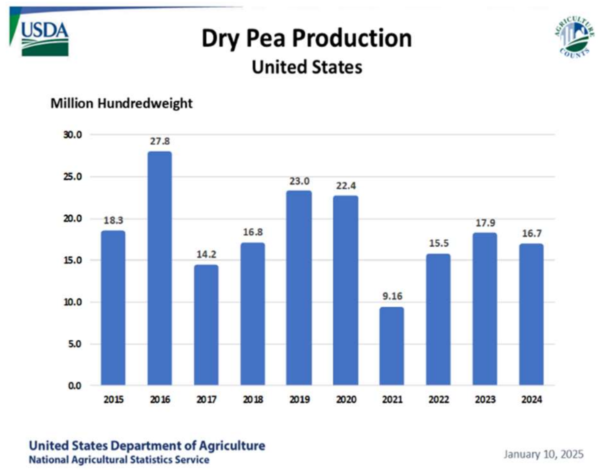
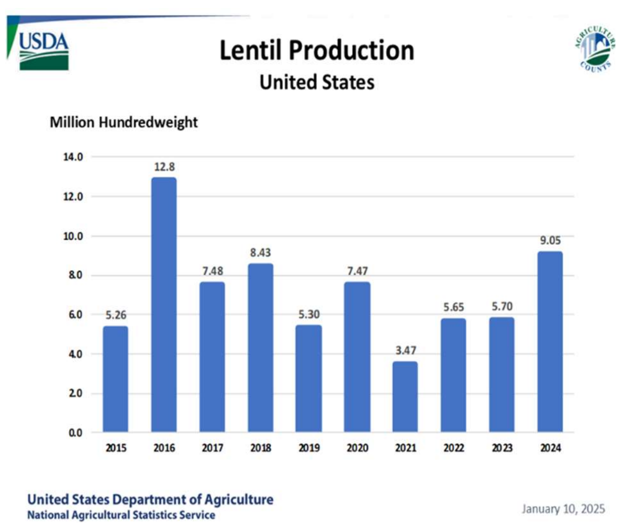
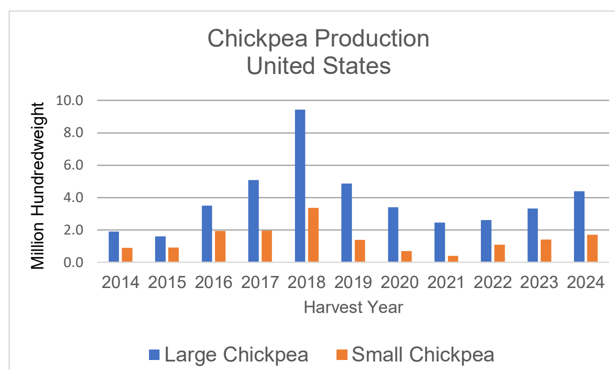
Pulse Production

The Northern Plains region and Pacific Northwest are the largest pulse producing areas within the USA. The U.S. pulse harvested acres in 2024 was 2,396,468 (Table 1), which was approximately 603,000 and 542,025 more acres than in 2023 and 2022, respectively. Total U.S. pulse production (Metric Tons (MT)) in 2024 is estimated to be 1,634,595 which is up significantly from the 1,255,714 and 1,095,890 produced in 2023 and 2022, respectively (Table 1). The favorable conditions affecting some of the pulse growing regions and higher acres planted likely contributed to the higher production compared to the previous crop years (2020-2023). The USDA estimated that the dry pea acreage was 977,687, which was up from 908,527 and 872,544 from 2023 and 2022, respectively (Table 1). Pea production (896,313 MT) was significantly more than the 791,760 and 676,289 MT in 2023 and 2022, respectively (Table 1). The long-term production shows that the million 100-weight of peas produced in 2024 matched the 2018 levels.





Lentil acreage was 895,770 in 2024. This value was more than acres harvest in the previous four years (Table 1). Lentil production in 2024 was 429,768 MT, which is higher than 255,000 and 256,259 MT produced in 2023 and 2022, respectively, and is nearly 2.5 times the 2021 production of 177,571 MT. The USDA estimate of 9.05 million 100-weight of lentil exceeds production from all previous years except 2016. Chickpea harvested acres (523,011) in 2024 was approximately 150,000 acres above the 2023 and 2022 acres of 374,003 and 361,714, respectively. Production was estimated at 308,514 MT, which is significantly higher than the production from previous years (Table 1). Furthermore, the production of large chickpeas more than doubled the production of small chickpeas. The higher production of pulses supports the producer's ability to meet the demand for U.S. pulses.



The yield for dry pea was 1775 lbs./acre in 2024, which is up slightly from 1747 lbs./acre in 2022 but slightly lower than the 1924 lbs./acre in 2023. Lentil yield (1002 lbs./acre) was slightly lower than the 1089 lbs./acre observed in 2023 but was up from 900 lbs./acre in 2022 and 606 lbs./acre in 2021. However, this value is still lower than the 2020 yield of 1,338 lbs./acre. Like peas and lentils, chickpea yield (~1,144 lbs./acre) was approximately the same as in 2022 (1049 lbs./acre), but slightly lower than the 1,306 lbs./acre for the chickpea crop in 2023. For additional in-depth production data, please visit https://www.usapulses.org/.

Table 1. United States pulses acreage and production summary for 2020-2024.

	2024		2023		2022		2021		2020	
Crop	Acres*	Production#	Acres	Production	Acres	Production	Acres	Production	Acres	Production
Dry Peas	977,687	896,313	908,527	791,760	872,544	676,289	942,794	425,466	964,078	967,271
Lentil	895,770	429,768	511,133	255,000	620,185	256,259	661,803	177,571	450,113	298,260
Chickpea	523,011	308,514	374,003	208,954	361,714	163,342	362,740	130,204	248,292	178,470
Total	2,396,468	1,634,595	1,793,663	1,255,714	1,854,443	1,095,890	1,967,337	733,241	1,662,483	1,444,001

*Acres = Acres Harvested, #Production = Metric Tons, Source: USDA Farm Service Agency, USDA NASS, and US Dry Pea and Lentil Council

Laboratory Methods Used to Measure Pulse Quality

Where applicable, standard methods were followed for the determination of each pulse quality attribute in 2024 (Table 2). For most analyses, data is provided on data collected between 2020 and 2024. The data is reported as a range, mean, and standard deviation (SD) for the 2024 harvest year, while preceding years were provided as a mean plus SD. Data on cultivars was reported only for the 2024 harvest years, and no comparisons were made in the tables to cultivars from the previous year. A summary of the testing methods can be found in Table 2. Further information on the testing methods is provided below.

- Moisture content is the quantity of water (i.e., moisture) present in a sample and is expressed as a percentage. Moisture content is an important indicator of pulse seed handling and storability. Pulse crops are recommended for harvest at 13-14% moisture. At lower moisture levels, the seeds are prone to mechanical damage such as fracturing. Pulses with higher moisture levels are more susceptible to enzymatic activity and microbial growth, which reduces quality and increases food safety risks.
- Pulses are rich in protein, which ranges from 20 to 30% depending on the growing location, cultivar, and year. Pulses are low in sulfur-containing amino acids but high in lysine, an essential amino acid for human health. Protein content is the quantity of protein present in a sample and is expressed as a percentage.
- The fat (i.e., lipid) content is the quantity of fat present in the pulse. Usually, peas and lentils have fat contents under 3% while chickpeas contain 5-8%.
- Ash content is the quantity of ash present in a sample and is expressed as a percentage. Ash is an indicator of minerals. Higher ash content indicates higher amounts of minerals such as iron, zinc, and selenium.
- Total starch is a measure of the quantity of starch present in a sample and is expressed as a percentage. Starch is responsible for a significant part of the pulse functionality, such as gel formation and viscosity enhancement. Enzymatic hydrolysis is the basis for starch determination. Starch functionality is measured using the RVA instrument. Pulses show a type C pasting profile, which is represented by a minimally definable pasting peak, a small breakdown in viscosity, and high final peak viscosity. This type of starch is ideal for glass noodle production.
- Test weight and 1000 seed weight are indicators of seed density, size, shape, and milling yield. Each pulse crop has its own market preference based on color, seed size, and shape. A grain analysis computer is used to determine test weight in lbs./bu.
- Water hydration capacity, percentage unhydrated seeds, and swelling capacity are physical characteristics of pulses that relate to the ability of the pulse to rehydrate. The swelling capacity relates to the increased size of the pulse as a result of rehydration. Cooking firmness provides information on the texture (i.e., firmness) of the pulse after a cooking process. The data obtained can be used to predict how a pulse might change during cooking and canning processes.
- Color analysis is provided as L*, a* and b* values. Color analysis is important as it provides information about the general pulse color and color stability during processing. Color difference is used specifically to indicate how a process affects color. In this report, a color difference between pre- and post-soaked pulses was determined.
    - "L*" represents the lightness on a scale where 100 is considered a perfect white and 0 is for black. Pulses such as chickpeas and yellow peas typically have higher L* values than green or red pulses. The "a*" value represents positive for redness and negative for green, and "b*" represents positive for yellow, negative for blue, and zero for gray. A pulse with a higher positive "b*" value would be indicative of a yellow pulse, while a higher "a*" value represents a pulse with a red-like hue; thus, brown pulses have a higher red value than a yellow pulse. Green pulses have negative "a*" values, and thus, the greater the negative value, the greener the pulse.
- Canning quality evaluation. This evaluation serves as an Indicator of pulse quality after a canning process and a three-week storage. The information allows for a relative difference in quality to be established following a canning process that used a brine solution containing calcium chloride.
- The functionality test includes emulsion activity and stability, foaming capacity and stability, water holding capacity, and oil holding capacity.
    - Emulsions are a heterogeneous combination or dispersion of two or more immiscible liquids, usually oil and water, which are formed with the aid of mechanical agitation. Stability of an emulsion is simply a gravitational separation of the two primary phases of a mixture.
    - Foams are a dispersion of gas bubbles in a liquid or solid phase. Foaming capacity is the amount of interfacial area that can be created by whipping the flour. Foam stability is defined as the time needed to lose 50% of either the liquid or the volume of foam. These properties can be important for products such as cakes.
    - Water holding capacity and oil holding capacity are measures that allow for the determination of the amount of water or oil that can bind to the flour. This information is important because it allows product developers to identify how much water, or oil may be taken up by flour and thus allows them to adjust formulations as needed.

Table 2. Quality attribute, analytical method, and remarks for analyses conducted for the 2024 pulse quality survey.

Quality Attribute	Method	Remarks
1. Moisture (%)	AACC Approved Method of Analysis, Method 44-15.02	An indicator of post-harvest stability, milling yield, and general processing requirements.
2. Protein (%)	AACC Approved Method of Analysis, Method 46-30.01	An indicator of nutritional quality and the amount of protein available for recovery.
3. Ash (%)	AACC Approved Method of Analysis, Methods 08-01.01	An indicator of total non-specific mineral content.
4. Total starch (%)	AACC Approved Method of Analysis, Method 76-13.01	An indicator of nutritional quality and the amount of starch available for recovery.
5. Fat (Lipid)	AOCS Method Ba 3-38	An indicator of nutritional quality as related to the amount of fat in the samples.
6. Test weight (lbs./bu)	AACC Approved Method of Analysis, Method 55-10.01	An indicator of sample density, size, and shape.
7. 1000 seed weight (g)	100-kernel sample weight times 10	Indicator of grain size and milling yield.
8. Chickpea Size Determination	Four samples of 250 seeds of chickpea were placed on a series of sieves (22/64", 20/64", 18/64") and rotated. The number of seeds retained on each sieve was determined and reported as % of seeds retained.	Indication of the size distribution within a sample of chickpea.
9. Water hydration capacity (%)	AACC Approved Method of Analysis, Method 57-12.02	An indicator of cooking and canning behavior.
10. Unhydrated seed (%)	AACC Approved Method of Analysis, Method 57-12.02	An indicator of cooking and canning behavior and the number of seeds that may not rehydrate.
11. Swelling Capacity (%)	Determined by measuring the volume before hydration (i.e., soaking) and after. The percentage increase was then determined.	An indicator of the amount of volume regained by a pulse after being rehydrated.
12. Color	Konica Minolta CR-410 Chroma meter. The L*, a*, and b* values were recorded.	An indicator of visual quality and the effect of processing on color.
13. Color Difference ($\Delta E^{*}ab$)	The color difference between the dried (pre-soaked) and the soaked pulse was determined using L*, a*, and b* values from the color analysis as follows (*Minolta*): $\Delta E^{*}ab = [(\Delta L^{*})^2 + (\Delta a^{*})^2 + (\Delta b^{*})^2]^{1/2}$	An indicator of the general color difference between pre- and post-soaked pulses. The lower the value, the more stable the color.
14. Starch Properties (RVU)	Rapid Visco Analyzer following a modified AACC Approved Method 61-02.01. Modification included a different heating profile and longer running time. Gel firmness was completed 2 hours after the RVA. The sample was compressed at a speed of 4 mm/s to a distance of 15 mm and trigger force of 2 g with a cylindrical plunger (diameter = 10 mm)	An indicator of texture, firmness, and gelatinization properties of the starch.
15. Cook Firmness	AACC Approved Method of Analysis, Method 57-14.02	An indicator of pulse firmness after the cooking process. The information allows for a relative difference in texture to be established.
16. Emulsion Properties	Maskus, et al. (2016). Cereal Foods World. 61(2): 59-64.	An indicator of the ability of the flour to facilitate the formation of an emulsion from oil and water when subjected to shear.
17. Foaming Properties	Stone, et al. (2015). Food Research International 76:31-38.	An indicator of the ability of the flour to foam when flour or protein is made into a solution and subjected to shear.
18. Water Holding Capacity	AACC Approved Method of Analysis, Method 57-13.02.	An indicator of the weight of water that will bind to one gram of flour. An important parameter for producing meat and bakery products.
19. Oil Holding Capacity	Method of Wang et al. (2020). Cereal Chemistry 97:1111-1117.	An indicator of the weight of oil that will bind to one gram of flour. An important parameter for producing meat and salad dressing products.
20. Canning Quality	Followed methods associated with quality attributes 9, 11, 13, and 15. Canning was completed in laminated metal cans using calcium chloride brine, with processing times of 20 minutes and 20 psi for pea and 70 minutes at 20 psi for chickpea.	Indicator of pulse quality after a canning process and 3-week storage. The information allows for a relative difference in quality to be established following a canning process that used a brine solution containing calcium chloride.

Dry Pea Quality Results

Sample distribution

A total of 127 dry pea samples were collected from Montana, Nebraska, North Dakota, and Washington from August 2024 to November 2024. Samples were delivered to SDSU between November 2024 and February 2025. The growing location, number of samples, market class, and genotype details of these dry pea samples are provided in Table 3. The majority of the pea samples were obtained from Montana. Green peas accounted for 39 of the samples collected, where Passion accounted for eight of the green pea samples and Arcadia accounted for six samples.

Yellow peas accounted for 78 of the pea samples collected. The samples collected were a mix of cultivars listed in Table 3, but CDC Meadow, AAC Julius, and AACC Chrome accounted for six, four, and four of the samples, respectively. Six winter peas were evaluated in 2024. The Blaze and Vail cultivars accounted for all the samples evaluated.

Table 3. Description of dry pea samples used in the 2024 pulse quality survey.

State	No. of Samples	Market Class	Cultivars	
Montana	100	Green	Arcadia	Banner
			Passion	Patrick
			Striker	
		Mottled or Maple	CDC Acer	CDC Mosaic
		Yellow	AAC Ironhorse	AAC Profit
			CDC Meadow	Early Star
			Montech	Salamance
			Treasure	
Nebraska	5	Yellow	AAC Chrome	AAC Julius
North Dakota	11	Green	Shamrock	
		Yellow	1140-2822	AAC Chrome
			AAC Harrison	AAC Julius
			AAC McMurphy	Caphorn
			Hyline	Salamanca
		Winter	Vail (green)	
Washington	10	Green	Ariel	Banner
			Passion	
		Winter	Blaze (Yellow)	Vail (Green)

Proximate composition of dry pea (Tables 4-6)

Moisture

The moisture content of dry pea ranged from 5.1-13.8% in 2024 (Table 4). The mean moisture content of all pea samples was 9.9%, which is slightly lower than the 5-year mean of 10.1% and the 10-year mean of 10.2%. The moisture content is lower than the 14% recommended for general storability; however, long term storage under dry conditions could reduce seed moisture to lower levels where damage during storage and handling could occur. In 2024, only three samples had moisture contents greater than 13%. Most pea samples had moisture contents between 8.5% and 10.5%. The mean moisture contents between the three market/color classes varied by approximately 2 percentage points. Mean moisture contents ranged from 8.5 % in winter peas to 10.2% for the yellow peas (Table 5). The green pea moisture percentage of 9.6% was comparable to both the 5- and 10-year mean moisture contents of 9.8%. The yellow pea mean moisture percentage was 10.2%, which was less than the 5- and 10-year mean values of 10.5 and 10.6%, respectively (Table 5). Overall, the mean moisture contents of the green peas from 2024 were most like moisture contents in peas from 2023. In contrast, moisture content in yellow peas from 2024 were similar to moisture contents in peas from 2020. Winter peas had lower moisture percentages in 2024 compared to winter peas from 2022 but similar to the values for winter peas from 2023 and 2021. The highest moisture contents were observed in the Striker (i.e., green pea) and Caphorn (yellow pea) cultivars (Table 6). Most of the green peas had values less than 10% while most of the yellow pea cultivars had mean moisture contents around 11%. The cultivars of winter and mottled peas had moisture contents below 10%.

Table 4. Proximate composition of dry pea grown in the USA, 2020-2024 plus the 5- and 10-year means.

Proximate Composition (%)*	Year							
	2024		2023	2022	2021	2020	5-year	10-year
	Range	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Moisture	5.1-13.8	9.9 (1.3)	9.4 (1.2)	9.3 (1.1)	9.7 (1.3)	9.5 (1.3)	10.1 (1.3)	10.2 (1.3)
Ash	1.6-3.3	2.5 (0.3)	2.3 (0.3)	2.8 (0.1)	2.6 (0.2)	2.5 (0.5)	2.5 (0.2)	2.5 (0.1)
Fat	0.2-1.8	1.0 (0.3)	1.0 (0.2)	1.2 (0.2)	1.0 (0.2)	1.7 (0.6)	1.4 (0.4)	**
Protein	18.3-33.6	23.0 (1.9)	22.9 (2.2)	23.4 (1.5)	23.1 (1.1)	21.4 (1.5)	22.4 (1.1)	21.9 (1.1)
Total Starch	33.6-52.3	42.8 (3.5)	40.9 (2.0)	42.6 (3.2)	42.9 (1.9)	44.4 (3.1)	42.8 (1.3)	42.8 (1.0)

*composition is on an "as is" basis; **not previously reported prior to 2017

Table 5. Proximate composition of different classes of dry pea grown in the USA, 2020-2024 plus the 5- and 10-year means.

Proximate Composition (%)*	Mean (SD) of green pea					5-year Mean (SD)	10-year Mean (SD)
	2024	2023	2022	2021	2020		
Moisture	9.6 (1.0)	9.6 (1.3)	9.4 (1.5)	9.4 (0.9)	9.2 (1.3)	9.8 (0.9)	9.8 (0.8)
Ash	2.4 (0.3)	2.4 (0.2)	2.8 (0.2)	2.6 (0.2)	2.6 (0.3)	2.6 (0.2)	2.5 (0.1)
Fat	1.0 (0.4)	1.0 (0.2)	1.2 (0.2)	1.0 (0.2)	1.6 (0.6)	1.4 (0.5)	1.7 (0.7)
Protein	23.3 (1.7)	23.9 (2.3)	23.2 (2.1)	23.3 (1.0)	23.5 (1.3)	23.0 (1.0)	22.4 (1.1)
Total Starch	42.6 (4.1)	39.9 (2.0)	43.1 (2.2)	42.7 (1.4)	45.1 (3.0)	42.8 (1.9)	42.5 (1.5)
Proximate Composition (%)*	Mean (SD) of yellow pea					5-year Mean (SD)	10-year Mean (SD)
	2024	2023	2022	2021	2020		
Moisture	10.2 (1.4)	9.5 (1.0)	9.3 (1.4)	10.8 (0.6)	9.9 (1.1)	10.5 (1.5)	10.6 (1.2)
Ash	2.5 (0.3)	2.3 (0.1)	2.8 (0.1)	2.5 (0.1)	2.4 (0.6)	2.5 (0.2)	2.5 (0.1)
Fat	1.0 (0.3)	1.1 (0.2)	1.2 (0.1)	1.1 (0.1)	1.7 (0.6)	1.4 (0.4)	1.7 (0.6)
Protein	22.7 (1.9)	21.7 (1.4)	22.6 (0.9)	23.0 (1.0)	21.4 (1.3)	21.9 (0.9)	21.5 (0.9)
Total Starch	43.3 (3.1)	41.8 (1.7)	45.6 (1.1)	43.5 (2.5)	43.9 (3.0)	43.6 (1.4)	43.1 (1.2)
Proximate Composition (%)*	Mean (SD) of winter pea					5-year Mean (SD)	10-year Mean (SD)
	2024	2023	2022	2021	2020		
Moisture	8.5 (1.4)	8.6 (0.4)	9.2 (0.5)	8.4 (0.9)	7.8 (0.9)	9.1 (0.6)	nd
Ash	2.6 (0.4)	2.8 (0.2)	2.9 (0.1)	2.7 (0.2)	2.5 (0.1)	2.7 (0.2)	nd
Fat	0.8 (0.4)	1.0 (0.2)	1.1 (0.1)	0.8 (0.1)	1.7 (0.4)	1.3 (0.5)	nd
Protein	23.6 (1.1)	23.4 (2.6)	24.1 (1.2)	23.1 (1.5)	21.3 (1.3)	22.7 (1.2)	nd
Total Starch	40.6 (1.7)	41.9 (1.8)	40.0 (2.8)	43.5 (1.3)	46.1 (2.4)	42.4 (1.4)	nd

*composition is on an "as is" basis; nd = not determined due to test not being performed for 10 years on samples.

Ash

The ash content of dry peas ranged from 1.6 to 3.3%, with a mean of 2.5%. The mean ash content (2.5%) of dry peas grown in 2024 was identical to the 5- and 10-year mean ash contents (Table 4). Ash content is a general indicator of minerals present and has been consistent over the ten-year evaluation of peas. The ash contents of green and yellow peas were 2.4 and 2.5%, respectively (Table 5). The green and yellow pea ash contents were essentially the same as their respective 5- and 10-year mean ash values of approximately 2.5%. Winter peas had a 2.6% ash content, which was slightly lower than the 5-year mean ash content of 2.7 (Table 5). The ash percentage in individual samples ranged from 1.9% in Ariel to 2.7% in Banner and Patrick green peas (Table 6). For yellow peas, Hyline (2.0%) and Caphorn (2.9%) had the lowest and highest ash contents, respectively. Interestingly, Hyline had the highest ash content in 2023. One possible reason could relate to the soil where the Hyline pea was grown, since soil mineral composition has a slight impact on ash content. Vail and Blaze winter peas had similar ash contents, while the ash content of mottled peas varied from 1.9 to 2.7% (Table 6). Although small variations were observed in ash content, overall, the ash contents were consistent.

Table 6. Mean proximate composition of dry pea cultivars grown in the USA in 2024.

Market Class	Cultivar	Concentration (%)* Moisture	Ash	Fat	Protein	Starch
Green	Arcadia	9.7	2.5	0.8	22.7	42.7
	Ariel**	9.9	1.9	0.5	24.4	39.2
	Banner	9.3	2.7	1.1	24.3	43.4
	Passion	8.6	2.4	1.1	22.8	43.2
	Patrick	10.8	2.7	1.0	23.5	43.9
	Shamrock**	8.8	2.1	1.0	21.9	44.4
	Striker	11.7	2.3	1.3	24.5	41.2
Yellow	1140-2822**	10.7	2.3	1.3	23.5	42.9
	AAC Chrome	11.1	2.6	0.6	23.1	44.6
	AAC Harrison**	10.4	2.5	0.4	22.1	44.0
	AAC Ironhorse**	10.1	2.6	0.9	22.6	47.5
	AAC Julius	11.1	2.6	0.9	23.0	44.0
	AAC McMurphy**	10.3	2.1	1.1	24.1	44.1
	AAC Profit**	10.7	2.1	1.1	20.9	42.2
	Caphorn**	12.5	2.9	0.9	20.4	49.3
	CDC Meadow	7.9	2.5	0.9	23.6	41.2
	Early Star**	8.8	2.6	1.5	22.7	45.2
	Hyline**	11.2	2.0	0.5	21.3	45.2
	Montech**	11.0	2.5	1.4	20.3	41.5
	Salamanca	11.0	2.4	0.8	22.5	44.0
	Treasure	9.4	2.5	1.1	23.4	42.9
Winter Green	Vail	9.7	2.5	0.7	23.7	39.6
Winter Yellow	Blaze	7.9	2.6	0.8	23.6	41.1
Mottled/Maple	CDC Acer**	8.5	1.9	0.7	27.1	39.1
	CDC Mosaic	9.6	2.7	0.8	25.8	38.3

*composition is on an "as is" basis; **Only one sample of cultivar tested

Fat (Lipid)

The fat content of dry peas ranged from 0.2 to 1.8%, with a mean of 1.0% (Table 4). The mean fat content (1.0%) of peas harvested in 2024 was lower than the fat content of peas harvested in 2022 and 2020. In addition, the fat content (1.0%) was lower than the 5-year mean fat content (1.7%). The fat contents of the green and yellow classes were slightly higher than the fat contents in winter peas (Table 5). Overall, the mean fat contents in the green and yellow peas were lower than the 5- and 10-year mean values (1.4 and 1.7%, respectively). The mean fat content (0.8%) of winter peas was also lower than the 5-year mean value (1.5%). The Striker cultivar had the highest fat content (1.3%) among green pea cultivars, while Early Star had the highest fat content of the yellow peas (Table 6). Regardless of color, most other cultivars had fat contents around 1.0-1.1% (Table 6). The fat content of winter and mottled pea samples was approximately 0.8% and differed by only 0.1 percentage point. Regardless of the sample, all peas had a very low-fat content.

Protein

Protein content of dry peas harvested in 2024 ranged from 18.3 to 33.6% with a mean of 23.0% (Table 4). The mean protein content of peas from 2024 was comparable to the value for peas from 2021-2023. Furthermore, the mean protein (23%) was higher than the 5- and 10-year mean protein contents of 22.4 and 21.9%, respectively (Table 4). The mean protein contents of the green, yellow, and winter pea samples were 23.3, 22.7, and 23.6%, respectively (Table 5). Green pea samples had a mean protein content that was higher than the 5- and 10-year mean values of 23.0 and 22.4%, respectively. Yellow peas had a mean protein content that was higher than the 5- and 10-year mean protein contents of 21.9 and 21.5%, respectively (Table 5). The protein content of Winter peas was 23.6%, which was higher than the 5-year mean value of 22.7%. The data support higher protein content in recent years compared to long-term mean values. The Striker cultivar had the highest mean protein content (24.5%) while Shamrock had the lowest (21.9%) among green peas (Table 6). AAC McMurphy and Montech cultivars had the highest (24.1%) and lowest (20.3%) protein contents of the yellow market class, respectively (Table 6). In winter peas, Vail and Blaze had similar protein contents, while the CDC Acer had the highest (27.1%) mean protein content of the mottled pea.

Total starch

Total starch content of dry pea ranged from 33.6 to 52.3% with a mean of 42.8% (Table 4). The mean total starch content of dry peas grown in 2024 was comparable to total starch in dry peas from the 2021 and 2021 harvest years and the 5- and 10-year mean total starch values of 42.8%. The starch contents of the green and yellow classes were 42.6 and 43.3%, respectively (Table 5). Green peas had a mean starch content (42.6%) that was approximately the same as the 5-year and 10-year mean values of 42.8% and 42.5%, respectively. The 5- and 10-year mean starch contents for the yellow peas were 43.6 and 43.1%, respectively. These values were slightly higher than the mean starch content (43.3%) of yellow peas harvested in 2024. Winter peas from 2024 had a mean starch content (40.6%) that was lower than winter peas from previous harvest years, except 2022 (Table 5). Furthermore, the mean starch value of winter peas from 2024 was lower than the 5-year mean value of 42.4%.

Among green peas, Shamrock and Ariel had the highest (44.4%) and lowest (39.2%) mean total starch contents, respectively. CDC Meadow and Caphorn had the lowest (41.2%) and highest (49.3%) mean total starch contents among yellow peas. Vail and Blaze had the lowest (39.6%) and highest (41.1%) mean total starch contents among winter pea samples (Table 6). The Blaze cultivar also had the highest (43.4 and 49.6%) total starch in 2023 and 2021, respectively, and suggests that production year may impact the starch content (Table 6).

The general trend for all samples supports higher protein, comparable starch, and lower fat contents in samples grown in 2024 compared to previous years. The higher starch contents may have been impacted more by varieties evaluated than by environmental conditions. However, the general temperature trend during June-August 2023 averaged 65.5°F, while the same period in 2024 had a mean temperature of 63.3°F. Warmer temperatures tend to cause less starch formation, which may be another reason for the lower starch in 2023.

Physical parameters of dry pea (Tables 7-11)

Test weight ranged from approximately 58.9 to 63.1 lbs./Bu with a mean of 63.1 lbs./Bu. This mean value was approximately the same as the 5- and 10-year mean values of 63.2 and 63.3 lbs./Bu (Table 7). The mean test weight for all pea samples harvested in 2024 was slightly lower than that of those harvested in previous years. The test weights of peas in the green and yellow classes were 63.0 and 63.2 lbs./Bu, respectively (Table 8). The mean value for green pea was comparable to the 5- and 10-year mean test weights. In contrast, the mean test weight for the yellow peas in 2024 was higher than both the 5- and 10-year mean values. Winter peas had a mean test weight of 62.7 lbs./Bu, which was lower than the winter peas from previous harvest years. The test weight of individual cultivars varied within their respective green and yellow classes, with few exceptions (Table 9). Shamrock (green) and AAC Harrison and CDC Meadows (yellow) had the highest test weights in their respective classes. The lowest test weights were 59.9 and 61.5 lbs./Bu for the Ariel (green) and 1140-2822 (yellow) varieties, respectively (Table 9). Among the winter peas, the Blaze cultivar had slightly higher test weight than Vail, both of which were less than the test weights of the mottled peas (Table 9).

Table 7. Physical parameters of dry pea grown in the USA, 2020-2024 plus the 5- and 10-year means.

Physical Parameter	Year							
	2024		2023	2022	2021	2020	5-year	10-year
	Range	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Test Weight (lb/bu)	58.9-67.0	63.1 (1.4)	63.7 (1.2)	59.5 (5.9)	64.7 (1.3)	63.6 (1.9)	63.2 (2.1)	63.3 (1.4)
1000 Seed Wt (g)	120-305	190 (28)	194 (34)	182 (41)	199 (40)	233 (33.0)	206 (21)	210 (16)
Water Hydration Capacity (%)	80-169	115 (13.0)	102 (9)	112 (6)	100 (6)	97 (8.0)	101 (6)	102 (5)
Unhydrated Seeds (%)	0-6	0 (1)	2 (3)	1 (4)	0 (1)	2 (3)	1 (1)	2 (1)
Swelling Capacity (%)	89-223	144 (21)	133 (14)	141 (19)	146 (12)	118 (12.4)	137 (12)	142 (10)
Cooked Firmness (N/g)	8.1-39.1	22.0 (5.5)	22.6 (6.2)	22.1 (7.3)	24.0 (5.2)	24.9 (6.3)	22.9 (2.0)	nd

nd = not determined due to test not being performed for 10 years.

Table 8. Physical parameters of different classes of dry pea grown in the USA, 2020-2024 plus the 5- and 10-year means.

Physical Parameter	Mean (SD) of green pea					5-year	10-year
	2024	2023	2022	2021	2020	Mean (SD)	Mean (SD)
Test Weight (lb/bu)	63.0 (1.6)	63.1 (1.0)	59.3 (5.9)	64.4 (1.9)	64 (2)	62.8 (2.0)	62.9 (1.4)
1000 Seed Wt (g)	180 (16)	193 (29)	182 (45)	193 (26)	220 (31)	196 (14)	200 (13)
Water Hydration Capacity (%)	118 (12)	102 (12)	111 (8)	105 (3)	99 (7)	105 (5)	105 (5)
Unhydrated Seeds (%)	0 (0)	3 (4)	3 (6)	0 (0)	2 (2)	2 (1)	1 (1)
Swelling Capacity (%)	144 (25)	133 (12)	137 (31)	149 (12)	120 (12)	138 (12)	141 (9)
Cooked Firmness (N/g)	20.2 (4.2)	23.0 (4.5)	24.2 (5.8)	21.4 (5.5)	21.7 (4)	22.1 (1.6)	nd
Physical Parameter	**Mean (SD) of yellow pea**					**5-year**	**10-year**
	2024	**2023**	**2022**	**2021**	**2020**	**Mean (SD)**	**Mean (SD)**
Test Weight (lb/bu)	63.2 (1.3)	64.6 (1.1)	54.2 (5.9)	63 (2)	64 (1)	62.1 (4.5)	62.6 (3.1)
1000 Seed Wt (g)	198 (30)	207 (36)	221 (30)	244 (28)	222 (31)	226 (14)	223 (11)
Water Hydration Capacity (%)	114 (14)	98 (5)	108 (5)	93 (7)	102 (8)	99 (6)	100 (6)
Unhydrated Seeds (%)	0 (0)	3 (2)	0 (0)	2 (3)	0 (2)	1 (1)	1 (1)
Swelling Capacity (%)	144 (21)	131 (14)	143 (20)	116 (12)	146 (14)	135 (12)	140 (11)
Cooked Firmness (N/g)	23.1 (5.4)	24.5 (6.5)	28.3 (7.1)	27.2 (6.6)	22.0 (7.1)	25.5 (2.5)	nd
Physical Parameter	**Mean (SD) of winter pea**					**5-year**	**10-year**
	2024	**2023**	**2022**	**2021**	**2020**	**Mean (SD)**	**Mean (SD)**
Test Weight (lb/bu)	62.7 (0.5)	63.2 (1.1)	63.6 (0.9)	65.0 (0.7)	65 (0.4)	64.4 (0.9)	64.4 (0.9)
1000 Seed Wt (g)	162 (15)	161 (24)	152 (12)	156 (14)	175 (12)	160 (9)	160 (9)
Water Hydration Capacity (%)	114 (9)	110 (3)	115 (2)	103 (5)	96 (5)	102 (12)	102 (12)
Unhydrated Seeds (%)	0 (1)	0 (1)	1 (1)	0 (0)	1 (1)	2 (3)	2 (3)
Swelling Capacity (%)	154 (8)	141 (24)	141 (6)	156 (7)	119 (8)	138 (14)	nd
Cooked Firmness (N/g)	17.4 (7.0)	16.1 (6.7)	16.0 (2.1)	24.3 (3.7)	21.6 (1.6)	20.5 (4.2)	nd

nd = not determined due to test not being performed for 10 years.

Table 9. Mean physical parameters of USA dry pea cultivars grown in 2024.

Market Class	Cultivar	Test Weight (lb/bu)	1000 Seed Weight (g)	Water Hydration Capacity (%)	Unhydrated Seeds (%)	Swelling Capacity (%)	Cooked Firmness (N/g)
Green	Arcadia	63.5	185	122	0	152	20.9
	Ariel**	59.9	177	109	0	140	19.4
	Banner	64.3	152	129	0	160	19.7
	Passion	61.8	183	118	0	122	22.4
	Patrick	61.6	163	130	0	150	21.8
	Shamrock**	66.0	211	113	0	177	20.1
	Striker	64.7	200	103	0	134	20.8
Yellow	1140-2822**	61.5	195	104	0	140	23.5
	AAC Chrome	62.2	201	109	0	154	23.4
	AAC Harrison**	64.8	189	106	0	161	19.2
	AAC Ironhorse*	64.6	252	94	0	144	24.3
	AAC Julius	62.1	183	108	1	146	20.9
	AAC McMurphy	63.3	200	110	0	149	17.8
	AAC Profit**	63.3	265	98	0	103	30.2
	Caphorn**	63.2	305	99	0	150	28.2
	CDC Meadow	64.8	169	124	0	152	15.6
	Early Star**	61.6	230	103	0	136	25.0
	Hyline**	62.6	249	94	0	139	29.9
	Montech**	63.3	208	104	1	146	22.8
	Salamanca	62.2	248	103	0	140	30.1
	Treasure	63.6	184	126	0	174	21.5
Winter Green	Vail	62.3	173	106	0	143	16.1
Winter Yellow	Blaze	62.9	156	118	1	159	18.0
Mottled/Maple	CDC Acer**	63.6	120	104	6	100	23.5
	CDC Mosaic	64.2	166	101	4	136	27.1

*composition is on an "as is" basis; **Only one sample of cultivar tested.

The range and mean **1000 seed weight** of dry peas grown in 2024 were 120-305 g and 190 g, respectively (Table 7). The mean value (190 g) was lower than the 5- and 10-year mean 1000 seed weight of peas. This supports lighter seeds for the peas harvested in 2024 compared to long-term averages. Peas of the green class had a mean 1000 seed weight of 180 g, which is lower than the 5- and 10-year mean value 1000 seed weights of 196 and 200 g, respectively (Table 8). Green peas had the same 1000 seed weight as green peas grown in 2022. Peas in the yellow class had a mean 1000 seed weight of 198 g, which is lower than the 5- and 10-year mean 1000 seed weight (Table 8). Winter pea samples harvested in 2024 had a higher 1000 seed weight compared to peas harvested in previous years, except 2020.

The individual cultivars (Table 9) varied extensively in 1000 seed weight, where the Banner and Shamrock cultivars in the green market had the lowest (152 g) and highest (211 g) mean 1000 seed weight. CDC Meadow (169 g) and Caphorn (305 g) had the lowest and highest 1000-seed weight in the yellow class, respectively (Table 9). The Blaze and Vail winter peas had the lowest (156 g) and highest (173 g) 1000-seed weight, respectively. CDC Mosaic had the highest 1000-seed weight among mottled peas.

The water absorption or hydration properties of peas are important for understanding how peas will hydrate and increase in size and weight.

Water hydration capacity of dry peas ranged from 80 to 169%, with a mean of 115% (Table 7). In 2024, the mean water hydration capacity was higher than the value from previous years, including the 5- and 10-year mean values of 101 and 102%, respectively. The mean water hydration capacity of peas in the green market class was 4% points higher than the mean hydration capacity of both the yellow and winter market classes (Table 8). The mean water hydration capacity of the green peas in 2024 was higher, by 13 percentage points, than the 5- and 10-year mean water hydration capacities (Table 8). The yellow peas from 2024 had a mean water hydration capacity that was higher than the 5- and 10-year mean water hydration capacities. The mean hydration capacity for the winter class was also higher than the 5- and 10-year means. In the green market class, Striker and Patrick had the lowest (103%) and highest (130%) water hydration capacities, respectively. Striker also had the lowest water hydration capacity in 2023. The water hydration capacity ranged from 94% in AAC Ironhorse and Hyline to 126% in the Treasure cultivar of yellow peas (Table 9). The Vail and Blaze cultivars had the lowest (106%) and highest (118%) water hydration capacity in the winter peas. The water hydration capacity for mottled peas ranged from 101 to 104%.

Unhydrated seed percentage ranged from 0-6% with a mean of 0%, which is less than the 5- and 10-year mean unhydrated seed percentage (Table 7). Green and yellow peas had unhydrated seed values of 0% (Table 8). Winter peas also had a 0% unhydrated seed rate. The yellow pea samples had lower unhydrated seed percentages than the 5- and 10-year mean values (Table 8). All the green pea cultivars had unhydrated seed rates of 0% (Table 9). The yellow cultivars had 0-1% unhydrated seed counts, where only AAC Julius and Montech had unhydrated seeds (1%). The Blaze cultivar in the winter peas had 1% unhydrated seeds, while the mottled peas had unhydrated seed percentages of 4% and 6 % for the CDC Mosaic and CDC Acer, respectively. Overall, the low unhydrated seed rates, especially those of (0%), suggest that no issues should occur during rehydration of the peas.

The **swelling capacity** is the amount of swelling that occurs during rehydration of the dry pea. The swelling capacity of all peas ranged from 89% to 223%, with a mean value of 144% (Table 7). The mean swelling capacity for peas from the 2024 harvest was comparable to the 5- and 10-year mean swelling capacity (Table 7). The mean swelling capacity was significantly higher than values from samples from 2020 and 2023 harvest years. The swelling capacity of green peas from 2024 was the same as the mean swelling capacity of yellow peas (Table 8). However, the green and yellow peas had lower swelling capacities than winter peas.

The green and yellow peas had swelling capacities that were higher than their respective 5- and 10-year mean swelling capacities. Variability in the swelling capacity among cultivars was observed (Table 9). Passion and Shamrock had the lowest (122%) and highest (177%) swelling capacity of the green peas. AAC Profit and Treasure had the lowest (103%) and highest (174%) swelling capacities among the cultivars evaluated (Table 9). The swelling capacity among winter peas ranged from 100% (CDC Acer) to 159% (Blaze).

The **cooked firmness** values for all peas combined were slightly lower in the peas from 2024 compared to the 5-year mean cooked firmness. The cooked firmness for all peas ranged from 8.1 to 39.1 N/g with a mean value of 22.0 N/g (Table 7). The cooked firmness of peas was different between market classes (Table 8). The winter peas had lower firmness values than those of the green and yellow peas. Similar to the overall cooked firmness, the mean cooked firmness of green and yellow peas obtained in 2024 was lower than the 5-year mean value (Table 8). The winter peas had mean cooked firmness values well below the firmness of cooked winter peas from 2020 and 2021 but slightly higher than winter peas from 2022 and 2023. Among the green cultivars, Ariel had the lowest cooking firmness (19.4 N/g) while Passion (22.4 N/g) was the firmest among commercial cultivars (Table 9). CDC Meadow and AAC Profit had the lowest (15.6 N/g) and highest (30.2 N/g) cooked firmness, respectively (Table 9). The winter peas had cooked firmness values that ranged from 16.1 to 27.1 N/g.

Color quality was measured using L*, a*, and b*, and from these values, a color difference can be determined between peas before and after soaking. **Color quality** for the pea samples in 2024 indicated that the green peas had L* values that were essentially the same as the 5- and 10-year mean L* values (Table 10). The L* values for green peas in 2024 were lower than the L* values for peas from 2021 to 2023. Overall, the lower L* indicates that the green peas from the 2024 crop year were darker in color than those from the 2021-2023 harvest years. The negative value for red-green (i.e., a* value) in 2024 indicates slightly less green color compared to samples from 2021-2022 (Table 10). The a* value for green peas from 2024 was comparable to the 5-year mean a* values, indicating that the peas had similar greenness. However, the samples were greener compared to the 10-year mean a* value. The b* value was most comparable to the 5-year mean b* for the green peas from 2024, but was significantly lower than the other recent harvest years and the 10-year mean b* values. The lower b* value indicates a bluer color. The lower (more negative) a*, combined with a lower b* value, indicates that the peas would be a blue-green color. Therefore, the green peas in 2024 appear slightly blue-green in color compared to peas from recent years and the long term.

The mean L* value of yellow peas was slightly lower than the 5- and 10-year mean L* values (Table 10), indicating that the peas in 2024 were slightly darker than samples from peas that made up the 5- and 10-year mean L* samples. The L* values for the yellow pea in 2024 were also significantly lower than L* values for samples from 2021 to 2023.

Table 10. Color quality of dry pea grown in the USA before and after soaking in water 16 hours, 2021-2024 plus the 5- and 10-year mean values.

Color Scale*	Mean (SD) of Green Pea											
	Before Soaking						After Soaking					
	2024	2023	2022	2021	5-Year	10-Year	2024	2023	2022	2021	5-Year	10-Year
L (lightness)	56.68 (4.78)	58.27 (2.11)	58.45 (2.23)	57.34 (2.63)	56.37 (3.72)	56.26 (4.37)	50.79 (4.24)	52.93 (3.72)	52.55 (2.15)	53.41 (2.63)	52.80 (1.39)	51.68 (3.80)
a (red-green)	-1.82 (1.37)	-1.25 (1.73)	-1.97 (0.56)	-2.21 (1.25)	-1.85 (0.47)	-1.48 (1.39)	-7.52 (2.19)	-6.65 (3.11)	-7.40 (0.59)	-7.43 (1.67)	-6.85 (0.48)	-6.78 (1.15)
b (yellow-blue)	9.84 (1.88)	9.63 (1.64)	10.16 (0.68)	10.14 (1.28)	9.80 (0.35)	11.64 (2.51)	16.96 (3.19)	18.01 (3.44)	17.73 (1.98)	16.11 (2.57)	16.40 (1.99)	20.78 (5.37)
Color Difference	12.82 (2.99)	11.78 (1.59)	11.10 (1.98)	9.04 (2.18)	9.83 (1.92)	12.10 (2.93)						

Color Scale*	Mean (SD) of Yellow Pea											
	Before Soaking						After Soaking					
	2024	2023	2022	2021	5-Year	10-Year	2024	2023	2022	2021	5-Year	10-Year
L (lightness)	61.48 (4.34)	63.45 (1.35)	63.57 (1.34)	63.30 (1.01)	62.08 (2.70)	62.24 (4.25)	62.23 (3.12)	62.73 (1.44)	62.54 (1.13)	63.91 (0.64)	62.99 (1.44)	63.77 (3.00)
a (red-green)	4.34 (0.97)	4.97 (0.50)	4.80 (0.95)	4.29 (1.16)	4.80 (0.26)	5.61 (1.05)	4.77 (1.04)	5.16 (0.61)	4.74 (0.65)	5.16 (1.16)	4.89 (0.56)	5.93 (1.94)
b (yellow-blue)	14.39 (2.14)	15.34 (0.59)	15.53 (0.33)	11.73 (2.32)	14.34 (1.37)	16.61 (3.20)	29.63 (3.79)	31.04 (2.71)	29.76 (0.62)	22.06 (2.57)	26.58 (4.13)	29.96 (5.78)
Color Difference	16.61 (3.55)	16.31 (0.99)	14.29 (0.50)	13.53 (2.18)	13.44 (2.65)	14.64 (3.85)						

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Winter peas were grouped into green or yellow.

The a* value of the yellow peas was on the red side of the scale, indicating the lack of a green appearance. The yellow pea in 2024 had a* values that were similar to the a* values in peas from 2021. However, the a* values for yellow peas from 2024 were less than the 5- and 10-year mean a* (Table 10). Similarly, the b* values for peas in 2024 were less than the 10-year mean b* value but comparable to the 5-year mean b* value. This indicates that the peas from 2024 were similar in yellowness compared to the 5-year mean but less yellow compared to samples that made up the 10-year mean. The b* value for the peas from 2024 was lower than for peas from 2022 and 2023, but significantly higher than the b* value of peas from 2021. This indicates that the yellowness of peas from 2024 was less than that of peas from 2022 and 2023, but was greater than that of peas from 2021. A higher b* value combined with an a* value on the red part of the scale indicates that the samples would be light yellow in color. A lower a* combined with a lower b* value indicates that the pulses would be a darker yellow to light brown color. Therefore, the yellow peas in 2024 appeared light yellow in color compared to peas from 2022 and 2023.

The color of the dry peas changed after the soaking process. The change in color as measured by color difference was greater for green peas from 2024 compared to the peas from previous crop years (Table 10). The green peas became darker (lower L*) while the a* value became more negative (i.e., greener), but more yellow (i.e., increased b* value). This trend was like previous crop years. In 2024, lightness increased slightly after soaking the green peas. The color changes (12.82) were more than the 5- and 10-year mean (9.83 and 12.10, respectively). However, the 5 and 10-year mean L* value indicates lighter peas after soaking compared to the samples from 2024 (Table 10). In addition, soaking caused a substantial change in greenness (i.e., more negative a* values post-soak) and yellowness (i.e., lower b* value than the 10-year mean) of the green peas. This suggests that the peas appeared greener after soaking (Table 10), including being greener than peas compared to peas that made up the 5- and 10-year mean color values.

Table 11. Color quality of USA dry pea cultivars before and after soaking, 2024.

		Mean Color Values*						
		Before Soaking			After Soaking			Color
Market Class	Cultivar	L	a	b	L	a	b	Difference
Green	Arcadia	57.63	-1.90	8.87	51.03	-8.30	16.99	13.48
	Ariel**	51.68	-3.00	11.45	51.21	-7.13	18.23	8.11
	Banner	54.72	-2.99	10.06	44.90	-6.93	13.44	13.93
	Passion	55.73	-2.07	10.61	50.77	-8.43	18.03	11.99
	Patrick	51.84	-0.41	8.12	51.71	-7.35	16.81	11.15
	Shamrock**	47.31	-4.00	13.95	51.37	-7.94	17.36	6.65
	Striker	61.12	-1.63	9.12	50.67	-6.62	15.56	14.33
Yellow	1140-2822**	57.07	5.14	15.18	63.65	5.40	25.98	12.65
	AAC Chrome	58.90	4.98	16.56	64.99	5.58	30.01	15.17
	AAC Harrison**	60.15	6.09	14.44	63.95	6.03	30.28	16.30
	AAC Ironhorse**	61.87	4.50	14.03	64.03	4.84	30.75	16.87
	AAC Julius	60.19	5.40	15.67	64.83	5.48	30.29	15.82
	AAC McMurphy**	55.97	6.32	17.41	62.73	5.86	29.66	14.00
	AAC Profit**	59.35	5.61	15.03	65.03	5.90	30.01	16.63
	Caphorn**	58.39	7.32	21.33	63.11	6.36	29.16	9.22
	CDC Meadow	65.44	4.08	14.69	57.10	3.88	23.82	13.27
	Early Star**	65.88	5.55	15.21	64.27	5.51	30.48	15.36
	Hyline**	58.30	6.22	20.58	62.98	7.56	29.25	9.94
	Montech**	63.07	4.74	15.36	63.56	4.86	30.35	15.00
	Salamanca	63.05	5.41	15.97	64.54	5.85	29.60	13.96
	Treasure	56.46	3.42	11.14	62.82	3.88	32.18	22.00
Winter Green	Vail	59.57	-3.50	13.67	56.44	-1.94	23.49	12.73
Winter Yellow	Blaze	52.04	2.39	16.51	59.42	2.82	32.24	17.54
Mottled/Maple	CDC Acer**	53.87	3.08	6.79	50.96	4.45	19.22	12.95
	CDC Mosaic	50.52	3.64	6.16	49.83	5.04	17.48	11.47

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Only one sample of cultivar tested.

The color difference between dry and soaked yellow peas was greater in peas from 2024 compared to previous years (2020-2022) and the 5- and 10-year mean values, but the same as peas from 2023. The yellow market class underwent more color change during soaking than did the green peas (Table 10). Although color difference is a general indicator of change, visual observations support an increase in yellowness (increased b*) after the soaking process in the yellow peas. The soaked peas from 2024 had L* values that were comparable to the peas from 2022 and 2023 and lower than the peas from 2021. The yellowness (b*) was slightly less intense than that of peas from 2023 but was more intense than the yellow peas from 2021. However, the yellowness of the yellow peas matched the 10-year mean yellowness.

The Shamrock cultivar had the lowest L* value (Table 11) among green peas. Shamrock also had the most negative a* value and the highest b* values, giving it a green-yellow appearance. CDC Striker had the highest L, which contributed to the pale green color of the dry sample. The L* value decreased in all cultivars upon soaking. The a* values became more negative (i.e., greener) and more yellow (i.e., increased b* value) after soaking. This combination of changes resulted in peas that appeared greener. Of the cultivars, the CDC Striker cultivar had the greatest color difference.

The Shamrock cultivar had the least color change during soaking. The cultivars of the yellow peas had L* values between 55.97 and 65.88, with Early Star being the lightest (Table 11). AAC Profit had the lightest color after soaking, while CDC Meadows became the darkest (i.e., lowest L*). Of the cultivars, Treasure had the lowest redness (a*) value and the lowest yellowness (b*) value, while the highest values were observed for the Caphorn cultivar (Table 11).
After soaking, CDC Meadow and Treasure cultivars had the lowest redness values, while Hyline had the highest redness. Treasure had the highest yellowness values while CDC Meadows had the lowest after soaking. The most significant color difference was observed in the Treasure cultivar. The substantial increase in yellowness during soaking likely contributed to the most significant color difference for Treasure. Caphorn had the least color change during soaking.

In 2024, two cultivars of mottled pea were evaluated (Table 11). Overall, the CDC Mosaic was darker brown compared to the CDC Acer. The same color trend was observed after soaking. However, the CDC Acer cultivar had a higher color difference. The mottled pea cultivars were less susceptible to color change compared to the yellow cultivars. However, both cultivars tended to undergo significant changes in yellowness values when soaked (Table 11).

Starch Properties (Tables 12-14)

The peas from 2024 had mean peak viscosity, hot and cold paste viscosities, and setback values that were significantly lower than 5- and 10-year mean values for these same parameters (Table 12). Mean peak time was the same as the 5-year mean peak time values, but slightly longer than the 10-year mean peak time. This indicates that the samples begin to form a paste at the same time as most samples from the 5-year period. The pasting temperature of the samples ranged from 71.0-84.7 °C, with a mean of 80.2°C. The mean value is nearly 2 °C higher than the 5- and 10-year mean pasting temperatures. The starch characteristics were like those of the samples from 2022 and 2023, except for cold paste viscosity, which tended to be lower in samples from 2024. The green and yellow peas had similar pasting properties, while the winter peas tended to have lower viscosity values (Table 13).

Table 12. Starch characteristics of dry peas grown in the USA, 2020-2024 plus the 5- and 10-year mean values.

Starch Characteristic	2024 Range	2024 Mean (SD)	2023 Mean (SD)	2022 Mean (SD)	2021 Mean (SD)	2020 Mean (SD)	5-Year Mean (SD)	10-Year Mean (SD)
Peak Viscosity (RVU)	62-170	125 (19)	126 (22)	114 (23)	126 (17)	134 (5)	129 (12)	135 (12)
Hot Paste Viscosity (RVU)	51-154	112 (16)	116 (17)	105 (20)	118 (15)	124 (14)	119 (10)	124 (9)
Breakdown (RVU)	1-54	14 (12)	10 (7)	9 (5)	9 (5)	10 (5)	11 (3)	10 (2)
Cold Paste Viscosity (RVU)	63-210	139 (25)	162 (35)	176 (33)	204 (38)	229 (38)	201 (31)	220 (30)
Setback (RVU)	1-91	27 (16)	46 (20)	71 (15)	86 (24)	105 (26)	82 (25)	96 (22)
Peak Time (Minute)	5.07-6.84	5.48 (0.43)	5.51 (0.41)	5.94 (0.89)	5.37 (0.31)	5.29 (0.41)	5.45 (0.31)	5.32 (0.39)
Pasting Temperature (°C)	71.0-84.7	80.2 (2.3)	80.0 (1.7)	80.6 (2.8)	79.9 (1.8)	77.7 (1.8)	78.9 (1.8)	78.1 (1.8)
RVA Starch Gel Firmness (g)	63-341	193 (65)	270 (86)	243 (73)	**	**	nd	nd

**not previously reported; nd = not determined due to test not being performed for 5 or 10 years.

The pasting values for the green and yellow peas were slightly higher than the pasting viscosity for the winter peas. Only the cold paste viscosity was higher in green peas compared to yellow peas. For example, a mean cold paste viscosity of 148 RVU was recorded for the green peas, while values of 134 and 129 RVU were recorded for the yellow and winter peas, respectively (Table 13). For the green and yellow peas, pasting properties followed the same trend, where the 5- and 10-year mean viscosities were substantially higher than the values for peas from 2024. Hot paste and peak viscosities for the winter pea samples were comparable to winter peas from previous years, except 2022 (Table 13). The pasting temperature was about 1 to 2 °C higher for green and yellow pea samples in 2024 compared to the 5- and 10-year mean pasting temperatures. Winter peas from 2024 had identical pasting temperatures as the 5-year mean value. Collectively, the data indicate that the starch is behaving in a manner similar to that of the starch from peas in prior years, except for the cold paste viscosity. New in 2022 was the RVA gel firmness measure. The RVA gel firmness was run again in 2024. The gel firmness varied significantly (63-341 g), where winter pea produced a gel that was the least firm, while green and yellow pea samples had essentially the same mean (195 g) RVA gel firmness (Tables 12 and 13).

Within each class, variability in starch characteristics was observed among cultivars. In the green pea, the Ariel, Arcadia, and CDC Striker cultivars had the highest peak, hot paste, and cold paste viscosities, respectively (Table 14). In contrast, the Shamrock cultivar had the lowest peak and hot paste viscosities. Montech had the highest peak viscosity, while Hyline had the highest hot paste and cold paste viscosities among yellow cultivars. The lowest peak, hot paste, and cold paste viscosities in the yellow market class were observed in the Early Star cultivar (Table 14). The Vail and Blaze winter peas had similar peak and hot paste

Table 13. Starch characteristic of different market classes of dry peas grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Physical Parameter	Mean (SD) of Green Pea 2024	2023	2022	2021	2020	5-year Mean (SD)	10-year Mean (SD)
Peak Viscosity (RVU)	125 (19)	131 (26)	131 (13)	127 (23)	138 (16)	134 (7)	137 (7)
Hot Paste Viscosity (RVU)	115 (16)	119 (21)	118 (13)	120 (20)	127 (13)	122 (4)	125 (5)
Breakdown (RVU)	10 (8)	11 (9)	13 (4)	6 (5)	11 (3)	12 (3)	11 (3)
Cold Paste Viscosity (RVU)	148 (26)	167 (45)	194 (28)	209 (53)	239 (40)	206 (27)	221 (26)
Setback (RVU)	33 (17)	48 (26)	75 (17)	89 (35)	112 (29)	83 (24)	96 (22)
Peak Time (Minute)	5.52 (0.36)	5.45 (0.35)	5.26 (0.21)	5.48 (0.40)	5.29 (0.30)	5.33 (0.13)	5.39 (0.36)
Pasting Temperature (°C)	80.7 (1.9)	80.3 (1.7)	79.4 (2.2)	80.4 (1.6)	78.3 (1.6)	79.1 (1.5)	78.2 (1.6)
RVA Gel Firmness (g)	194 (61)	266 (87)	249 (89)	**	**	nd	nd
Starch Characteristics	**Mean (SD) of Yellow Pea 2024**	**2023**	**2022**	**2021**	**2020**	**5-year Mean (SD)**	**10-year Mean (SD)**
Peak Viscosity (RVU)	126 (19)	122 (14)	127 (16)	130 (13)	132 (15)	132 (10)	136 (8)
Hot Paste Viscosity (RVU)	111 (16)	113 (13)	117 (13)	120 (12)	122 (13)	121 (7)	126 (7)
Breakdown (RVU)	15 (13)	9 44)	11 (6)	9 (4)	13 (5)	12 (3)	11 (2)
Cold Paste Viscosity (RVU)	134 (24)	157 (24)	196 (28)	205 (30)	223 (34)	204 (31)	221 (28)
Setback (RVU)	23 (13)	43 (14)	79 (15)	84 (19)	101 (23)	83 (26)	96 (22)
Peak Time (Minute)	5.47 (0.45)	5.39 (0.24)	5.22 (0.23)	5.37 (0.14)	5.29 (0.48)	5.27 (0.13)	5.26 (0.13)
Pasting Temperature (°C)	80.0 (2.5)	78.9 (1.15)	78.1 (1.6)	79.9 (0.7)	77.2 (1.7)	78.1 (1.5)	77.3 (1.5)
RVA Gel Firmness (g)	195 (69)	304 (74)	290 (71)	**	**	nd	nd
Physical Parameter	**Mean (SD) of Winter Pea 2024**	**2023**	**2022**	**2021**	**2020**	**5-year Mean (SD)**	**10-year Mean (SD)**
Peak Viscosity (RVU)	118 (9)	118 (21)	91 (13)	121 (14)	126 (11)	118 (16)	nd
Hot Paste Viscosity (RVU)	103 (9)	112 (18)	85 (13)	111 (12)	113 (12)	108 (13)	nd
Breakdown (RVU)	15 (13)	6 (6)	6 (2)	10 (6)	13 (2)	10 (4)	nd
Cold Paste Viscosity (RVU)	129 (20)	157 (30)	147 (19)	197 (28)	216 (33)	185 (31)	nd
Setback (RVU)	25 (11)	45 (13)	62 (7)	86 (19)	103 (22)	78 (24)	nd
Peak Time (Minute)	5.42 (0.37)	6.04 (0.60)	6.98 (0.05)	5.25 (0.33)	5.18 (0.17)	6.41 (2.03)	nd
Pasting Temperature (°C)	80.5 (1.4)	81.8 (1.4)	83.4 (0.7)	80.9 (2.2)	78.8 (1.4)	80.5 (2.4)	nd
RVA Gel Firmness (g)	167 (54)	186 (32)	203 (36)	**	**	nd	nd

**not previously reported; nd = not determined due to test not being performed for 5 or 10 years.

viscosities. However, Vail had the highest cold paste viscosity. The CDC Mosaic cultivar of mottled peas had peak, hot paste, and cold paste viscosities that were significantly higher than the CDC Acer cultivar. The breakdown ranged from 1 to 54 RVU, which represents a small breakdown value of the starch pastes. The setback values ranged from 1 to 91 RVU, which represents a small setback for some of the samples. This was observed in samples that had minimal breakdown.

Table 14. Mean starch characteristics of dry pea cultivars grown in the USA in 2024.

Market Class	Cultivar	Peak Viscosity (RVU)	Hot Paste Viscosity (RVU)	Breakdown (RVU)	Cold Paste Viscosity (RVU)	Setback (RVU)	Peak Time (Min)	Pasting Temperature (°C)	Gel Firmness (g)
Green	Arcadia	135	124	12	147	23	5.51	81.6	150
	Ariel**	141	92	49	92	1	4.93	76.8	292
	Banner	112	104	9	138	34	5.24	81.0	194
	Passion	131	121	11	153	32	5.46	80.9	196
	Patrick	121	113	8	141	28	5.67	82.8	207
	Shamrock**	104	90	14	129	39	5.20	77.5	239
	Striker	126	122	4	192	70	5.72	77.3	172
Yellow	1140-2822**	127	101	26	109	8	5.33	81.5	263
	AAC Chrome	123	98	26	124	26	5.57	78.1	277
	AAC Harrison**	122	96	26	107	12	5.13	79.2	285
	AAC Ironhorse**	138	99	39	112	13	5.07	76.8	312
	AAC Julius	132	109	23	136	27	5.21	79.0	253
	AAC McMurphy*	121	100	22	108	8	5.20	80.1	238
	AAC Profit**	97	92	5	141	48	7.00	83.2	293
	Caphorn**	132	96	37	103	8	5.07	76.8	274
	CDC Meadow	124	110	14	136	26	5.33	80.5	183
	Early Star**	78	73	5	88	15	5.80	80.7	110
	Hyline**	136	118	18	156	37	5.06	80.3	243
	Montech**	148	98	50	102	4	5.00	75.8	290
	Salamanca	135	106	29	129	23	5.06	77.8	227
	Treasure	105	101	4	116	16	5.87	82.8	183
Winter Green	Vail	115	106	9	140	34	5.55	82.5	152
Winter Yellow	Blaze	122	101	21	117	17	5.30	78.6	181
Mottled/Maple	CDC Acer**	87	51	36	128	78	4.93	76.7	276
	CDC Mosaic	120	112	8	150	38	5.73	80.4	161

**Only one sample of cultivar tested

Functionality Properties (Tables 15-17)

Functionality property evaluation was new in 2022 and was run again in 2023 and 2024. The emulsion activity and stability for all samples both ranged from 53-58% (Table 15). The mean value was the same as that of peas from 2023 but slightly less than that of peas from 2022. The peas from the various classes had the same emulsion activity and stability (Table 16). Furthermore, no one cultivar had emulsion activity and stability values that were substantially different from those of others. Foaming capacity varied to a greater extent (87-247%). Differences in foaming capacity among different classes of peas were observed (Table 16); however, less variability was observed in the foam stability of the peas from different market classes. In contrast, at the cultivar level, differences in foaming capacity and stability were evident (Table 17). Among cultivars, Caphorn had the highest water holding capacity while AAC Chrome had the lowest. In oil holding capacity, only minor differences were present, with Patrick having the highest value (0.35 g/g) and Caphorn the lowest (0.14 g/g).

Table 15. Functional properties of dry pea grown in the USA, 2022-2024.

Functional Properties	Year 2024 Range	2024 Mean (SD)	2023 Mean (SD)	2022 Mean (SD)
Emulsion Activity (%)	53-58	56 (1)	56 (1)	59 (1)
Emulsion Stability (%)	53-58	56 (1)	57 (1)	58 (2)
Foaming Capacity (%)	87-247	149 (35)	166 (29)	215 (27)
Foam Stability (%)	28-135	69 (16)	71 (11)	62 (10)
Water Holding Capacity (g/g)	0.35-2.59	1.70 (0.30)	1.30 (0.21)	1.28 (0.12)
Oil Holding Capacity (g/g)	0.12-0.56	0.20 (0.10)	0.21 (0.06)	0.37 (0.27)

Table 16. Functional properties of different classes of dry pea grown in the USA, 2022-2024.

Physical Parameter	Mean (SD) of Green Pea 2024	2022	2022
Emulsion Activity (%)	56 (1)	56 (1)	59 (1)
Emulsion Stability (%)	56 (1)	57 (1)	58 (1)
Foaming Capacity (%)	147 (32)	165 (27)	221 (33)
Foam Stability (%)	65 (17)	73 (9)	58 (9)
Water Holding Capacity (g/g)	1.57 (0.28)	1.30 (0.22)	1.34 (0.14)
Oil Holding Capacity (g/g)	0.27 (0.07)	0.20 (0.06)	0.17 (0.04)
Physical Parameter	**Mean (SD) of Yellow Pea 2024**	**2023**	**2022**
Emulsion Activity (%)	56 (1)	56 (0.7)	59 (1)
Emulsion Stability (%)	56 (1)	57 (0.8)	59 (1)
Foaming Capacity (%)	152 (38)	168 (30)	208 (25)
Foam Stability (%)	71 (17)	68 (10)	67 (14)
Water Holding Capacity (g/g)	1.75 (0.29)	1.40 (0.16)	1.31 (0.10)
Oil Holding Capacity (g/g)	0.23 (0.06)	0.22 (0.06)	0.16 (0.03)
Physical Parameter	**Mean (SD) of Winter Pea 2024**	**2023**	**2022**
Emulsion Activity (%)	57 (1)	56 (1)	58 (1)
Emulsion Stability (%)	56 (1)	57 (1)	58 (3)
Foaming Capacity (%)	128 (19)	162 (33)	215 (26)
Foam Stability (%)	79 (5)	72 (18)	63 (8)
Water Holding Capacity (g/g)	1.60 (0.16)	1.10 (0.13)	1.22 (0.11)
Oil Holding Capacity (g/g)	0.21 (0.04)	0.18 (0.05)	0.68 (0.15)

Table 17. Mean functional properties of dry pea cultivars grown in the USA, 2024.

Market Class	Cultivar	Emulsion Activity (%)	Emulsion Stability (%)	Foaming Capacity (%)	Foam Stability (%)	Water Holding Capacity (g/g)	Oil Holding Capacity (g/g)
Green	Arcadia	57	56	136	74	1.61	0.28
	Ariel**	56	56	160	64	1.53	0.32
	Banner	56	56	116	84	1.46	0.24
	Passion	56	56	154	65	1.62	0.26
	Patrick	56	56	183	38	2.02	0.35
	Shamrock**	56	56	117	79	1.54	0.22
	Striker	54	56	157	54	1.66	0.23
Yellow	1140-2822**	55	56	133	80	1.98	0.24
	AAC Chrome	55	56	157	73	1.31	0.26
	AAC Harrison**	56	56	143	69	1.60	0.23
	AAC Ironhorse*	54	55	153	76	1.69	0.30
	AAC Julius	55	55	145	77	1.58	0.25
	AAC McMurphy	55	53	103	88	1.63	0.23
	AAC Profit**	57	57	180	53	1.86	0.17
	Caphorn**	54	55	143	79	2.59	0.14
	CDC Meadow	56	56	151	59	1.62	0.22
	Early Star**	57	56	150	64	1.71	0.21
	Hyline**	56	56	127	64	1.80	0.17
	Montech**	55	55	127	63	1.41	0.27
	Salamanca	56	56	126	75	1.53	0.22
	Treasure	55	56	152	83	2.01	0.17
Winter Green	Vail	56	56	117	78	1.61	0.22
Winter Yellow	Blaze	57	56	152	82	1.59	0.17
Mottled/Maple	CDC Acer**	56	57	163	71	1.86	0.21
	CDC Mosaic	57	57	157	72	1.80	0.18

**Only one sample of cultivar tested

Lentil Quality Results

Sample distribution

A total of 97 lentil samples were collected from Montana and Washington between August 2024 and October 2024. Samples were delivered to SDSU between November 2024 and January 2025. The growing location, number of samples, market class, and genotype details of these dry pea samples are provided in Table 18. CDC Richlea (48) accounted for most of the lentil samples. In addition, CDC Viceroy (13) and Pardina (13) accounted for the other significant number of samples evaluated in 2024.

Table 18. Description of lentils used in the 2024 pulse quality survey.

State	No. of Samples	Market Class	Cultivars	
Montana	76	Green	Avondale	CDC Richlea
			CDC Viceroy	Laird
		Red	Red Chief	
		Spanish Brown	Pardina	
Washington	21	Green	Brewer	Merrit
		Spanish Brown	Morena	Pardina

Proximate composition of lentils (Tables 19-21)

Moisture

The moisture content of lentils ranged from 6.8 to 13.1% in 2024 (Table 19). The mean moisture content (8.9%) was slightly higher than the 5- and 10-year mean moisture content of 8.1 and 8.8%, respectively. In general, the mean moisture in 2024 was higher than mean moisture values from 2020-2022, but comparable to the lentils from 2023. Overall, all samples evaluated had moisture contents below the 13-14% recommended maximum for general storability. The moisture contents of the different classes were between 7.8 and 9.1% (Table 20). The green and red lentils had mean moisture contents of 9.1% and 8.7%, respectively, while Spanish brown lentils had moisture contents of 7.8%. The green lentils from 2024 had moisture contents comparable to the 5- and 10-year mean moisture contents of 9.0 and 9.3%, respectively. The mean moisture content of green lentils from 2024 was similar to that of green lentils from 2023. Spanish brown lentils had a mean moisture content that was lower than the 5-year mean value, but comparable to lentils from 2020, 2021, and 2023. The red lentils had a mean moisture content that was comparable to the 5- and 10-year mean moisture contents of 8.8 and 8.7%, respectively. The highest mean moisture contents were observed in the Avondale and Laird (9.5%) cultivar (i.e., green lentil) while the Pardina (7.8%) cultivar (i.e., Spanish brown lentil) had the lowest moisture content (Table 21).

Ash

The ash content of lentils ranged from 2.0 to 3.6% with a mean of 2.6% (Table 19). The mean ash content of lentils grown in 2024 was comparable to the 5- and 10-year mean ash contents of 2.6 and 2.5%, respectively. Ash content is a general indicator of minerals present. The mean ash contents of the green, red, and Spanish brown market classes were 2.6, 2.1, and 2.6%, respectively (Table 20). In general, the different classes of lentils had mean ash values that were comparable to their respective 5- and 10-year mean ash contents, except the red lentils. The Morena and Red Chief cultivars had the highest (3.6%) and lowest (2.1%) ash contents among cultivars evaluated (Table 21).

Fat

The fat content of lentils ranged from 0.3 to 1.4% with a mean of 0.8% (Table 19). The fat content was lower than the 5-year mean fat content of 1.1%. The mean fat content of lentils from 2024 was similar to the fat content in lentils from 2021 to 2023, where the difference in fat content was approximately ± 0.2% from the 1% observed in other years. Literature reports indicate that lentils have fat contents between 1 and 3%; therefore, the fat content of the lentils grown in 2024 falls at the lower end of the range reported by others. Only minor differences in fat percentages were observed between the different market classes (Table 20). Minimal difference in the mean fat contents was observed among the cultivars (Table 21). However, variation (0.6-1.1%) was observed among the samples, with Red Chief having the lowest fat content and Avondale having the highest fat content. Like previous years, this data supports the consistent low-fat content of lentils.

Table 19. Proximate composition of lentils grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Proximate Composition (%)*	2024		Mean (SD)					
	Range	Mean (SD)	2023	2022	2021	2020	5-year	10-year
Moisture	6.8-13.1	8.9 (1.1)	9.0 (1.3)	8.5 (0.6)	8.0 (0.9)	8.2 (1.2)	8.1 (0.8)	8.8 (1.1)
Ash	2.0-3.6	2.6 (0.3)	2.5 (0.3)	2.8 (0.2)	2.7 (0.3)	2.6 (0.4)	2.6 (0.2)	2.5 (0.1)
Fat	0.3-1.4	0.8 (0.2)	1.0 (0.2)	1.0 (0.1)	0.9 (0.1)	1.3 (0.5)	1.1 (0.2)	nd
Protein	21.8-29.3	25.1 (1.5)	24.2 (1.7)	24.9 (1.4)	24.5 (1.3)	24.8 (1.5)	24.5 (0.3)	23.5 (1.0)
Total Starch	36.2-50.4	42.2 (3.5)	41.1 (2.3)	40.9 (1.7)	43.0 (2.0)	44.4 (2.8)	42.4 (1.5)	42.5 (2.0)

*composition is on an "as is" basis; nd = not determined due to test not being performed for 10 years.

Table 20. Proximate composition of different market classes of lentils grown in the USA, 2020-2024 plus 5- and 10-year means.

Market Class	Proximate Composition (%)	Mean (SD)						
		2024	2023	2022	2021	2020	5-Year	10-Year
Green	Moisture	9.1 (1.0)	9.4 (1.2)	8.6 (0.6)	8.1 (0.9)	8.5 (1.2)	9.0 (0.9)	9.3 (0.9)
	Ash	2.6 (0.2)	2.5 (0.3)	2.9 (0.1)	2.7 (0.3)	2.5 (0.5)	2.6 (0.2)	2.6 (0.2)
	Fat	0.8 (0.2)	1.0 (0.2)	1.0 (0.1)	0.9 (0.1)	1.3 (0.5)	1.1 (0.1)	nd
	Protein	25.2 (1.6)	24.3 (1.9)	25.7 (1.3)	24.9 (1.3)	24.5 (1.6)	24.8 (0.5)	23.9 (1.3)
	Total Starch	42.0 (3.6)	40.4 (2.2)	39.0 (1.2)	42.0 (1.3)	44.7 (2.9)	41.6 (2.1)	42.3 (2.3)
Red	Moisture	8.7 (0)	9.0 (0)	*	10.6 (0)	7.9 (1.2)	8.8 (1.2)	8.7 (1.6)
	Ash	2.1 (0)	2.8 (0)	*	2.5 (0)	2.7 (0.3)	2.6 (0.2)	2.7 (0.2)
	Fat	0.6 (0)	1.2 (0)	*	0.8 (0)	1.3 (0.4)	1.3 (0.5)	nd
	Protein	26.5 (0)	25.4 (0)	*	25.1 (0)	26.3 (0.9)	25.5 (0.7)	24.7 (1.1)
	Total Starch	38.0 (0)	42.6 (0)	*	39.2 (0)	43.6 (4.1)	42.2 (1.7)	43.2 (3.6)
Spanish Brown	Moisture	7.8 (0.3)	7.8 (0.4)	8.5 (0.6)	7.6 (0.4)	7.5 (0.8)	8.2 (1.0)	8.4 (0.8)
	Ash	2.6 (0.3)	2.7 (0.3)	2.8 (0.2)	2.8 (0.4)	2.6 (0.1)	2.6 (0.2)	2.6 (0.2)
	Fat	0.8 (0.1)	1.1 (0.1)	1.0 (0.1)	0.9 (0.1)	1.6 (0.4)	1.1 (0.3)	nd
	Protein	24.9 (1.2)	24.0 (0.4)	24.4 (1.2)	23.9 (1.3)	24.9 (0.9)	24.1 (0.5)	23.4 (1.2)
	Total Starch	43.5 (2.4)	42.7 (1.5)	41.8 (1.0)	44.6 (1.5)	43.9 (1.8)	43.4 (1.1)	42.6 (2.3)

* no red lentils evaluated in 2022, 5 and 10 year determination was done on 2018-21, 23 and 2013-21, 23 for red lentils, respectively; nd = not determined due to test not being performed for 10 years.

Protein

Protein content of lentils ranged from 21.8 to 29.3% with a mean value of 25.1% (Table 19). The mean protein content of lentils grown in 2024 was higher than the 5- and 10-year mean protein content of 24.5 and 23.5%, respectively. The protein content of the red market class was higher than the mean protein for green and Spanish brown lentils (Table 20). Red lentils had a mean protein content (26.5%) that was greater than the 5- and 10-year mean values. In addition, the mean protein contents of the green and Spanish brown lentils were higher than their respective 5- and 10-year mean protein values (Table 20). However, the mean protein content of all three lentil classes in 2024 most closely aligns with the mean protein contents of lentils from 2021. The Merrit (green) cultivars had the highest protein percentage (27.8%) among the tested cultivars (Table 21). The CDC Richlea lentils had the lowest protein content (24.5%) in 2024.

Table 21. Mean proximate composition of lentil cultivars grown in the USA in 2024.

Market Class	Cultivar	Concentration (%)				
		Moisture	Ash	Fat	Protein	Starch
Green	Avondale	9.5	2.6	1.1	25.1	41.9
	Brewer**	9.2	2.5	1.0	25.5	41.9
	CDC Richlea	9.3	2.7	0.8	24.5	43.0
	CDC Viceroy	8.8	2.5	0.8	26.5	40.6
	Laird	9.5	2.6	0.9	24.8	41.3
	Merrit	7.8	2.5	0.7	27.8	39.2
Red	Red Chief**	8.7	2.1	0.6	26.5	38.0
Spanish Brown	Morena**	8.1	3.6	0.8	25.2	41.6
	Pardina	7.8	2.6	0.8	24.9	43.6

**Only one sample of cultivar tested

Total starch

Total starch content of lentils ranged from 36.2 to 50.4%, with a mean of 42.2% (Table 19). The mean total starch percentage of lentils grown in 2024 was lower than the starch percentage in lentils from the previous five and ten years. The mean 5- and

10-year starch contents were 42.4 and 44.0%, respectively. The mean starch content in peas grown in 2024 was approximately 1% higher than the starch content of peas from 2022 and 2023, but 2 percentage points lower than that of lentils from 2020 and 2021. The Spanish brown (43.5%) and green (42.0%) classes had higher starch contents than the red lentils (38.0%) (Table 20). The green and Spanish brown lentils produced in 2024 had mean starch contents that were higher than lentils from other crop years, except 2020 and 2021. The starch content of 42.0% for the green lentils from 2024 was slightly higher and lower than the 5- and 10-year mean starch contents of 41.6 and 42.3%, respectively. In the Spanish brown market class, the mean starch content in 2024 was 43.5% while the 5- and 10-year mean starch contents were 43.4 and 42.6%, respectively (Table 20). The mean total starch content (38.0%) of the red lentils from 2024 was lower than the 5- and 10-year mean values of 42.2 and 43.2%, respectively. The highest mean starch content was observed in the Pardina cultivar at 43.6% (Table 21). The Red Chief cultivar had the lowest mean starch content (38.0%) among cultivars evaluated. The Red Chief and Merrit cultivars had the highest protein contents and lowest starch contents, thus supporting the assumption that the higher protein percentage contributed to the lower starch percentage.

Physical parameters of lentils (Tables 22-24)

Test weight, 1000 seed weight, water hydration capacity, percentage unhydrated seeds, swelling capacity, cooking firmness, and color represent the physical parameters used to define physical quality. **Test weight** ranged from 59.1 to 68.5 lbs./Bu with a mean of 63.2 lbs./Bu. This mean value was slightly lower than the 5-year mean test weight but higher than the 10-year mean test weight of 62.9 lbs./Bu (Table 22). The mean test weight of lentils in the Spanish brown market class was approximately 3 and 4 percentage points higher than test weights of lentils from the green and red classes, respectively (Table 23). The mean test weight for lentils in the Spanish brown and green market classes in 2024 was approximately the same as the 5- and 10-year mean test weights. In contrast, the lentils in the red class from 2024 had a lower mean test weight compared to the 5- and 10-year mean test weights. The CDC Viceroy cultivar had the highest mean test weight of 65.8 lbs./Bu, while Merrit had the lowest test weight of 60.6 lbs./Bu (Table 24).

Table 22. Physical parameters of lentils grown in the USA, 2020-2024 plus 5- and 10-year means.

Physical Parameters	2024		Mean (SD)					
	Range	Mean (SD)	2023	2022	2021	2020	5-year	10-year
Test Weight (lb/Bu)	59.1-66.5	63.2 (1.9)	63.5 (2.3)	64.1 (2.6)	64.3 (2.9)	64.3 (2.0)	63.7 (0.8)	62.9 (1.0)
1000 Seed Wt (g)	26-74	47 (10)	52 (12)	40 (11)	45 (13)	48 (10)	46 (5)	45 (3)
Water Hydration Capacity (%)	67-149	104 (14)	97 (13)	94 (8)	87 (8)	91 (21)	92 (4)	96 (9)
Unhydrated Seeds (%)	0-20	4 (4)	10 (10)	9 (7)	4 (4)	5 (6)	6 (3)	4 (3)
Swelling Capacity (%)	30-164	127 (21.0)	156 (23)	101 (18)	98 (15)	117 (21)	123 (26)	130 (25)
Cooked Firmness (N/g)	8.8-21.0	13.5 (2.2)	17.8 (3.6)	17.9 (4.1)	19.8 (4.2)	19.9 (4.3)	18.2 (1.7)	16.3 (2.8)

nd = not determined due to test not being performed for 10 years.

The range and mean **1000 seed weight** of lentils grown in 2024 were 26 to 74 g and 47.0 g, respectively (Table 22). The mean 1000 seed weight was higher than the 5- and 10-year mean values of 46 and 45 g, respectively. This data supports a similar seed size of the lentils in 2024 compared to longer-term averages. Lentils from the green market class had a mean 1000 seed weight of approximately 50 g, which is lower than the mean 1000 seed weights for green lentils grown in 2020-2023. However, the mean 1000 seed weight is approximately the same as the 5- and 10-year mean values (Table 23). The red lentils from 2024 had same mean 1000 seed weights as the 5- and 10-year mean 1000 weight values. A lower (34 g) 1000 seed weight was observed in 2024 in the Spanish Brown class compared to the 5- and 10-year mean values of 37 g. The lentil weights from the green and Spanish brown classes support smaller seed size compared to previous evaluations. These smaller seeds are likely reflected in the specific cultivar differences evaluated in 2024 compared to other years. The Morena and Pardina cultivars had the lowest (34 g) 1000 seed weight, while Laird had the highest (60 g) mean 1000 seed weight among lentils from 2024 (Table 24). Laird also had the highest 100 seed weight in 2023.

Water hydration capacity of lentils ranged from 67 to 149%, with a mean of 104% (Table 22). The mean water hydration capacity value of lentils from 2024 was higher than the lentils that made up the 5- and 10-year mean water hydration capacity of 92 and 96%, respectively. The water hydration capacity (105%) was highest for the green and red lentils, while the Spanish brown market classes had the lowest (95%) water hydration capacities (Table 23). The green lentils from 2024 had water hydration capacities that were slightly higher than the 5- and 10-year mean values. Red lentils had a mean water hydration capacity (105%) that was lower than the 5- and 10-year mean values of 112 and 104, respectively. Spanish brown lentils had slightly higher (95%) water hydration capacity than the 5- and 10-year mean value of 89 and 93%, respectively (Table 23). The mean water hydration capacity ranged from 77% to 119% in Morena and Brewer cultivars, respectively (Table 24).

Table 23. Physical parameters of different market classes of lentils grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Market class	Physical Parameter	Mean (SD) 2024	2023	2022	2021	2020	5-Year	10-Year
Green	Test Weight (lb/Bu)	62.8 (1.8)	62.9 (2.3)	61.0 (1.8)	62.3 (2.5)	63.6 (1.8)	62.1 (0.9)	62.2 (0.8)
	1000 Seed Wt (g)	49.7 (9.4)	57 (9)	55 (3)	51 (13)	51 (10)	50 (3)	48 (7)
	Water Hydration Capacity (%)	105 (14)	98 (12)	99 (7)	85 (9)	88 (11)	103 (24)	103 (18)
	Unhydrated Seeds (%)	4 (4)	9 (11)	3 (3)	3 (3)	6 (7)	3 (2)	3 (3)
	Swelling Capacity (%)	129 (21)	164 (19)	116 (19)	97 (13)	117 (18)	123 (20)	128 (24)
	Cooked Firmness (N/g)	13.5 (2.3)	17.2 (3.0)	16.6 (1.4)	19.7 (4.7)	19.2 (4.2)	17.1 (2.3)	16.0 (2.4)
Red	Test Weight (lb/Bu)	61.9 (0.0)	64.1 (0.0)	*	64.7 (0)	63.9 (2.5)	63.5 (1.2)	63.1 (1)
	1000 Seed Wt (g)	44 (0)	49 (0)	*	63 (0)	43 (9)	44 (11)	44 (9)
	Water Hydration Capacity (%)	105 (0)	107 (0)	*	93 (0)	126 (41)	112 (20)	104 (17)
	Unhydrated Seeds (%)	0 (0)	2 (0)	*	3 (0)	5 (6)	4 (3)	4 (2)
	Swelling Capacity (%)	105 (0)	177 (0)	*	128 (0)	138 (35)	136 (6)	nd
	Cooked Firmness (N/g)	14.6 (0.0)	12.2 (0.0)	*	19.6 (0)	21.7 (5.3)	17.2 (3.2)	nd
Spanish Brown	Test Weight (lb/Bu)	65.7 (0.4)	65.0 (1.7)	65.7 (1.0)	66.7 (0.7)	66.1 (1.0)	65.3 (1.7)	65.1 (1.3)
	1000 Seed Wt (g)	33.9 (1.0)	39 (6)	32 (2)	35 (3)	42 (4)	37 (5)	37 (4)
	Water Hydration Capacity (%)	95 (10)	93 (15)	92 (8)	88 (6)	81 (13)	89 (5)	93 (13)
	Unhydrated Seeds (%)	8 (4)	14 (6)	12 (6)	6 (3)	5 (4)	7 (3)	7 (4)
	Swelling Capacity (%)	116 (16)	132 (19)	93 (12)	97 (16)	109 (15)	116 (23)	128 (29)
	Cooked Firmness (N/g)	13.7 (1.3)	20.0 (4.0)	18.5 (4.9)	19.8 (4.0)	21.7 (3.9)	18.3 (2.6)	nd

* no red lentils evaluated in 2022; 5 and 10 year determination was done on 2018-21, 23 and 2013-21, 23 for red lentils, respectively; nd = not determined due to test not being performed for 10 years.

Unhydrated seed percentage ranged from 0 to 20% with a mean of 4%, which is lower than the 5-year mean value of 6% but the same as the 10-year mean of 4% (Table 22). Many of the samples had unhydrated seed rates around 0%, which likely contributed to the 4% unhydrated seed rate in 2024 by offsetting the few samples with high unhydrated levels. The mean unhydrated seeds varied from 0% in red lentils to 8% in Spanish Brown (Table 23). The green lentils from 2024 had a mean unhydrated seed percentage that was comparable to the 5- and 10-year mean unhydrated seed percentage of 3%. For the Spanish brown lentils, the unhydrated seed count was comparable (8%) to the 5- and 10-year mean unhydrated seed percentage (7%). In contrast, the red lentils had unhydrated seed rates that were lower than the 5- and 10-year mean unhydrated seed percentage. The Laird (green, 1%) and Red Chief (red, 0%) cultivars had the lowest unhydrated seed percentage, while the Morena cultivar had the highest mean unhydrated seed weight of 15% (Table 24). The unhydrated seed percentage follows the trends from previous years, where the Spanish brown seeds tended to hydrate less than the green lentils. However, the lentils in 2024 tended to hydrate better than in previous years.

The **swelling capacity** of all lentils ranged from 30 to 164%, with a mean value of 127% (Table 22). The mean swelling capacity from 2024 samples was comparable to that of the lentils that made up the 5- and 10-year mean swelling capacities. The mean swelling capacity of lentils from the green market class was 129% (Table 23). The swelling capacity of the green lentils was most comparable to lentils that made up the 5- and 10-year mean swelling capacities of 123 and 128%, respectively. The swelling capacity of the red lentils was significantly lower than that of lentils from previous years, and the 5-year mean swelling capacity of 136%. The mean swelling capacity (116%) of the Spanish brown lentils in 2024 was similar to the mean swelling capacity (116%) for the Spanish brown lentils that made up the 5-year mean swelling capacity. Additionally, the mean swelling capacity of the Spanish brown lentils in 2024 was significantly lower than the 10-year mean swelling capacity (Table 23). The highest swelling capacity (133%) was observed in the CDC Richlea cultivar, while the Morena cultivar had the lowest (88%) mean swelling capacity (Table 24). The reason for this might be due to the low water uptake as supported by low water

Table 24. Mean physical parameters of USA lentil cultivars grown in 2024.

Market Class	Cultivar	Test Weight (lb/bu)	1000 Seed Wt (g)	Water Hydration Capacity (%)	Unhydrated Seeds (%)	Swelling Capacity (%)	Cooked Firmness (N/g)
Green	Avondale	62.2	43	117	10	103	15.4
	Brewer**	61.4	51	119	6	91	14.6
	CDC Richlea	62.8	50	107	3	133	13.7
	CDC Viceroy	65.9	41	97	6	132	11.3
	Laird	60.8	60	106	1	127	13.8
	Merrit	60.5	52	103	5	115	14.7
Red	Red Chief**	61.9	44	105	0	105	14.6
Spanish Brown	Morena**	65.6	34	77	15	88	12.3
	Pardina	65.7	34	97	7	118	13.4

**Only one sample of cultivar tested

hydration capacity.

The **cooked firmness** of all lentils ranged from 8.8 to 21.0 N/g with a mean value of 13.5 N/g (Table 22). The lentils from 2024 had lower cooked firmness values than all previous years, including the 5- and 10-year mean cooked firmness values. The cooked firmness of lentils was not substantially different between the green and Spanish brown classes; however, the red lentils had cooked firmness values that were one percentage point higher than the values from the other classes (Table 23). The lentils from the green market class had a mean cooked firmness value (13.5 N/g) that was lower than the 5- and 10-year mean cooked firmness values of 17.1 and 16.0 N/g, respectively. In contrast, the red lentils had a mean cooked firmness of 12.2 N/g, which is higher than the cooked firmness of samples from 2023. The cooked firmness of the red lentils was, however, about 3 N/g less than the 5-year mean value. The mean cooked firmness (13.7 N/g) of Spanish brown lentils was nearly 5 N/g lower for the lentils from 2024 compared to the 5-year mean value. Among the cultivars, Avondale had the highest cooked firmness value while CDC Viceroy had the lowest cooked firmness (Table 24).

Color quality was measured using L*, a*, and b* values, and from these values, a color difference can be determined on lentils before and after soaking (Table 25). The color quality for all lentils in 2024 indicated that the lentils had higher L* values than lentils from previous years. This data indicates that the lentils from the 2024 crop year were lighter in color than those from recent years. The L* value of the green lentils was higher than the 5- and 10-year mean L* value, which supports a lighter color compared to long-term averages. The L* values of the red and Spanish Brown lentils were significantly higher than the 5- and 10-year mean L* values. The L* values were approximately 10 color units higher than in previous samples (Table 25). In 2024, the a* value of 1.19 indicates that the lentils were less green than the lentils from recent years. Additionally, green lentils had a* values that were lower than the 5- and 10-year mean a* values, indicating less greenness in lentils for the 2024 samples compared to long-term mean values. The mean a* value for the Spanish brown lentils was lower than the 5-year mean a* value, indicating less redness. Similarly, the red lentils from 2024 had lower a* compared to the 5- and 10-year mean a* values, indicating less redness for the sample from 2024. The green lentils had a lower mean b* value than the 10-year mean values, but the same as the 5-year mean value, suggesting the 2024 samples are less yellow in nature. The Spanish brown a mean b* value for 2024 was lower than the b* value of samples from all years, including the samples that made up the 5- and 10-year mean b* values. This indicates that the lentils were a darker brown compared to the lentils from previous years, due to the lower yellowness of the lentils in 2024. The red lentils had significantly lower b* values in 2024, supporting a lentil with a redder hue. The color of the lentils changed after the soaking process. The green lentil became darker as evidenced by the slightly lower L* value. Additionally, the soaked red and Spanish brown lentils became darker compared to pre-soaked lentils (Table 25). In the green lentils, the decreased a* value indicated an increase in greenness of the lentils after soaking. In contrast, the other lentil classes had increased a* values, indicating an increase in redness. Lentils from all market classes became more yellow (i.e., increased b* value) after soaking. The color

Table 25. Color quality of lentils grown in the USA before and after soaking, 2021-2024 plus 5- and 10-year values.

Color Scale	Mean (SD) of green lentils											
	Before Soaking						After Soaking					
	2024	2023	2022	2021	5-Year	10-year	2024	2023	2022	2021	5-Year	10-Year
L (lightness)	60.33 (5.25)	57.75 (1.00)	58.82 (0.77)	57.10 (0.96)	56.30 (4.71)	56.71 (3.96)	58.50 (1.49)	58.51 (1.19)	59.02 (0.45)	56.69 (2.59)	57.46 (2.82)	58.27 (2.48)
a (red-green)	1.19 (1.31)	1.87 (1.44)	2.72 (0.82)	3.20 (1.85)	1.83 (1.16)	2.82 (1.59)	-0.44 (1.40)	0.12 (1.83)	1.20 (1.33)	2.00 (1.35)	0.44 (1.17)	1.60 (1.97)
b (yellow-blue)	13.37 (2.10)	14.07 (7.49)	11.73 (1.13)	12.22 (2.10)	13.39 (1.47)	16.84 (4.28)	24.25 (1.71)	24.64 (1.77)	19.93 (3.04)	14.23 (3.89)	19.95 (3.72)	24.89 (6.05)
Color Difference	12.16 (4.55)	10.82 (1.45)	8.38 (1.99)	5.57 (1.48)	8.46 (1.92)	9.04 (1.93)						
Color Scale*	Mean (SD) of red lentils											
	Before Soaking						After Soaking					
	2024	2023	2022	2021	5-Year	10-Year	2024	2023	2022	2021	5-Year	10-Year
L (lightness)	61.21 (0)	51.17 (0)	**	53.60 (0)	51.17 (3.93)	51.49 (4.43)	57.17 (0)	50.36 (0)	**	54.52 (0)	50.36 (2.68)	52.15 (2.80)
a (red-green)	2.96 (0)	4.14 (0)	**	3.47 (0)	4.14 (1.81)	4.99 (1.91)	7.56 (0)	7.60 (0)	**	5.48 (0)	7.6 (3.41)	9.44 (3.10)
b (yellow-blue)	11.55 (0)	17.49 (0)	**	5.29 (0)	17.49 (5.29)	13.00 (4.51)	22.83 (0)	18.29 (0)	**	10.21 (0)	18.29 (6.74)	21.62 (6.30)
Color Difference	12.83 (0)	11.37 (0)	**	5.40 (0)	11.37 (3.29)	11.28 (3.98)						
Color Scale	Mean (SD) of brown lentils											
	Before Soaking						After Soaking					
	2024	2023	2022	2021	5- Year	10-Year	2024	2023	2022	2021	5-Year	10-Year
L (lightness)	61.70 (6.86)	54.98 (0.98)	54.01 (0.36)	51.11 (0.47)	50.32 (6.23)	49.20 (6.10)	52.69 (1.19)	51.17 (1.09)	54.71 (0.73)	52.42 (1.22)	50.26 (6.42)	50.29 (4.60)
a (red-green)	2.00 (0.52)	3.04 (0.37)	2.65 (0.23)	3.17 (0.26)	2.25 (1.05)	3.32 (1.69)	2.78 (0.42)	3.20 (0.60)	2.20 (0.43)	2.99 (0.56)	2.08 (1.71)	3.74 (2.76)
b (yellow-blue)	5.95 (0.65)	7.27 (0.56)	6.78 (0.21)	6.93 (0.47)	7.21 (0.83)	9.83 (3.88)	16.42 (1.11)	10.74 (0.60)	15.42 (1.12)	11.96 (4.85)	12.59 (2.36)	19.08 (7.51)
Color Difference	15.27 (3.68)	10.81 (1.34)	8.69 (1.11)	5.58 (4.33)	7.47 (2.89)	11.06 (5.58)						

*color scale L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. Color difference = change in value before soaking and after soaking. **no red lentils evaluated in 2022; 5 and 10 year determination was done on 2018-21, 23 and 2013-21, 23 for red lentils, respectively; nd = not determined due to test not being performed for 10 years.

difference in lentil samples was comparable between red and green market classes (Table 25). However, the color difference in Spanish Brown lentils was slightly higher. Overall, the colors of lentils in 2024 were impacted (higher value) more by soaking in comparison to lentils that made up the 5-year mean color difference value.

Brewer had the lowest L* value among the cultivars, followed by CDC Richlea (Table 26). The highest L* was observed in the Morena cultivar. This did not follow expectations, as red and brown lentils would typically be darker than green ones. The L* values of lentil decreased for all lentils after soaking (Table 26). The green lentil cultivars became greener (i.e., reduction of the a* value) after soaking. The CDC Viceroy had the greenest appearance (the most negative a* value). The green lentil cultivar Avondale had the highest b* value (i.e., yellowness) of the soaked lentils. This is a green-coated lentil, but it has a yellow cotyledon; thus, the soaking may have reduced the impact of the hull on color and resulted in increased yellowness. The red and Spanish Brown classes became redder in color after soaking. The Red Chief cultivar had the most significant increase in redness. The increased b* values indicated that the lentils in all market classes became more yellow in color. The change in yellowness contributed to the greatest color difference that was observed in the individual cultivars (Table 26). The change in greenness and yellowness during soaking likely contributed to the greatest color difference in the green cultivar. In the Red Chief cultivar, the change in redness likely contributed most to the color difference value.

Table 26. Color quality of USA lentil cultivars before and after soaking, 2024.

		Mean Color Values*						
		Before Soaking			After Soaking			Color
Market Class	Cultivar	L	a	b	L	a	b	Difference
Green	Avondale	62.73	0.43	12.09	59.55	-1.50	25.80	14.26
	Brewer**	59.01	4.15	12.78	58.41	2.70	22.04	9.40
	CDC Richlea	59.87	1.01	13.72	58.68	-0.64	24.62	12.40
	CDC Viceroy	60.41	0.05	12.92	58.33	-1.91	24.73	12.69
	Laird	60.38	1.87	14.29	59.37	0.08	24.18	10.27
	Merrit	62.79	3.32	10.81	55.95	2.64	20.76	12.31
Red	Red Chief**	61.21	2.96	11.55	57.17	7.56	22.83	12.83
Spanish Brown	Morena**	63.73	1.90	5.55	50.98	3.34	14.93	15.89
	Pardina	61.54	2.00	5.98	52.82	2.73	16.54	15.22

*color scale L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. Color difference = change in value before soaking and after soaking. **Only one sample of cultivar tested.

Pasting properties (Tables 27-29)

Peak, hot paste, and breakdown viscosities of lentils grown in 2024 were comparable to samples from 2022 but higher than samples from 2021 and 2023. However, cold paste viscosity was significantly lower than the respective values from lentils of other harvest years, except 2023. For example, a significantly lower cold paste viscosity (149 RVU) was observed for lentils from 2024, which was comparable to the samples from 2023 (Table 27). The pasting temperature ranged from 76.6 to 80.4 °C, with a mean value of 80.2 °C, which is higher than the 5- and 10-year mean pasting temperatures. The peak, hot paste, and cold paste viscosities were different among the market classes (Table 28). The peak, hot paste, and cold paste viscosities obtained for lentils in the Spanish Brown market class were lower than those of the lentils from the green and red market classes. However, this was not the general trend found in samples from previous years and in the long-term mean values. Pasting characteristics for the green and red classes in 2024 were comparable to the 5- and 10-year mean viscosity values for peak, hot paste, and breakdown viscosities. However, the cold paste viscosity and setback values were lower than the 5- and 10-year mean viscosity values. All parameters for the Spanish Brown lentils were lower than the 5- and 10-year mean viscosity values. This indicates that the lentils from 2024 produce thinner pastes and gels.

Table 27. Starch characteristics of lentils grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Starch Characteristic	2024		Means (SD)					
	Range	Mean (SD)	2023	2022	2021	2020	5-Year	10-year
Peak Viscosity (RVU)	82-161	128 (20)	118 (32)	124 (19)	117 (23)	142 (21)	129 (14)	132 (13)
Hot Paste Viscosity (RVU)	79-152	123 (17)	110 (26)	120 (18)	110 (23)	133 (17)	122 (13)	125 (11)
Breakdown (RVU)	0-24	6 (5)	7 (10)	4 (3)	7 (7)	9 (6)	7 (2)	8 (3)
Cold Paste Viscosity (RVU)	81-191	149 (22)	151 (39)	221 (32)	210 (50)	237 (35)	214 (39)	221 (32)
Setback (RVU)	11-68	28 (11)	39 (19)	101 (16)	100 (28)	104 (21)	92 (30)	96 (23)
Peak Time (Minute)	4.80-7.00	5.89 (0.56)	6.09 (0.58)	6.46 (0.56)	6.10 (0.76)	5.68 (0.62)	5.96 (0.38)	5.85 (0.37)
Pasting Temperature (°C)	76.6-84.8	80.4 (1.4)	79.8 (1.5)	80.2 (1.4)	80.0 (1.8)	78.9 (1.5)	79.1 (1.2)	78.0 (1.6)
RVA Gel Fimness (g)	81-299	174 (37)	255 (75)	285 (35)	**	**	nd	nd

**not previously reported; nd = not determined due to test not being performed for 5 or 10 years.

New in 2022 was the RVA gel firmness, which was run again in 2024. The gel firmness ranged from 81 to 299 g, with a mean of 174 g (Table 27), where red lentils had the greatest gel firmness (Table 28). Overall, lentils had gel firmness values that were lower in the 2024 harvest year compared to previous years, regardless of market class (Table 28).

Variability in pasting characteristics was observed among cultivars (Table 29). In the green market class, the variability among cultivars was noticeable. Brewer had the lowest peak, hot paste, and cold paste viscosities. In 2023, Brewer also had the lowest viscosity values. The Avondale lentils from 2024 had the highest peak and hot paste viscosities and the third highest cold paste viscosity. Morena (177 RVU) and Red Chief (166 RVU) had the two highest cold paste viscosities. Pardina had the lowest pasting temperature while Morena had the highest. The Pardina cultivar had the lowest RVA gel firmness values (154 g) while the Merrit cultivar produced the firmest (191 g) gel among samples (Table 29).

Table 28. Starch characteristic of different market classes of lentils grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Market class	Physical Parameter	Mean (SD) 2024	2023	2022	2021	2020	5-Year Mean (SD)	10-Year Mean (SD)
Green	Peak Viscosity (RVU)	130 (19)	119 (35)	110 (15)	111 (22)	146 (21)	126 (17)	133 (15)
	Hot Paste Viscosity (RVU)	124 (16)	110 (29)	105 (14)	103 (21)	135 (17)	117 (16)	123 (13)
	Breakdown (RVU)	6 (5)	9 (11)	5 (2)	8 (9)	10 (6)	8 (2)	9 (3)
	Cold Paste Viscosity (RVU)	151 (20)	148 (42)	194 (15)	193 (41)	241 (35)	204 (39)	217 (33)
	Setback (RVU)	27 (9)	38 (20)	89 (7)	90 (21)	106 (22)	86 (28)	94 (23)
	Peak Time (Minute)	5.84 (0.55)	5.97 (0.59)	6.55 (0.67)	6.11 (0.83)	5.54 (0.55)	5.94 (0.43)	5.70 (0.47)
	Pasting Temperature (°C)	80.3 (2.8)	79.4 (3.2)	81.2 (1.9)	80.6 (2.1)	78.7 (1.6)	79.3 (1.7)	78.1 (2)
	RVA Gel Firmness (g)	177 (37)	272 (62)	268 (34)	**	**	nd	nd
Red	Peak Viscosity (RVU)	128 (0)	77 (0)	*	97 (0)	130 (21)	120 (26)	119 (21)
	Hot Paste Viscosity (RVU)	126 (0)	77 (0)	*	84 (0)	123 (17)	114 (22)	114 (18)
	Breakdown (RVU)	2 (0)	0 (0)	*	13 (0)	7 (6)	6 (5)	5 (4)
	Cold Paste Viscosity (RVU)	166 (0)	107 (0)	*	132 (0)	218 (39)	200 (54)	203 (42)
	Setback (RVU)	40 (0)	30 (0)	*	48 (0)	95 (23)	86 (33)	89 (24)
	Peak Time (Minute)	7.00 (0)	6.57 (0)	*	5.27 (0)	5.77 (0.53)	6.85 (1.83)	6.86 (1.97)
	Pasting Temperature (°C)	81.5 (0)	81.5 (0)	*	79.2 (0)	79.0 (1.8)	79.4 (1.3)	78.2 (1.8)
	RVA Gel Firmness (g)	181 (0)	223 (0)	*	**	**	nd	nd
Spanish Brown	Peak Viscosity (RVU)	116 (20)	116 (22)	130 (17)	126 (24)	139 (21)	133 (14)	136 (13)
	Hot Paste Viscosity (RVU)	113 (17)	111 (18)	127 (15)	121 (23)	132 (18)	127 (12)	129 (11)
	Breakdown (RVU)	4 (3)	3 (2)	4 (3)	5 (4)	6 (5)	5 (2)	6 (4)
	Cold Paste Viscosity (RVU)	138 (33)	161 (25)	234 (30)	237 (49)	235 (33)	223 (35)	229 (30)
	Setback (RVU)	29 (19)	43 (15)	108 (16)	116 (27)	102 (16)	100 (33)	102 (25)
	Peak Time (Minute)	6.11 (0.52)	6.40 (0.41)	6.42 (0.50)	6.16 (0.68)	6.03 (0.70)	6.09 (0.39)	5.84 (0.51)
	Pasting Temperature (°C)	79.6 (1.3)	79.5 (0.5)	79.7 (0.5)	79.3 (1.0)	79.5 (0.8)	79.1 (0.9)	78.2 (1.5)
	RVA Gel Firmness (g)	154 (36)	208 (93)	293 (33)	**	**	nd	nd

* no red lentils evaluated in 2022; 5 and 10 year determination was done on 2018-21, 23 and 2013-21, 23 for red lentils. **not previously measured; nd = not determined due to test not being performed for 5 or 10 years.

Table 29. Mean starch characteristics of lentil cultivars grown in the USA in 2024.

Market Class	Cultivar	Peak Viscosity (RVU)	Hot Paste Viscosity (RVU)	Breakdown (RVU)	Cold Paste Viscosity (RVU)	Setback (RVU)	Peak Time (Min)	Pasting Temperature (°C)	RVA Gel Firmnes (g)
Green	Avondale	151	143	8	165	22	5.64	81.1	180
	Brewer**	85	92	8	94	16	6.01	79.5	170
	CDC Richlea	136	129	7	156	27	5.79	80.1	181
	CDC Viceroy	121	117	4	147	29	6.32	80.1	154
	Laird	130	123	7	150	27	5.63	80.7	180
	Merrit	112	108	6	130	29	5.67	80.9	191
Red	Red Chief**	128	126	2	166	40	7.00	81.5	181
Spanish Brown	Morena**	111	109	2	177	68	6.91	82.2	166
	Pardina	116	114	5	135	26	6.04	79.4	153

**Only one sample of cultivar tested.

Functional properties (Tables 30-32)

Functionality property evaluation was completed for the third time in 2024. These tests include emulsion activity and stability, foaming capacity and stability, water holding capacity, and oil holding capacity. The emulsion activity and stability for all lentil samples ranged from 52 to 61% and 54 to 60% (Table 30). The lentils from the various market classes had comparable emulsion activity and stability, with the red lentils having slightly higher emulsion properties (Table 31). Furthermore, Red Chief cultivar had emulsion activity and stability values that were slightly higher than those of other cultivars (Table 32).

Table 30. Functional properties of lentils grown in the USA, 2022-2024.

Functional Properties	2024 Range	2024 Mean (SD)	2023 Mean (SD)	2022 Mean (SD)
Emulsion Activity (%)	52-61	57 (2)	55 (1)	59 (1)
Emulsion Stability (%)	54-60	57 (1)	56 (1)	59 (2)
Foaming Capacity (%)	87-203	138 (25)	180 (37)	205 (45)
Foam Stability (%)	51-100	75 (10)	76 (9)	67 (14)
Water Holding Capacity (g/g)	1.08-2.01	1.55 (0.21)	1.27 (0.14)	1.30 (0.16)
Oil Holding Capacity (g/g)	0.11-0.37	0.21 (0.05)	0.16 (0.06)	0.40 (0.28)

In contrast to emulsion activity, foaming capacity varied to a greater extent (87-203%). Differences in foaming capacity among different classes of lentils were observed (Table 31), with the Spanish Brown lentils having mean foaming capacities that were approximately 14 to 35 percentage points higher than the mean foaming capacity of the green and red lentils, respectively. In contrast, the Spanish brown lentils had foam stability that was approximately five percentage points higher than the foaming stability of the green and red lentils. The Merrit cultivar had significantly higher foaming capacity (170%) compared to other cultivars except Morena (167%) (Table 32). However, Morena had the highest foam stability. The Morena cultivar had higher water holding capacity compared to the other cultivars. Red Chief had a slightly higher oil holding capacity value compared to the other cultivars. In general, higher water holding capacity means lower oil holding capacity, which was observed in the 2024 lentils from different market classes (Table 31).

Table 31. Functional properties of different market classes of lentils grown in the USA, 2022-2024.

		Mean (SD)		
Market Class	Functional Properties	2024	2023	2022
Green	Emulsion Activity (%)	57 (1)	55 (1)	58 (1)
	Emulsion Stability (%)	57 (1)	56 (1)	59 (2)
	Foaming Capacity (%)	136 (23)	189 (37)	189 (36)
	Foam Stability (%)	74 (9)	74 (9)	71 (12)
	Water Holding Capacity (g/g)	1.53 (0.21)	1.22 (0.10)	1.28 (0.11)
	Oil Holding Capacity (g/g)	0.22 (0.06)	0.16 (0.07)	0.29 (0.21)
Red	Emulsion Activity (%)	60 (0)	54 (0)	*
	Emulsion Stability (%)	58 (0)	55 (0)	*
	Foaming Capacity (%)	117 (0)	227 (0)	*
	Foam Stability (%)	74 (0)	73 (0)	*
	Water Holding Capacity (g/g)	1.55 (0)	1.19 (0)	*
	Oil Holding Capacity (g/g)	0.27 (0)	0.15 (0)	*
Spanish Brown	Emulsion Activity (%)	56 (2)	56 (1)	58 (1)
	Emulsion Stability (%)	56 (1)	56 (1)	59 (2)
	Foaming Capacity (%)	150 (32)	151 (16)	189 (36)
	Foam Stability (%)	79 (11)	80 (6)	71 (12)
	Water Holding Capacity (g/g)	1.67 (0.14)	1.41 (0.16)	1.28 (0.11)
	Oil Holding Capacity (g/g)	0.19 (0.03)	0.17 (0.05)	0.29 (0.21)

*No red lentils evaluated in 2022

Table 32. Mean functional properties of lentil cultivars grown in the USA, 2024.

Market Class	Cultivar	Water Holding Capacity (g/g)	Oil Holding Capacity (g/g)	Emulsion Activity (%)	Emulsion Stability (%)	Foaming Capacity (%)	Foam Stability (%)
Green	Avondale	1.49	0.22	56	56	133	77
	Brewer**	1.39	0.15	56	57	133	72
	CDC Richlea	1.55	0.22	57	57	134	75
	CDC Viceroy	1.46	0.23	57	57	129	75
	Laird	1.53	0.20	57	57	134	74
	Merrit	1.64	0.18	56	55	170	70
Red	Red Chief**	1.55	0.27	60	58	117	74
Spanish Brown	Morena**	1.70	0.16	57	56	167	83
	Pardina	1.66	0.19	56	56	149	79

**Only one sample of cultivar tested.

Chickpea Quality Results

Sample distribution

A total of 54 chickpea samples were collected from Idaho, Montana, North Dakota, Oregon, and Washington between August 2024 and November 2024. Samples were delivered to SDSU between November 2024 and January 2025. The growing location, number of samples, market class, and genotype details of these dry chickpea samples are provided in Table 33. CDC Orion (3), Sawyer (4), Royal (6), and Sierra (12) accounted for most of the chickpea of the known cultivars evaluated.

Table 33. Description of chickpea samples used in the 2024 pulse quality survey.

State	No. of Samples	Market Class	Cultivars	
Idaho	3	Kabuli	Royal	Sierra
Montana	28	Kabuli	Marvel	CDC Orion
			Royal	Sawyer
North Dakota	2	Kabuli	Kasin	
Oregon	1	Kabuli	Sierra	
Washington	20	Kabuli	Billy Beans	Dylan
			Ellie	Nash
			Quinn	Royal
			Sawyer	Sierra

Proximate composition of chickpea (Tables 34-35)

The **moisture content** of chickpeas ranged from 7.4 to 11.9% in 2024 (Table 34). The mean moisture content of the samples was 9.5%, which is higher than the 5- and 10-year mean of 9.0%. The mean moisture content of chickpea was higher than the previous individual values from samples collected in 2020-2023. This supports the fact that the long-term mean moisture content of the chickpea from the region is consistent. No sample exceeded the 13-14% moisture threshold for proper storage. The Marvel cultivar had the highest mean moisture content at 11.4% while the Sierra had the lowest moisture content (8.2%) among all chickpeas (Table 35).

The **ash content** of chickpeas ranged from 2.3 to 3.3% with a mean of 2.8% (Table 34). The mean ash content of chickpeas grown in 2024 was comparable to the ash contents of chickpea that were used in determining the 5- and 10-year mean values (Table 34). Of the known cultivars grown, Kasin and Royal had the lowest ash contents at 2.7%, while Billy Bean and Dylan had ash contents of 3.0%, thus indicating minimal variability of the ash composition (Table 35). The mean **fat content** was

Table 34. Proximate composition of Kabuli chickpeas grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Proximate Composition*	Year 2024 Range	2024 Mean (SD)	2023 Mean (SD)	2022 Mean (SD)	2021 Mean (SD)	2020 Mean (SD)	5-year Mean (SD)	10-year Mean (SD)
Moisture (%)	7.4-11.9	9.5 (1.2)	8.8 (1.2)	8.5 (0.9)	8.5 (0.9)	7.9 (1.1)	9.0 (1.4)	9.1 (1.2)
Ash (%)	2.3-3.3	2.8 (0.2)	2.8 (0.3)	2.9 (0.1)	3.0 (0.2)	3.0 (0.6)	2.8 (0.1)	2.8 (0.2)
Fat (%)	4.3-7.1	5.3 (0.5)	5.3 (0.4)	5.6 (0.4)	5.6 (0.3)	5.4 (0.6)	5.9 (0.8)	nd
Protein (%)	16.4-26.0	21.2 (2.2)	21.6 (2.6)	20.8 (2.3)	19.8 (1.5)	21.1 (2.0)	20.3 (0.8)	20.0 (1.0)
Starch (%)	34.7-50.2	40.9 (4.1)	40.4 (3.2)	41.3 (2.4)	40.7 (1.3)	40.8 (3.6)	40.7 (0.5)	40.7 (0.7)

*composition is on an "as is" basis; nd = not determined due to test not being performed for 10 years.

5.3% with a range from 4.3 to 7.1% (Table 34). Literature reports indicate that chickpea has a fat content between 2 and 7%; therefore, the fat content of chickpeas grown in 2024 falls within the range reported by others but is less than the fat content recorded in previous years, except for chickpeas from 2023. Fat content was slightly lower than the 5-year mean fat content of 5.9% (Table 34). The Kasin cultivar had the highest (5.7%) fat content among chickpeas (Table 35). Furthermore, the fat content of Billy Bean was the lowest (4.3%) among chickpeas.

Protein content of chickpeas ranged from 16.4 to 26.0%, with a mean of 21.2% (Table 34). The mean protein content of chickpea grown in 2024 was greater than the 5- and 10-year mean protein contents of 20.3 and 20.0%, respectively. Overall, the protein content of chickpea from 2024 was most similar to the protein content of peas from 2020. Quinn had the lowest (19.8%) mean protein content, while Billy Bean had the highest mean protein content at 24.5% (Table 35).

Total starch content of chickpea ranged from 34.7 to 50.2%, with a mean of 40.9% (Table 33). The mean total starch content of chickpeas grown in 2024 was similar to the mean starch content observed in chickpeas from the previous harvest years and was slightly higher than the 5- and 10-year mean total starch content of 40.7%. The Marvel cultivar had the lowest (34.7%) mean starch content, while the highest (44.3%) was observed in the Kasin and royal cultivars. Marvel also had the lowest starch content in 2023.

Table 35. Mean proximate composition of chickpea cultivars grown in the USA, 2024.

Cultivar	Concentration (%) Moisture	Ash	Fat	Protein	Starch
Billy Bean**	8.3	3.0	4.3	24.5	39.2
CDC Orion	10.0	2.8	5.2	19.9	41.5
Dylan**	10.4	3.0	5.0	21.7	42.7
Ellie**	9.0	2.9	5.0	24.1	37.1
Kasin**	10.3	2.7	5.7	19.9	44.3
Marvel**	11.4	2.8	5.0	23.6	34.7
Nash**	8.5	2.9	4.7	22.9	39.5
Quinn**	8.8	2.8	5.2	19.8	36.9
Royal	8.4	2.7	5.3	21.3	43.3
Sawyer	9.2	2.9	5.4	22.5	42.6
Sierra	8.2	2.9	5.6	21.2	41.9

*composition is on an "as is" basis; **Value from one sample of cultivar tested.

Physical parameters of chickpeas (Tables 36-39)

Test weight, 1000 seed weight, water hydration capacity, percentage unhydrated seeds, swelling capacity, cooked firmness, and color represent the physical parameters used to define physical quality. The data presented also includes size distribution. Test weight ranged from 53.0 to 60.8 lbs./Bu with a mean of 57.8 lbs./Bu. This mean value is less than both the 5- and 10-

Table 36. Physical parameters of Kabuli chickpeas grown in the USA, 2020-2024 plus 5- and 10-year mean values.

Physical Parameter	Year 2024 Range	2024 Mean (SD)	2023 Mean (SD)	2022 Mean (SD)	2021 Mean (SD)	2020 Mean (SD)	5-year Mean (SD)	10-year Mean (SD)
Test Weight (lb/Bu)	53.0-60.8	57.8 (1.8)	60.6 (2.1)	61.2 (1.9)	61.2(1.8)	61.6 (1.5)	61.1 (0.4)	61.3 (0.5)
1000 Seed Wt	245-591	411 (77)	398 (77)	477 (50)	464 (67)	417 (71)	440 (33)	426 (31)
Water Hydration Capacity (%)	97-129	110 (8)	109 (9)	105 (7)	105 (9)	108 (8)	106 (3)	104 (3)
Unhydrated Seeds (%)	0-0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Swelling Capacity (%)	122-184	142 (13)	133 (15)	125 (12)	144 (20)	145 (17)	137 (8)	133 (12)
Cooked Firmness (N/g)	11.8-26.0	18.8 (2.99)	18.6 (2.9)	19.7 (2.3)	19.6 (2.9)	20.7 (3.8)	19.8 (0.8)	nd
% of Sample Retained on 22/64 Sieve	1.6-93.6	62.1 (24.2)	53.8 (27.7)	79.5 (15.3)	69.0 (21.5)	55.6 (26.5)	64.4 (10.5)	nd
% of Sample Retained on 20/64 Sieve	4.8-66.4	26.6 (13.9)	29.9 (16.1)	16.7 (11.9)	22.8 (12.6)	34.3 (18.6)	26.6 (6.9)	nd
% of Sample Retained on 18/64 Sieve	0-52.4	9.4 (11.0)	11.9 (14.7)	3.6 (3.2)	7.1 (9.9)	9.7 (12.4)	7.7 (3.2)	nd
% of Sample Passed Through an 18/64 Sieve	0-19.6	1.9 (3.7)	4.5 (12.6)	0.3 (0.9)	1.1 (2.5)	0.4 (0.9)	1.4 (1.8)	nd

*data not reported; nd = not determined due to test not being performed for 10 years.

year mean test weights (Table 36). The test weights of individual cultivars ranged from 54.3 lbs./Bu in Nash to 59.6 lbs./Bu in the Marvel cultivars (Table 37). The range and mean 1000 seed weight of chickpeas grown in 2024 were 245-591 g and 411 g, respectively (Table 36). The mean 1000 seed weight was lower than the 5-year and 10-year mean values of 440 and 426 g, respectively. The Nash cultivar had the highest 1000 seed weight at 591 g, while the Marvel cultivar had the lowest mean value at 245 g (Table 37). In 2023, Nash also had the highest 1000 seed weight of 526 g. The lower overall 100 seed weight in 2024 compared to long-term averages simply relates to the higher number of samples of small chickpea cultivars being evaluated.

Water hydration capacity of chickpeas ranged from 97 to 127%, with a mean of 110% (Table 36). The water hydration capacity of chickpeas from 2024 was slightly higher than the 5- and 10-year mean values. Differences in water hydration capacities were observed among cultivars. The Marvel cultivar had the lowest water hydration capacity (101%) while Billy Bean had the highest (127%) (Table 37).

The **unhydrated seed percentage** was 0% for all chickpeas. The 0% unhydrated seeds matched the 5- and 10-year mean values of 0 and 1%, respectively (Table 36). All the cultivars had 0% mean unhydrated seed values (Table 37). No issues were observed with the rehydration of the chickpea samples. The **swelling capacity** of chickpeas ranged from 122 to 184%, with a mean value of 142% (Table 36). The mean swelling capacity value of chickpea from 2024 was comparable to the chickpeas from 2020 and 2021, and was higher than the 5- and 10-year mean swelling capacity of 137 and 133%, respectively. The Billy Bean cultivar had the greatest mean swelling capacity (168%) while the Kasin cultivar had the lowest value (123%) among chickpeas (Table 37). The higher water hydration capacity for the Billy Bean cultivar may be the reason for the higher swelling capacity.

Table 37. Mean physical properties of chickpea cultivars grown in the USA, 2024.

Cultivar	Test Weight (lb/Bu)	1000 Seed Wt (g)	Water Hydration Capacity (%)	Unhydrated Seeds (%)	Swelling Capacity (%)	Cooked Firmness (N/g)	% of Sample Retained on 22/64 Sieve	% of Sample Retained on 20/64 Sieve	% of Sample Retained on 18/64 Sieve	% of Sample Passed Through an 18/64 Sieve
Billy Bean**	59.2	294	127	0	168	21.2	7.6	42.4	41.6	8.4
CDC Orion	59.1	379	106	0	140	17.9	57.8	36.8	4.9	0.5
Dylan**	55.3	484	124	0	145	18.3	85.6	13.2	1.2	0.0
Ellie**	59.3	350	120	0	144	13.1	47.6	37.6	11.6	3.2
Kasin**	58.8	361	107	0	123	21.5	15.6	66.4	17.2	0.8
Marvel**	59.6	245	101	0	153	18.1	1.6	26.4	52.4	19.6
Nash**	54.3	591	118	0	149	20.9	93.6	4.8	1.6	0.0
Quinn**	57.0	512	110	0	145	18.6	92.0	6.8	1.2	0.0
Royal	56.7	512	119	0	146	21.2	81.8	14.1	3.7	0.3
Sawyer	57.7	414	110	0	137	18.3	59.0	32.2	7.4	1.4
Sierra	55.7	466	112	0	135	18.4	81.0	15.0	3.3	0.7

**Value from one sample of cultivar tested.

The **cooked firmness** of all chickpeas ranged from 11.8 to 26.0 N/g, with a mean value of 18.8 N/g (Table 36). The mean firmness value for chickpea in 2024 was lower than the 5-year mean value (19.8 N/g). This supports that chickpeas were slightly less firm after cooking compared to chickpeas from previous years (2020-2022) and that the chickpea cooking using a standard time produced chickpeas with a tender structure. Among the cultivars, Ellie had the lowest cooked firmness (13.1 N/g) while the Kasin (21.5 N/g) cultivar was the firmest (Table 37).

Retention of chickpea on a series of sieves was used to determine chickpea size. The mean retentions of 62.1, 26.6, 9.4, and 1.9% on the 22/64-, 20/64-, 18/ 64- and passed through the 18/64-inch sieves were observed in the 2024 chickpeas, respectively (Table 36). The range of retention on the largest screen (22/64-inch sieve) was from 1.6 to 93.6%. The percentage of retention of chickpeas on the two largest screens (22/64 and 20/64-inch sieves) was approximately 88.7% in 2024, while retention values of 84, 96, 92, and 90% were observed for the chickpea harvested in 2023, 2022, 2021, and 2020, respectively. This data shows that more samples of cultivars with smaller seeds were evaluated in 2024, which is supported by the 1000 seed weight. The highest percentage retention (93.6%) of the sample on the 22/64-inch sieve was observed for the Nash cultivar, while the lowest (1.6%) retention on the 22/64-inch sieve was observed in the Marvel cultivar (Table 37). The combination of Marvel and Billy Beans (9.2% retained on 22/64-inch sieve) contributed most to the lower seed retention on the 22/64-inch sieve in 2024.

Color quality was measured using L*, a*, and b* values, and from these values, a color difference was determined on chickpeas before and after soaking (Table 38). **Color quality** indicated that the lightness (i.e., L*) of the chickpeas from 2024 was higher than that of chickpeas grown in 2023, and the chickpea that made up the 5- and 10-year mean L* values (Table 38). In contrast, the L* value for chickpeas grown in 2024 was lower than the L* values of chickpeas from 2020 and 2021. In 2024, the a* value of 6.34 was most like the a* value of chickpea from 2021. Furthermore, the a* value was substantially higher for the chickpea from 2024 compared to the 5-year a* values of 5.94 but lower than the a* value (6.98) for chickpeas that made up the 10-year mean. This indicates that the chickpea had less redness compared to the long-term (10 years) average. The b* value for chickpeas from 2024 indicated similar yellowness to the chickpea from 2021-2023 and the samples that made up the 5-year mean b* value. However, the 2024 chickpeas on average had less yellowness compared to chickpea samples that were used to determine the 10-year mean yellowness (i.e., b*) (Table 38). The color of the chickpeas changed after the soaking process. Soaked chickpeas became darker as evidenced by the lower L* values (Table 38) compared to pre-soaked chickpeas. This same trend occurred in samples from 2023 but not in other years or for samples that made up the 5- and 10-year mean L* values. The redness (i.e., a* value) did change slightly after soaking. Chickpeas from all years became yellower (i.e., increased b* value) after soaking. The color difference between the pre- and post-soaked chickpea from 2024 was most similar to the color difference for samples from 2021 but higher than in chickpea from 2023 and lower than in chickpea that were used in the determination of the 10-year mean b* value (Table 38).

Table 38. Physical parameters of Kabuli chickpeas grown in the USA, 2021-2024 plus 5- and 10-year mean values.

Color Scale*	Mean (SD) Color Values					
	Before Soaking				5-Year	10-Year
	2024	2023	2022	2021	Mean	Mean
L* (lightness)	60.12 (1.87)	59.21 (1.59)	60.57 (1.17)	61.33 (1.25)	59.45 (2.24)	58.89 (4.52)
a* (red-green)	6.34 (0.67)	6.14 (0.63)	6.01 (0.51)	6.31 (3.73)	5.94 (0.45)	6.98 (1.50)
b* (yellow-blue)	14.80 (0.88)	14.64 (1.27)	14.48 (0.67)	14.41 (2.07)	14.00 (1.75)	17.05 (4.08)
Color Scale*	After Soaking				5-Year	10-Year
	2024	2023	2022	2021	Mean	Mean
L* (lightness)	58.82 (2.00)	59.68 (1.13)	60.96 (1.12)	61.79 (0.68)	59.99 (2.29)	60.03 (4.29)
a* (red-green)	6.62 (0.62)	6.52 (0.48)	6.77 (0.46)	6.69 (0.52)	6.32 (0.64)	7.92 (2.33)
b* (yellow-blue)	24.79 (2.94)	25.24 (3.52)	24.40 (1.27)	24.81 (1.68)	23.44 (3.64)	28.14 (5.74)
Color Difference	10.80 (3.26)	9.85 (1.10)	11.23 (3.35)	10.47 (1.79)	9.70 (1.94)	12.74 (5.05)

color scale L(lightness) axis – 0 is black and 100 is white; a *(red-green) axis – positive values are red, negative values are green, and zero is neutral; and b* (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. Color difference is the change in color after soaking.

Table 39. Mean color quality of chickpea cultivars grown in the USA, 2024.

	Mean Color Values**						
	Before Soaking			After Soaking			Color
Cultivar	L	a	b	L	a	b	Difference
Billy Bean**	58.68	7.34	15.15	59.17	7.22	28.16	13.03
CDC Orion	58.88	6.99	15.40	58.67	7.23	26.28	10.90
Dylan**	64.33	4.66	13.11	54.98	5.37	17.85	10.61
Ellie**	59.70	6.93	15.04	59.65	7.44	27.91	12.88
Kasin**	58.80	7.13	15.23	60.80	7.45	27.66	12.60
Marvel**	60.73	6.44	16.50	61.83	6.15	25.57	9.14
Nash**	62.35	5.93	14.50	60.37	6.71	25.02	10.75
Quinn**	62.03	5.76	13.82	59.25	6.93	25.64	12.20
Royal	60.36	6.30	14.28	58.68	6.72	23.73	10.77
Sawyer	60.18	6.30	15.13	58.37	6.18	23.25	9.53
Sierra	62.09	5.44	13.97	58.99	5.82	22.14	10.16

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Only one sample of cultivar tested.

Among cultivars, Dylan had the highest L* value (64.33) while Billy Bean had the lowest (i.e., 58.68). The Dylan cultivar had the lowest a* value (4.66) among cultivars, while Billy Bean had the highest (7.34). The highest yellowness value (i.e., b*) was observed in Kasin (Table 39), while Dylan had a b* value of 13.11. Visual observations support the color value differences as the Dylan cultivar appeared cream in color and less yellow than other cultivars. Except for a few cultivars, most underwent a decrease in lightness during soaking, as evidenced by the lower L* value of the soaked samples. An increased redness and yellowness (increased a* and b* values, respectively) was observed for all cultivars. The greatest color difference was observed in the Billy Bean cultivar (Table 39), while the Marvel cultivar had the least color change. The Sierra cultivar also had the least color change after soaking in 2021-2023. The change in color observed in the samples was likely due to the significant increase in yellowness (a change in b* values) during the soaking. The color change is supported by visual observations, where the chickpea appeared more yellow after soaking.

Pasting properties (Tables 40-41)

Large variability in peak (57-264 RVU), hot paste (51-177 RVU) and cold paste (68-234 RVU) viscosities were observed in the 2024 chickpea crop. Peak, hot paste, and cold paste viscosities of chickpeas grown in 2024 were lower than the 5- and 10-year mean peak, hot paste, and cold paste viscosities (Table 40). The peak time was longer for samples from 2024 compared to other crop years, including the 5- and 10-year mean peak time value. This indicates that the starch gelatinization requires additional heating time to form a gel compared to samples from previous years.

Among chickpeas, Billy Beans and CDC Orion had the lowest peak viscosity (108 RVU) while Dylan (141 RVU) had the highest peak viscosity (Table 41). The Kasin and Sawyer cultivars had the lowest and highest hot paste viscosities, respectively. Kasin and Dylan cultivars had the lowest and highest cold paste viscosities, respectively (Table 41). Pasting temperature was lowest (76.2 °C) and highest (79.4 °C) for Billy Beans and Sierra cultivars, respectively.

Table 40. Starch characteristics of Kabuli chickpeas grown in the USA, 2020-2024 plus 5- and 10 year mean values.

Starch Characteristic	Year						5-year	10-year
	2024		2023	2022	2021	2020		
	Range	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Peak Viscosity (RVU)	57-264	116 (30)	122 (20)	125 (14)	129 (20)	136 (16)	130 (6)	132 (7)
Hot Paste Viscosity (RVU)	51-177	106 (23)	116 (19)	121 (12)	123 (18)	128 (13)	124 (6)	127 (6)
Breakdown (RVU)	1-87	10 (13)	6 (5)	4 (4)	10 (1)	7 (5)	6 (2)	6 (2)
Cold Paste Viscosity (RVU	68-234	126 (36)	154 (33)	189 (28)	200 (53)	186 (23)	185 (19)	192 (17)
Setback (RVU)	3-57	22 (13)	37 (16)	68 (17)	77 (36)	58 (15)	62 (15)	60 (19)
Peak Time (Minute)	4.80-7.00	6.46 (0.68)	6.59 (0.50)	6.53 (0.58)	6.47 (0.63)	6.12 (0.56)	6.41 (0.19)	6.25 (0.23)
Pasting Temperature (°C)	74.3-85.5	78.7 (2.1)	78.2 (3.4)	77.1 (1.4)	76.9 (1.2)	78.0 (1.4)	77.1 (1.0)	76.1 (1.4)
RVA Gel Firmness (g)	31-213	116 (47)	159 (37)	272 (54)	*	*	nd	nd

*not previously measured; nd = not determined due to test not being performed for 5 or 10 years.

The RVA gel firmness ranged from 31 to 213 g with a mean of 116 g (Table 40). The mean gel firmness was substantially less for samples in 2024 than the gel firmness of chickpeas from 2022 and 2023. The Ellie cultivar had the firmest (i.e., highest value) RVA gel firmness while Marvel produced a gel with the least firmness (Table 41). The gels formed from samples in 2024 were visually less firm compared to samples from previous years. However, the basis for the observed low firmness was not apparent based on the composition measured.

Table 41. Mean starch characteristics of chickpea cultivars grown in the USA, 2024.

Cultivar	Peak Viscosity (RVU)	Hot Paste Viscosity (RVU)	Breakdown (RVU)	Cold Paste Viscosity (RVU)	Setback (RVU)	Peak Time (Min)	Pasting Temperature (°C)	RVA Gel Firmness (g)
Billy Bean**	108	114	7	159	43	6.50	76.2	202
CDC Orion	108	95	15	101	9	6.48	79.3	90
Dylan**	141	133	8	162	29	6.20	79.2	199
Ellie**	119	114	4	155	39	6.92	78.6	213
Kasin**	120	93	20	95	28	6.15	76.3	103
Marvel**	110	104	6	121	18	7.00	78.3	64
Nash**	135	115	14	135	13	5.90	78.9	104
Quinn**	120	114	6	159	41	6.90	79.3	151
Royal	115	104	11	127	22	6.08	78.1	149
Sawyer	121	119	3	146	32	6.67	77.3	161
Sierra	116	110	6	135	24	6.67	79.4	123

**Value from one sample of cultivar tested.

Functional properties (Tables 42-43)

Functionality property evaluation was new in 2022. Thus, only 3 years of data exist on emulsion activity and stability, foaming capacity and stability, water holding capacity, and oil holding capacity. Emulsion activity and stability for all chickpea samples ranged from 52 to 57% and 54 to 58% (Table 42). No differences in emulsion activity and stability were observed between the samples from 2024 compared to the previous years. Furthermore, consistent results were observed among cultivars (Table 43). In contrast to emulsion activity, foaming capacity varied to a greater extent (97-183%). The mean foaming capacity in samples from 2024 was significantly lower than the foaming capacities from 2022 and 2023. However, the mean foaming stability observed in 2024 was not significantly different from the foaming capacities in chickpeas from 2022 and 2023. Differences in foaming capacity among different cultivars of chickpeas were observed (Table 43). Marvel had a mean foaming capacity of approximately 183%. In contrast, the Nash had the lowest foaming capacity at 103%. Marvel also had the highest foam stability (91%). Billy Beans and Sierra had a slightly lower foam stability than other cultivars. Higher mean water holding capacity was observed in chickpeas from 2024 compared to chickpeas from 2022 and 2023. Billy Beans had the highest water holding capacities compared to other cultivars, while CDC Orion, Dylan, and Marvel had the lowest water holding capacities. Differences in the oil holding capacities were observed in the chickpeas from 2024 compared to chickpeas from 2023, but not 2022. The cultivars Nash and Kasin had the highest and lowest oil holding capacities, respectively.

Table 42. Functional properties of Kabuli chickpeas grown in the USA, 2022-2024.

Starch Characteristic	Year			
	2024		2023	2022
	Range	Mean (SD)	Mean (SD)	Mean (SD)
Emulsion Activity (%)	52-57	56 (1)	55 (1)	57 (1)
Emulsion Stability (%)	54-58	55 (1)	56 (1)	58 (1)
Foaming Capacity (%)	97-183	127 (20)	169 (29)	164 (20)
Foam Stability (%)	50-97	83 (9)	86 (8)	85 (5)
Water Holding Capacity (g/g)	0.99-1.95	1.35 (0.23)	1.10 (0.20)	1.01 (0.11)
Oil Holding Capacity (g/g)	0.18-0.46	0.26 (0.07)	0.20 (0.07)	0.25 (0.09)

Table 43. Functional properties of chickpea cultivars grown in the USA, 2024.

Cultivar	Emulsion Activity (%)	Emulsion Stability (%)	Foaming Capacity (%)	Foam Stability (%)	Water Holding Capacity (g/g)	Oil Holding Capacity (g/g)
Billy Bean**	56	57	107	83	1.9	0.26
CDC Orion	54	55	143	88	1.2	0.26
Dylan**	56	56	113	84	1.2	0.26
Ellie**	54	54	123	84	1.6	0.27
Kasin**	56	56	117	88	1.8	0.21
Marvel**	55	55	183	91	1.2	0.26
Nash**	54	56	103	91	1.7	0.38
Quinn**	56	56	133	79	1.7	0.32
Royal	56	55	118	79	1.3	0.24
Sawyer	56	56	136	85	1.3	0.30
Sierra	56	56	130	83	1.3	0.31

**Value from one sample of cultivar tested

Canning Quality Results

Canning quality was completed only on peas and chickpeas. The quality evaluation includes hydration capacity, swelling capacity, canned firmness, and color evaluation. Hydration capacity and swelling capacity were determined following the soak test method. The only difference was that the hydration and swelling capacity were measured on a canned pea or chickpea.

Peas (Tables 44-46)

The mean **water hydration capacity** of canned peas was 208% for all peas (Table 44). This value is higher than the water hydration capacity of peas from the crop years except 2020 and 2021. The water hydration capacity of the pea from 2024 is similar to the 5-year mean water hydration value. Water hydration capacities ranged from 157 to 367% for all peas in 2024. A difference in water hydration capacity between the green (198%), yellow (212%), and winter (223%) classes was observed (Table 44). Overall, the data for the green and yellow peas indicate similar water uptake of the peas from 2024 compared to the 5-year mean water hydration capacities of their respective classes. In winter peas, peas from 2024 had higher water uptake than the peas that made up the 5-year mean water hydration capacity. In green peas, mean water hydration capacity ranged from 179% (Arcadia) to 226% (Ariel) (Table 45). In yellow cultivars, AAC Ironhorse had the highest (367%) mean water hydration capacity, while the Salamanca cultivar had the lowest (175%) value (Table 45). The winter pea cultivar Blaze had the highest water hydration capacity (247%) compared to other winter and mottled peas. The results of the soak test did not directly translate into equivalent results as in the canning water hydration in the context of an order for the cultivars.

Table 44. Mean physical parameters of canned dry pea grown in 2020-2024 plus the 5-year mean value.

Physical Parameter	2024		Mean (SD)				
	Range	Mean (SD)	2023	2022	2021	2020	5-year
All Pea Samples							
Water Hydration Capacity (%)	157-367	208 (31)	210 (37)	231 (24)	143 (28)	199 (30)	209 (43)
Swelling Capacity (%)	51-290	199 (26)	200 (24)	165 (18)	181 (12)	205 (19)	191 (17)
Canned Firmness (N/g)	2.1-21.2	6.3 (2.6)	9.1 (5.2)	5.8 (2.0)	17.8 (7.6)	7.3 (3.0)	9.2 (5.0)
Green Pea Samples							
Water Hydration Capacity (%)	162-252	198 (19)	206 (27)	221 (20)	137 (21)	198 (32)	203 (43)
Swelling Capacity (%)	51-228	193 (28)	189 (16)	156 (14)	180 (11)	204 (20)	186 (19)
Canned Firmness (N/g)	3.7-12.7	6.8 (2.1)	9.2 (3.7)	6.6 (1.0)	19.0 (6.7)	7.2 (3.1)	9.7 (5.3)
Yellow Pea Samples							
Water Hydration Capacity (%)	157-367	212 (35)	206 (42)	219 (30)	162 (29)	199 (28)	210 (37)
Swelling Capacity (%)	119-290	200 (26)	210 (25)	152 (17)	182 (14)	206 (20)	191 (25)
Canned Firmness (N/g)	2.1-21.2	6.0 (2.9)	9.7 (6.8)	7.4 (1.9)	12.6 (6.7)	7.4 (3.0)	8.6 (2.7)
Winter Pea Samples							
Water Hydration Capacity (%)	183-271	223 (29)	236 (46)	248 (7)	123 (8)	217 (23)	208 (49)
Swelling Capacity (%)	172-237	204 (21)	210 (30)	181 (5)	180 (12)	211 (6)	197 (15)
Canned Firmness (N/g)	3.5-11.5	6.5 (2.4)	7.1 (4.3)	3.9 (0.4)	23.7 (3.6)	7.3 (2.4)	9.9 (7.9)

Table 45. Mean physical and color parameters of canned dry pea cultivars grown in 2024.

Market Class	Cultivar	Hydration Capacity (%)	Swelling Capacity (%)	Canned Firmness (N/g)	Mean Color Values*						Mean Color Difference
					Before Soaking			After Soaking			
					L*	a*	b*	L*	a*	b*	
Green	Arcadia	179	173	7.2	58.98	-2.30	9.90	49.33	0.22	15.38	11.46
	Ariel**	226	187	5.2	59.65	-2.61	9.62	50.73	-0.75	17.33	11.95
	Banner	209	206	8.7	55.43	-3.04	9.88	49.04	-0.28	15.34	9.07
	Passion	204	189	6.4	58.37	-1.99	9.75	51.46	-1.06	16.89	10.11
	Patrick	190	185	9.2	57.71	-0.73	10.85	48.26	-0.21	16.50	11.18
	Shamrock**	199	204	5.2	54.18	-3.11	10.43	49.39	-0.12	17.45	9.03
	Striker	205	207	7.5	58.74	-1.90	8.79	50.23	0.45	17.25	12.25
	Unknown	197	200	6.0	59.09	-2.02	9.76	50.43	-0.04	16.53	11.38
Yellow	1140-2822**	250	192	3.5	61.64	4.47	12.14	58.16	5.10	20.58	9.46
	AAC Chrome	252	213	4.2	62.55	4.53	14.37	57.70	3.83	23.50	10.57
	AAC Harrison**	333	252	2.4	59.49	5.96	14.61	60.48	4.60	25.49	11.02
	AAC Ironhorse**	367	290	2.5	61.58	4.23	14.12	60.66	3.73	25.85	11.78
	AAC Julius	250	200	3.7	62.73	4.99	14.40	58.93	4.15	24.26	10.72
	AAC McMurphy**	239	200	3.5	60.35	5.24	8.74	58.05	5.15	23.46	14.93
	AAC Profit**	185	125	4.5	63.12	5.86	15.87	57.89	4.05	24.93	10.62
	Caphorn**	238	170	3.4	60.32	6.24	15.95	55.08	3.58	24.27	11.33
	CDC Meadow	215	210	4.5	63.48	4.13	15.24	55.86	5.05	23.74	11.69
	Early Star**	207	200	8.7	65.40	5.28	15.54	54.75	5.28	20.55	11.81
	Hyline**	214	187	5.3	61.62	5.21	15.55	55.27	4.93	20.83	8.32
	Montech**	193	210	7.2	62.72	4.50	16.02	53.95	6.03	19.77	10.05
	Salamanca	175	182	8.9	63.84	5.17	14.85	55.88	5.65	22.14	11.08
	Treasure	190	198	6.1	63.05	3.81	15.24	55.64	5.32	23.55	11.45
	Unknown	202	199	6.6	63.43	4.53	15.01	56.13	5.06	23.03	11.41
Winter Green	Vail	223	179	4.1	59.57	-3.50	13.67	54.10	-2.32	20.71	11.49
Winter Yellow	Blaze	247	220	5.6	58.64	0.89	12.75	52.20	2.72	20.27	13.13
Mottled/Maple	CDC Acer**	191	204	11.5	47.84	3.81	8.70	42.83	6.68	9.87	5.93
	CDC Mosaic	201	200	7.6	47.47	4.26	7.86	42.65	7.03	10.15	6.30

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Only one sample of cultivar tested.

The **swelling capacity** is the amount of swelling that occurs during the rehydration of the dry pea and the canning operation. The swelling capacity of all peas ranged from 51 to 290%, with a mean value of 199% (Table 44). These values matched the swelling capacity of peas from the 2023 crop year, but were slightly higher than the 5-year mean value. The yellow and winter peas had similar mean swelling capacities (200-204%) while green peas had slightly lower (198%) mean swelling capacity. All classes of peas from 2024 had swelling capacities that were higher than their respective 5-year mean swelling capacities. The green pea cultivars Striker and Arcadia had the highest (207%) and lowest (173%) mean swelling capacities, respectively. In yellow cultivars, AAC Ironhorse had the highest (290%) mean swelling capacity, while the AAC Profit cultivar had the lowest swelling capacity at 125% (Table 45). The winter pea cultivars Blaze and Vail had the highest (220%) and lowest (179%) mean swelling capacities, respectively. Mottled peas had essentially the same swelling capacities.

As expected, the **canned firmness** values of peas were significantly lower than the cooked firmness values of soaked peas in 2024. For comparison, the mean cooked firmness for all peas from 2024 was 22.0 N/g (Table 7), while for canned pea, in 2024, the mean firmness value was 6.3 N/g (Table 44). This observation is typical of what is expected and demonstrates the typical behavior of peas from 2024. The mean canned firmness of the peas from 2024 most closely matched the mean canned firmness of peas from 2022. The mean canned firmness of peas from 2024 was lower than that of the 5-year mean canned firmness value (Table 44). In general, the peas from different classes had similar canned firmness values that ranged from 6.0 N/g in yellow peas to 6.8 N/g in green peas. For all peas, the mean firmness values were lower than the values for the 5-year mean, suggesting less firm canned peas. The Ariel and Shamrock cultivars were the least firm (5.2 N/g) among the green peas, while Patrick (9.2 N/g) was the firmest (Table 45). AAC Harrison had the lowest (2.4 N/g) firmness while Salamanca had the greatest (8.9 N/g) firmness among yellow cultivars. In mottled and winter peas, Vail had the least firmness (4.1 N/g) while CDC Acer had the highest firmness (11.5 N/g).

Table 46. Mean color characteristics of canned dry pea grown in 2019-2024 plus the 5-year mean value.

	Mean (SD) Color Values*						
	Before Canning			After Canning			Color Difference
Sample**	L	a	b	L	a	b	
Green Pea Samples							
2024	58.35 (1.43)	-2.13 (0.60)	9.81 (0.63)	50.19 (1.32)	-0.24 (0.85)	16.38 (1.45)	10.88 (1.55)
2023	55.85 (3.12)	-2.01 (0.18)	10.23 (2.57)	48.21 (2.65)	0.37 (1.19)	19.20 (7.03)	12.85 (3.20)
2022	58.25 (2.03)	-2.08 (0.52)	10.11 (0.65)	50.05 (1.41)	0.13 (1.05)	18.92 (1.43)	12.51 (1.33)
2021	57.33 (2.35)	-2.30 (1.01)	10.45 (0.74)	48.03 (1.38)	0.32 (0.41)	14.50 (1.26)	10.67 (1.67)
2020	58.60 (2.46)	-1.87 (0.74)	9.46 (0.78)	51.62 (1.55)	-0.35 (1.37)	19.59 (2.06)	12.88 (1.65)
5-Year Mean	56.69 (2.12)	-2.03 (0.18)	9.45 (1.42)	48.65 (2.37)	-0.03 (0.44)	16.92 (3.26)	11.79 (1.34)
Yellow Pea Samples							
2024	63.17 (1.27)	4.61 (0.59)	14.88 (1.00)	56.43 (1.99)	4.94 (1.03)	23.13 (1.86)	11.30 (1.20)
2023	61.76 (2.81)	5.24 (1.03)	14.79 (2.17)	55.07 (2.35)	5.34 (1.41)	23.44 (5.45)	11.87 (1.74)
2022	63.65 (1.20)	4.91 (0.90)	15.62 (0.43)	55.03 (2.62)	4.97 (1.42)	22.97 (3.03)	12.10 (1.07)
2021	64.29 (1.26)	5.30 (0.39)	15.04 (0.78)	55.91 (1.54)	7.04 (0.98)	23.14 (1.44)	11.95 (1.09)
2020	63.47 (2.66)	4.99 (0.69)	14.57 (1.25)	56.46 (4.86)	4.14 (1.43)	24.49 (2.24)	13.08 (4.63)
5-Year Mean	62.36 (2.29)	4.91 (0.48)	14.28 (1.66)	54.71 (2.12)	5.09 (1.23)	21.94 (3.56)	11.59 (1.56)
Green Winter Pea Samples#							
2024	59.57 (0.47)	-3.50 (1.92)	13.67 (0.29)	54.10 (8.00)	2.31 (3.26)	20.71 (6.82)	11.49 (0.25)
2023	53.45 (3.00)	-0.80 (0.96)	8.43 (0.64)	49.98 (1.66)	-0.59 (0.44)	18.29 (1.11)	10.59 (0.87)
2021	53.88 (0.34)	-2.54 (0.23)	8.49 (0.51)	45.06 (1.12)	0.24 (0.23)	12.99 (0.62)	10.35 (1.39)
2020	55.31 (1.11)	-1.84 (0.61)	8.93 (0.67)	51.10 (0.31)	-2.89 (0.19)	21.77 (1.30)	13.56 (0.92)
2019	49.36 (0.53)	-2.25 (0.04)	6.09 (0.03)	44.52 (0.41)	-0.88 (0.53)	11.57 (1.12)	7.47 (0.63)
5-Year Mean	nd	nd	nd	nd	nd	nd	nd
Yellow Winter Pea Samples							
2024	58.64 (3.89)	0.89 (2.59)	12.75 (2.73)	52.20 (4.45)	2.72 (0.20)	20.27 (3.90)	13.13 (1.29)
2023	59.77 (0.31)	3.55 (0.77)	14.48 (1.06)	54.90 (1.05)	5.12 (0.35)	23.81 (2.03)	10.80 (0.87)
2022	60.28 (0.58)	2.01 (0.57)	13.36 (0.44)	56.32 (0.53)	2.81 (0.67)	24.32 (1.44)	11.77 (1.33)
2021	59.71 (3.01)	1.96 (1.87)	13.91 (0.88)	51.37 (0.25)	3.43 (0.81)	19.58 (0.16)	10.67 (1.43)
2020	60.29 (0.83)	2.52 (0.32)	14.28 (0.49)	57.42 (1.49)	3.82 (0.28)	26.78 (3.20)	13.04 (2.95)
5-Year Mean	nd	nd	nd	nd	nd	nd	nd

color scale: L (lightness) axis – 0 is black and 100 is white; a* (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b* (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Includes all pea samples or separated into market class. #Canning quality not determined on winter pea in 2022 as no sample of green winter was available; thus, no 5 year mean was calculated. nd =not determined since data was not collected for the last 5 years prior to 2024.

The color of the dry pea changed after the canning process. The color difference fell between 10.88 and 13.13 for all peas, with green peas having the lowest color difference values. Both mean color differences for the green and yellow classes were lower than their respective 5-year mean color differences (Table 46). The lightness decreased during canning for all classes. This indicates that the samples became darker after canning, which is the same general trend for soaked peas (Table 10). The green peas tended to become less green and more yellow during canning, as evidenced by the increase in a* and b* values, respectively. The yellow peas and yellow winter peas became darker and yellower after canning. The most significant color difference was observed in the Blaze (yellow winter) cultivar after canning (Table 45), while the CDC Acer (Mottled) had the lowest color difference. Of the pea classes, the green peas from 2024 most aligned with green peas from 2022. No other class had two years of peas with similar color data.

Chickpeas (Tables 47-48)

The mean **water hydration capacity** of canned chickpea was 165% with a range from 142 to 195%. The mean water hydration value in 2024 was significantly comparable to the canned chickpeas from 2020 and 2022 (Table 47). The mean water hydration capacity of canned chickpea from 2024 was approximately the same as the 5-year mean (163%) water hydration capacity. The Billy Bean cultivar had the highest water hydration capacity at 184% while Sierra had the lowest at 162% (Table 48). Billy Bean also had the highest water hydration in the soak test (Table 37). The **swelling capacity** is the amount of swelling that occurs during the rehydration of the dry chickpea and the canning operation. The swelling capacity of all chickpeas ranged from 131 to 230%, with a mean value of 181%. The Sierra cultivar had the lowest swelling capacity at 158% while Marvel had the highest at 200% (Table 48). This same trend was observed in the samples from 2023.

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Table 47. Mean physical and color parameters of canned chickpea grown in 2020-2024 plus the 5-year mean value.

				Mean (SD) Color Values*						
			Canned	Before Soaking			After Soaking			
	Hydration	Swelling	Firmness							Color
Year	Capacity (%)	Capacity (%)	(N/g)	L	a	b	L	a	b	Difference
2024	165 (12)	181 (21)	6.7 (0.7)	60.02 (1.55)	6.39 (0.75)	15.12 (1.03)	53.24 (1.25)	5.70 (0.84)	16.20 (2.07)	7.36 (1.75)
2023	198 (15)	188 (16)	8.2 (2.1)	59.12 (1.59)	6.12 (0.60)	14.52 (1.18)	53.63 (1.08)	6.18 (0.61)	18.25 (1.15)	6.99 (1.39)
2022	163 (10)	124 (10)	6.6 (0.6)	61.36 (1.05)	6.16 (0.54)	14.77 (0.68)	53.88 (1.01)	5.53 (0.45)	17.68 (1.05)	8.24 (1.17)
2021	128 (9)	163 (13)	14.8 (1.4)	61.38 (1.11)	5.85 (0.56)	14.35 (0.69)	51.79 (0.80)	6.42 (0.53)	15.66 (0.90)	9.81 (1.17)
2020	162 (9)	177 (12)	8.0 (0.9)	60.34 (1.39)	5.89 (1.76)	15.66 (1.40)	53.48 (1.99)	5.00 (1.54)	19.19 (2.20)	8.39 (2.02)
5-Year Mean	163 (25)	124 (27)	6.6 (3.4)	61.36 (4.64)	6.16 (0.35)	14.77 (1.84)	53.88 (2.96)	5.53 (0.80)	17.68 (2.99)	8.24 (1.12)
2023 (Data Range)	142-195	131-230	5.3-8.0	57.16-64.31	4.54-7.57	13.14-17.05	51.01-56.45	3.01-7.21	8.45-19.45	4.41-11.14

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral.

The **canned firmness** values of chickpeas were lower than the cooked firmness values of soaked chickpeas. The mean canned firmness value of all chickpeas was 6.7 N/g (Table 47). In comparison, the mean cooked firmness for all chickpeas was 18.8 N/g (Table 36). As expected, the canned chickpeas were less firm than the cooked chickpeas. The mean firmness value for canned chickpeas in 2024 most closely matched the canned chickpeas from 2022. The firmness of chickpeas in 2024 was approximately the same as the chickpeas that made up the 5-year mean value. The range in firmness was narrow (5.3-8.0) for samples from 2024.Canned Kasin chickpeas had the highest firmness (7.7 N/g) while the Marvel and Sawyer chickpeas were the least firm (5.8 N/g) (Table 48).

Table 48. Mean physical and color parameters of canned dry chickpea cultivars grown in 2024.

				Mean Color Values*						
				Before Soaking			After Soaking			
	Hydration	Swelling	Canned							Mean
	Capacity	Capacity	Firmness							Color
Cultivar	(%)	(%)	(N/g)	L	a	b	L	a	b	Difference
Billy Bean**	184	180	6.1	57.75	7.43	15.71	54.26	4.74	16.59	4.67
CDC Orion	167	199	6.9	59.60	7.16	16.17	53.58	5.14	16.93	6.53
Dylan**	174	164	6.7	64.31	4.54	13.28	53.62	5.79	16.11	11.14
Ellie**	183	182	6.1	59.21	6.96	15.50	53.21	5.55	16.83	6.36
Kasin**	175	183	7.7	58.76	7.16	15.67	53.09	5.31	16.78	6.10
Marvel**	169	200	5.8	61.02	6.55	17.01	54.75	5.57	17.58	6.38
Nash**	170	176	6.4	62.01	5.52	13.98	52.96	4.55	14.63	9.13
Quinn**	170	187	6.5	61.11	5.61	13.75	51.02	4.58	13.73	10.15
Royal	166	172	7.4	59.80	6.14	14.08	53.45	6.12	16.62	7.31
Sawyer	164	163	5.8	59.15	6.25	15.20	53.46	5.76	15.58	5.90
Sierra	162	158	6.7	61.86	5.44	14.12	52.67	5.73	15.01	9.34

*color scale: L (lightness) axis – 0 is black and 100 is white; a (red-green) axis – positive values are red, negative values are green, and zero is neutral; and b (yellow-blue) axis – positive values are yellow, negative values are blue, and zero is neutral. **Only one sample of cultivar tested.

The color of the chickpeas changed after the canning process. The color difference fell between 4.41 and 11.14, with a mean value of 7.36 for all chickpeas (Table 47). The color difference for the canned chickpea in 2024 was lower than the canned chickpeas that made up the 5-year mean color change value. Only samples from 2023 had lower color differences than the chickpeas from 2024. This supports less intense color changes for the canned samples compared to previous years, except 2023. A higher color difference was observed in soaked (10.80) chickpeas compared to canned (7.36) chickpeas. This same trend was found in previous years and is likely attributed to the greater yellowness in soaked chickpeas. Furthermore, the L* or lightness decreased during canning (Table 47), which agrees with canned chickpeas from previous years. In contrast, the L* values of chickpeas increased in the soak test. The yellowness increased in canned chickpea and again agrees with the trend of increasing yellowness after canning as observed in prior years. Unlike prior years, the redness value (a*) increased in the canned chickpea. The highest color difference after canning was observed in the Dylan cultivar (11.14) while Billy Bean had the least (4.67) color change (Table 48). The main reason for the observed color trends was that Dylan is a cream-colored chickpea, and after canning, it had a yellow brown color, which is measured by a substantial drop in L*. In contrast, Billy Bean did not undergo significant change in L* and had a similar yellow brown color after canning compared to the dry sample.

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