2011 U.S. Pulse Quality Survey

Northern Pulse Growers Association

USA Dry Pea & Lentil Council

NDSU NORTH DAKOTA STATE UNIVERSITY

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2011 Overview

USA grown pulses are an important component of the world's food supply and contribute to better human nutrition and health. While a significant portion of the pulses grown in the USA are consumed locally, the majority is exported to international markets. Because both the supply and demand of pulses are forecast to grow, quality information is vital to continued efforts by the US pulse industry to produce higher quality products. The US pulse quality survey provides data to aid growers in the production of high quality pulses, to aid processors and suppliers in assuring pulse quality, and to inform local and international consumers. The objectives of this report are to provide (1) proximate quality parameters (moisture, protein, total starch, soaking ability, starch properties, color, and canning quality) and (2) data on total micronutrients (iron, zinc, calcium, magnesium, potassium, selenium, beta-carotene) and phytic acid concentrations in dry peas, lentils, and chickpea that are commercially grown in the USA.

Pulse quality data collected from 30 dry pea, 18 lentil, and 16 chickpea samples acquired from industry representatives in pulse growing areas in North Dakota, South Dakota, Idaho, Montana, and Washington State are included in the 2011 report. The proximate quality parameters determined include moisture, protein, ash, total starch, water absorption, unsoaked seeds, test weight, 1000 seed weight, and starch parameters of peak viscosity, hotplate viscosity, break down, cold paste viscosity, setback, and peak time (National Pulse Quality survey, 2010). In addition, average color quality (before and after soaking) and canning quality were also determined. The results of each quality parameter are provided in this report for each pulse crop category.

In 2011, US pulse production was below the long-term annual average due to excess moisture and flooding situations in the majority of pulse-growing areas (Northern Pulse Growers Association, 2011). Therefore, the total number of samples used in the 2011 quality survey was low compared to 2010. However, physical quality parameters such as starch, color, and canning quality parameters of the 2011 samples were consistent with previous years with the exception of low moisture and protein levels.

The pulses grown in 2011 are an excellent source of a wide range of micronutrients including minerals and beta-carotene. This is important because micronutrient malnutrition, also known as "hidden hunger", affects more than 2 billion people worldwide. Sixty percent of the seven billion people in the world are iron deficient, over 30% are zinc deficient, and more than 15% are selenium deficient. Approximately three million children around the world develop xerophthalmia (damage to the cornea of the eye) and every year more than half a million of children go blind as a result of vitamin A deficiency. This report provides iron, zinc, calcium, magnesium, potassium, selenium and beta-carotene levels of the US grown pulses. Phytic acid is an antinutrient in the seeds of legumes and cereals that has the potential to bind mineral micronutrients in food and reduce their bioavailability. The phytic acid data presented in this report highlight the fact that USA grown pulses are low in phytic acid and thus their mineral micronutrients are highly bioavailable. This report includes the percent of the recommended dietary allowance (RDA) of minerals from a 50 g serving of pulses for 19 to 50 year old adults, and these data highlight the potential of US grown pulses to be a whole food solution to mineral micronutrient malnutrition in particular and a contributor to better human nutrition in general.

Pulse Production

Significant land area has recently been added to pulse crop production in the Northern Plains region of the USA, including parts of North Dakota, South Dakota, Washington State, and eastern Montana. Over the last two decades, pulse production area has increased from less than 10,000 acres to over 1 million acres. The USA is one of the major pea exporters in the world and the production of lentils continues to increase. The total US pulse production in 2010 was approximately 1,131,261 MT. As a result of adverse weather conditions experienced, US pulse production in 2011 was reduced by approximately 46% compared to 2010 values. Late spring seeding and severe flooding conditions across the Northern Plains growing regions impacted the amount of seeded acreage and pulse production. The total acreage seeded with pulse crops was 917,548 in 2011 compared to 1,456,347 in 2010, representing a 37% decrease. Total dry pea and lentil production decreased by 55 and 43%, respectively; however, total chickpea production increased by approximately 7% (Figure 1).

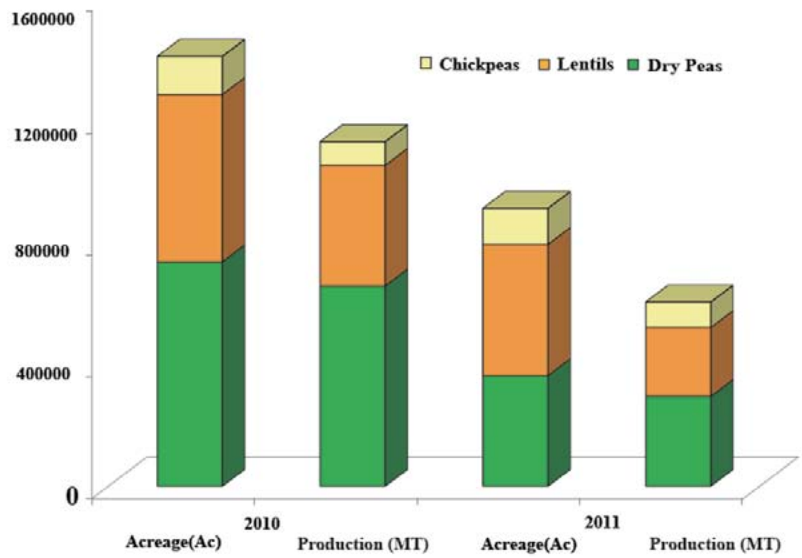

Figure 1. USA dry pea, lentil, and chickpea acreage (acres) and production (MT) in 2010 and 2011 (based on USA Dry Pea Lentil Council data)**.**

Dry Pea: Dry pea production in the US was 55% less in 2011 compared to 2010. In North Dakota, acres seeded with dry pea dropped from 394,667 in 2010 to 86,000 acres in 2011. Dry pea acreage in Montana dropped by about 25,000 acres in 2011 compared to 2010. Dry pea acreage in the Pacific Northwest growing region remained fairly constant, with the exception of 16,000 acre decrease in Idaho (USA Dry Pea Lentil Council, 2012).

Lentil: Total lentil acreage declined from 594,425 in 2010 to 430,843 in 2011, a decrease of 27%. Total lentil acreage decreased from 232,270 in 2010 to 86,000 in 2011 in North Dakota, and by about 50% from 2010 to 2011 in Idaho. Acreage seeded with medium and small lentil each declined by about 6,000 acres in Washington State. However, lentil acreage in Montana increased from 225,488 in 2010 to 256,800 in 2011 (USA Dry Pea Lentil Council, 2012).

Chickpea: Total chickpea acreage in the US was comparable in 2010 and 2011. Interestingly, chickpea acreage in Montana increased from 6,405 acres in 2010 to 12,400 acres in 2011, but decreased in North Dakota from 9,676 acres in 2010 to 2,295 acres in 2011.

Laboratory Analysis

Standard methods were followed for the determination of each pulse quality attribute in 2011. Table 1 includes the reference for each method. All 2011 pulse samples were stored at -40°C for quality preservation until sample analysis.

Table 1. Quality attribute, analytical method, and remarks.

Quality Attribute	Method	Remarks
Moisture (%)	AACC method 44-15A	Indicator of post-harvest handling, milling yield
Protein (%)	AACC method 46-30	Indicator of nutritional quality and processing
Ash (%)	AACC method 08-01	Indicator of total mineral content
Total starch (%)	AACC method 76-13	Indicator of nutritional quality and processing
Water absorption (%)	AACC method 56-35.01	Indicator of cooking quality/uniformity and canning
Unsoaked seed (%)	AACC method 56-35.01	Indicator of cooking quality/uniformity and canning
Test weight (lb/bu)	AACC method 55-10	Indicator of sample density, size, and shape
1000 seed weight	100-kernel sample weight times 10	Indicator of grain size and milling yield
Starch properties	Rapid Visco Analyzer	Indicator of texture, firmness, and gelatinization of starch
Color	Konica Minolta CR-310 Chroma meter	Indicator of visual quality and processing
Canning	Modified from Uebersax and Hosfield, 1985	Indicator of canning quality and visual appearance
Micronutrients	Thavarajah et al., 2008, 2009a	Micronutrient analysis and malnutrition/cancer protection
Beta-carotene	Katrangi et al., 1984	Pro vitamin A analysis and vitamin rich foods
Phytic acid	Thavarajah et al., 2009b	Phytic acid analysis and phytic acid levels in foods

Dry Pea Quality

Sample distribution

A total of 30 dry pea samples were collected from Montana, North Dakota, Idaho, and Washington State from January to March, 2012. Growing location, number of samples, market class, and genotype details of these dry peas samples are described in Table 2.

Table 2. Description of dry pea samples used in the 2011 pulse quality survey.

State	No. of samples	Market class	Genotype
Montana	7	Yellow	Korando
		Yellow	Thunderbird
		Green	CDC Striker
		Green	Aragon
		Green	Ariel
North Dakota	6	Yellow	DS Admiral
		Yellow	Thunderbird
		Yellow	CDC Golden
		Green	CDC Striker
		Green	K-2
Idaho	8	Green	Aragon
		Green	Ariel
		Green	Banner
		Small Marrowfat	90-7 Marrowfat
		Small Green	Small Sieve Alaska
Washington	9	Yellow	Universal
		Green	Ariel
		Green	Columbian
		Green	Prodigy
		Green	Aragon
Total	30		

Proximate analysis of dry pea (Table 3)

Moisture

Moisture content of dry pea ranged from 7-9% in 2011. The average moisture content of the 30 samples was 7.3%, which is considerably lower than the 3-year average of 12.6%.

Protein

Protein content of dry pea ranged from 18.3-27.4% with an average of 22.5%. Similar to moisture, the average protein content of dry peas grown in 2011 was lower than the 3-year average of 24.4%.

Ash

Ash content of dry pea ranged from 2.4-3.5% with an average of 2.6%. The average ash content of dry peas grown in 2011 was equal to the 3-year average of 2.6%.

Total starch

Total starch content of dry pea ranged from 32-59% with an average of 41%. The average total starch content of dry peas grown in 2011 was lower than the 3-year average of 46%.

Table 3. Proximate analysis of dry pea grown in the USA, 2011.

	2011		Mean			3--year
Characteristics*	range	mean (SD)	2010	2009	2008	mean
Physical Quality						
1. Moisture (%)	7.0-9.0	7.3 (0.3)	13.2	11.9	12.8	12.6
2. Protein (%)	18.3-27.4	22.5 (2)	27.1	24.1	21.9	24.4
3. Ash (%)	2.4-3.5	2.6 (0.2)	2.6	2.5	2.6	2.6
4. Total starch (%)	32-59	41 (5.8)	45	43	51	46
5. Water absorption (%)	93-108	101 (3.9)	98	94	98	97
6. Unsoaked seed (%)	0-6	0.6 (1.2)	1.1	3.9	-	2.5
7. Test weight (lb/Bu)	59-64	61 (1)	63	63	63	63
8. 1000 seed weight (g)	160-272	203 (26)	241	225	235	234
Starch Properties						
1. Peak viscosity (RVU)	148-747	215 (103)	126	117	118	120
2. Hot paste viscosity (RVU)	124-434	165 (54)	118	108	96	107
3. Break down (RVU)	14-69	41 (12)	8	9	22	13
4. Cold paste viscosity (RVU)	236-500	355 (65)	204	184	180	189
5. Setback (RVU)	103-325	200 (51)	87	76	84	82
6. Peak time (min)	7.7-9.5	8.2 (0.4)	8.6	8.3	14	10.3

* all measurements were done based on a sample arrival basis (dry basis).

Water absorption

Water absorption of dry pea ranged from 93-108% with an average of 101%. These values bracket the 3-year average of 97%.

Unsoaked seed

Unsoaked seed percentage ranged from 0-6% with an average of 0.6%, which was lower than the 3-year average of 2.5%.

Test weight

Test weight ranged from 59-64 lb/Bu with an average of 61 lb/Bu. These values bracket the 3-year average of 63 lb/Bu.

1000 seed weight

The average 1000 seed weight of dry peas grown in 2011 was 203 g, which was lower than the 3-year average of 234.

Starch properties

Average values of all starch properties in 2011 were significantly higher than the 3-year averages.

Proximate analysis of dry pea market classes (Table 4)

Both yellow and green dry pea market classes showed similar proximate analysis with the exception of total starch, unsoaked seed, 1000 seed weight, and starch properties. Yellow peas had higher levels of total starch, unsoaked seed, and 1000 seed weight compared to green peas. For both market classes, average moisture and protein levels decreased from 2010 values. Green peas had higher starch properties compared to yellow peas and, for both market classes, average starch properties increased from 2010. DS Admiral and CDC Golden had the highest protein content and CDC Golden and Korando had the highest total starch content compared to the other yellow market class genotypes. For the green pea market class, Columbian had the highest protein content and K-2 had the highest starch content compared to the other genotypes. The green dry pea market class also had higher peak viscosity values compared to the yellow pea market class.

Table 4: Proximate analysis of dry pea market classes.

	Mean (SD) of yellow pea		Mean (SD) of green pea	
Characteristics*	**2011**	**2010**	**2011**	**2010**
Physical Quality				
1. Moisture (%)	7.3 (0.1)	13.6 (2)	7.4 (0.4)	12.8 (2)
2. Protein (%)	22.8 (2)	27.2 (2)	22.4 (2)	27.0 (2)
3. Ash (%)	2.7 (0.2)	2.7 (0.5)	2.6 (0.2)	2.4 (0.5)
4. Total starch (%)	44 (4)	45 (3)	40 (6)	45 (3)
5. Water absorption (%)	99 (4)	99 (8)	101 (4)	99 (8)
6. Unsoaked seed (%)	0.8 (0.9)	1 (2)	0.5 (1.3)	1.1 (2)
7. Test weight (lb/Bu)	62 (1)	63 (1)	61 (1)	63.3 (1)
8. 1000 seed weight (g)	225 (22)	248 (27)	195 (22)	232 (36)
Starch Properties				
1. Peak viscosity (RVU)	192 (14)	127 (14)	223 (120)	124 (19)
2. Hot paste viscosity (RVU)	152 (12)	120 (13)	169 (62)	115 (16)
3. Break down (RVU)	41 (5)	7 (5)	41 (13)	9 (7)
4. Cold paste viscosity (RVU)	331 (33)	204 (29)	365 (72)	204 (35)
5. Setback (RVU)	179 (23)	85 (17)	209 (57)	89 (21)
6. Peak time (min)	8 (0.2)	9 (0.7)	8 (0.4)	9 (1)

* all measurements were done based on a sample arrival basis (dry basis)

Proximate analysis of pea market classes (Table 5)

Dry peas grown in the US in 2011 had lower moisture content, protein, total starch, and 1000 seed weight compared to 3-year average values (mean of 2008, 2009, and 2010). Starch properties were substantially greater in 2011 compared to the 3-year average as a result of the lower moisture content observed in the dry pea crop. These data are important because the Asian noodle market, for example, prefers a medium to high peak viscosity flour product as it gives better textural characteristics. For the yellow market class, CDC Golden and DS Admiral had the highest protein content and Korando had the highest total starch content. For the green market class, Marrow Fat 90-7 had the highest protein content and K-2 had the highest total starch content.

Table 5. Mean protein and starch content for different field pea cultivars grown in the USA, 2011.

Market Class	Cultivar	Protein (%)*	Total Starch (%)#
Yellow	CDC Golden	24.4	47.0
	DS Admiral	24.7	44.4
	Korando	22.6	48.0
	Thunderbird	23.6	41.9
	Universal	20.1	41.0
Green	Aragon	20.9	39.7
	Ariel	21.7	37.6
	Banner	22.4	36.4
	CDC Striker	22.5	47.3
	Columbian	25.1	35.4
	Cruiser	22.7	38.6
	K-2	23.9	59.3
	Marrow Fat 90-7	24.3	42.2
	Prodigy	20.8	37.5
	Small Sieve Alaska	23.3	39.7

*Protein (%) was calculated on the basis of the total seed nitrogen content.
#Total starch was measured by AACC method 76-13.

Color quality of dry peas (Tables 6 and 7)

Color is an important quality attribute for the dry pea food industry. Color quality was measured by using an L, a, and b type scale as follows:

- 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
- b (yellow-blue) axis - positive values are yellow, negative values are blue, and zero is neutral

Color quality for both market classes in 2011 was fairly similar to results reported in 2010. The higher negative value for red-green (axis a) in 2011 indicates a greener color. Among the genotypes, Banner had the highest a axis value (greenest color) before soaking and Colombian the highest after soaking. Color quality effects on the final product are required by end-users. Generally, a bright green color is more desirable in dry pea for many products. Green dry pea cultivars Aragon, Arial, Banner, and Columbian had the greenest color compared to other cultivars.

Table 7. Mean color quality of green pea cultivars grown in the USA, 2011.

	a*(red-green)	
Cultivars	Whole seed color	Seed color after soaking
Aragon	-2.4	-8.8
Arial	-2.5	-9.1
Banner	-3.1	-9.1
Columbian	-2.3	-9.5
Cruiser	-1.5	-8.3
K2	-0.9	-7.5
Marrow Fat 90-7	-1.6	-6.4
Small sieve Alaska	-1.9	-8.8
Prodigy	4.8	-8.7
CDC Striker	-1.5	-8

*negative values are green and zero is neutral.

Table 6. Color quality of yellow and green peas before and after soaking.

	Mean (SD) of yellow pea				Mean (SD) of green pea			
	Before soaking		After soaking		Before soaking		After soaking	
Color scale	2011	2010	2011	2010	2011	2010	2011	2010
L (lightness)†	65 (2)	63 (1)	66 (2)	67 (1)	61 (2)	59 (4)	55 (2)	57 (2)
a (red-green)±	4.7 (0.3)	5.6 (1)	5.6 (1)	5.5 (1)	-0.9 (3)	-1.7 (1)	-8.7 (1)	-6.7 (1)
b (yellow-blue)*	14 (0.4)	15 (1)	30 (0.4)	28 (2)	10 (2)	9 (1)	18 (1)	17 (1)

† Zero is black, 100 is white.
± Positive values are red; negative values are green and zero is neutral
* Positive values are yellow; negative values are blue and zero is neutral

Canning quality of dry peas (Tables 8 and 9)

The color quality of canned dry pea was measured using an L, a, and b type scale. Other quality characters were measured as follows:

- Clumping: 1 = no clumping, 5 = highest clumping
- Splitting: 1 = no splitting, 5 = highest splitting
- Turbidity: 1 = no turbidity or clear, 5 = highest or cloudy
- Overall acceptance: 1 = very good, 5 = very poor

Overall acceptance was based on the visual appearance. For green cultivars, Banner, K-2, CDC Striker, and Alaska had higher overall acceptance compared to Ariel and Aragon. Yellow market class cultivar Korando had the highest overall acceptance compared to other cultivars.

Table 8. Mean canning quality of USA grown green peas.

Quality Attributes	Ariel	Banner	Aragorn	K-2	CDC Striker	Alaska
L (lightness)†	48.9	47.8	51.4	51.4	51.8	49.1
a (red-green)±	-0.5	0.6	-0.3	0.7	0.9	0.4
b (yellow-blue)*	16.9	14.6	19.6	15.1	15.7	15.2
Clumping (1-5)	3	0	5	0	0	1
Splitting (1-5)	5	4	5	5	5	2
Turbidity (1-5)	5	5	5	5	5	5
Overall (1-5)	4	3	5	3	3	3

† Zero is black, 100 is white.
± Positive values are red; negative values are green and zero is neutral
* Positive values are yellow; negative values are blue and zero is neutral

Table 9. Mean canning quality of USA grown yellow peas.

Quality Attributes	Universal	CDC Golden	DS Admiral	Korando	Thunderbird
L (lightness)†	54.5	55.6	54.5	54.9	55.2
a (red-green)±	5.6	5.5	5.6	5.5	5.9
b (yellow-blue)*	21.4	24.6	24.0	22.0	22.4
Clumping (1-5)	1	2	1	0	0
Splitting (1-5)	4	3	5	3	5
Turbidity (1-5)	5	5	3	2	4
Overall (1-5)	3	3	3	2	3

† Zero is black, 100 is white.
± Positive values are red; negative values are green and zero is neutral
* Positive values are yellow; negative values are blue and zero is neutral

Mineral Micronutrients

Dry pea micronutrients

Iron, zinc, calcium, magnesium, potassium, and selenium are essential human mineral micronutrients. Improvement of micronutrient content is a new initiative towards nutritional quality improvement in US pulses. Table 10 compares the mineral micronutrient content of yellow and green dry pea market classes. The total selenium concentration of the yellow market class is higher than that of the green market class. Other mineral micronutrients levels are similar for both market classes.

Phytic acid is an antinutrient for mineral absorption in humans and animals. Both yellow and green dry pea market classes have low levels of phytic acid, which is a positive factor for increased human mineral micronutrient bioavailability.

Beta-carotene is a precursor for vitamin A synthesis. The green market class has higher level of beta-carotene compared to the yellow market class.

Impact of location on dry pea mineral micronutrients

Growing location soil, weather, and other environmental factors affect mineral micronutrient levels in dry pea. Dry pea grown in North Dakota and Montana has higher selenium concentrations. Dry pea grown in North Dakota is high in iron for both market classes. Table 11 provides mineral micronutrient concentrations for dry pea grown in each of three states.

Mineral nutrient levels of dry pea cultivars

Dry pea cultivars vary with respect to seed mineral micronutrient levels. Among different dry pea genotypes, Korando and Thunderbird of the yellow market class and Cruiser of the green market class have the highest selenium levels. Details of the mineral micronutrients of different genotypes are shown in Table 12.

Selenium is an essential element for both humans and animals. It plays an important role in enzymes, cofactors, and antioxidant protective pathways of human body. The recommended daily allowance (RDA) of 55 μg of Se day^{-1} is generally met by North Americans. However, an estimated 30-100 million people around the world are selenium deficient. Low dietary intake of selenium is also linked to arsenic poisoning in Bangladesh, juvenile cardiomyopathy (heart problems) in China, poor skeletal muscle strength in adults, infections, chronic heart failure, and prostate and bladder cancer.

Iron and zinc are essential elements for all life forms and for normal human physiology. Iron is critical for many proteins and enzymes and is essential for oxygen transport, regulation of cell growth, and differentiation. Zinc exhibits antioxidant properties and is necessary for protein synthesis, DNA replications, proper sense of taste and smell, and stress reduction. Populations largely dependent on cereal diets are often deficient in minerals such as potassium, magnesium, and calcium.

Table 10. Mean micronutrient concentration of dry pea grown in the USA, 2011.

	Market class*	
Micronutrient	Yellow	Green
Iron (mg/kg)	42 (7)	39 (6)
Zinc (mg/kg)	22 (3)	25 (4)
Calcium (mg/kg)	529 (68)	507 (114)
Magnesium (mg/kg)	821 (35)	769 (58)
Potassium (mg/kg)	5830 (312)	6000 (320)
Selenium (μg/kg)	700 (400)	326 (288)
Phytic acid (mg/g)	6.2 (2)	4.8 (1)
Beta-carotene (μg/100g)	160 (21)	989 (488)

*mean values with standard deviation

For the yellow market class, CDC Golden had higher iron and zinc levels compared to the other cultivars. Korando and Thunderbird had higher selenium content compared to the other cultivars. For the green market class, K-2 had the highest iron content compared to the other cultivars. Generally, dry peas are low in phytic acid indicating greater mineral bioavailability.

Table 11. Growing location effects on mineral micronutrient concentration of field pea grown in the USA, 2011.

		Mean concentration (mg/kg)					
Market Class of dry peas	State	Selenium (µg/kg)	Iron	Zinc	Calcium	Magnesium	Potassium
Yellow	ND	770	44	22	506	839	5845
	WA	40	39	24	525	757	5530
	MT	1360	38	23	500	829	5532
	Mean	**723**	**40**	**23**	**510**	**808**	**5636**
Green	ND	590	48	24	429	846	6118
	WA	16	37	23	557	780	6025
	MT	620	38	28	527	756	5990
	ID	150	40	25	458	726	5943
	Mean	**344**	**41**	**25**	**493**	**777**	**6019**

Table 12. Mean nutritional quality of dry pea cultivars grown in the USA, 2011.

Market Class	Genotype	Iron mg/kg	Zinc mg/kg	Calcium mg/kg	Magnesium mg/kg	Potassium mg/kg	Selenium µg/kg	Phytic acid mg/g
Yellow	CDC Golden	45.6	25.4	506	864	6450	531	6.5
	DS Admiral	42.7	20.5	648	859	5575	815	7.1
	Korando	44.9	14.8	584	840	5622	1100	5.1
	Thunderbird	35.7	21.0	466	823	5624	1000	5.7
	Universal	35.7	24.2	562	761	5750	90	4.6
Green	Aragon	36.8	25.1	601	768	6003	196	4.6
	Ariel	40.4	22.2	437	736	6104	311	4.6
	Banner	35.7	23.9	446	725	5955	147	4.2
	CDC Striker	43.5	27.8	546	784	5744	498	6.0
	Columbian	34.9	23.1	531	806	6098	187	4.8
	Cruiser	42.7	26.9	433	845	6085	962	5.1
	K-2	50.4	25.2	488	874	6316	577	5.3
	Marrow Fat 90-7	40.1	28.2	533	730	5594	145	5.0
	Prodigy	35.4	30.0	685	767	6171	194	4.3
	Small Sieve Alaska	43.8	20.3	438	719	5775	166	4.0

Lentil Quality

Sample Distribution

A total of 18 lentil samples were collected from Montana, North Dakota, Idaho, and Washington State. Similar to dry peas, lentil samples were also collected from January to March 2012. Growing location, number of samples, market class, and genotypes used in 2011 quality survey are described in Table 13.

Proximate analysis of lentils (Table 14)

Moisture

Moisture content of lentils ranged from 6-9% in 2011. The average moisture content of the 18 samples was 7.1%, which is considerably lower than the 3-year average of 10.6%.

Protein

Protein content ranged from 19.0-25.4% with an average of 22.2%. Similar to moisture, the average protein content of 2011 grown lentils was lower than the 3-year average of 25.2%.

Ash

Ash content of lentils ranged from 1.9-3.0% with the average of 2.7%. The average ash content of lentils grown in 2011 was equal to the 3-year average.

Total starch

Total starch content ranged from 29-53% with an average of 40%. This average was lower than the 3-year average of 47%.

Water absorption

The average water absorption of dry pea ranged from 59-123% with an average of 88%. These values bracketed the 3-year average of 94%.

Unsoaked seed

The unsoaked seed percentage was 6.0%, which was higher than the 3-year average of 3.0%.

Test weight

Test weight ranged from 56-65 lb/Bu with an average of 60 lb/Bu. These values bracket the 3-year average of 62 lb/Bu.

1000 seed weight

The average seed density of lentils grown in 2011 was 49 g, which was similar to the 3-year average of 48 g.

Starch properties

The average values of starch properties of lentils grown in 2011 were higher than the 3-year average values.

Table 13. Description of lentil genotypes used in 2011 pulse quality survey.

State	No. of samples	Market class	Genotype
Montana	5	Green	CDC Richlea
		Green	Laird
		Green	CDC Meteor
North Dakota	8	Red	CDC Impala
		Red	CDC Redberry
		Red	CDC Maxim
		Green	CDC Richlea
		Green	Riveland
Idaho	1	Black/Beluga	Black/Beluga
Washington	3	Red-Winter	Not available
		Spanish Brown	Pardina
Not available	1		
Total	**18**		

Table 14. Proximate analysis of lentils grown in the USA, 2011.

Characteristics	2011 range	2011 Mean (SD)†	Mean 2010	Mean 2009	Mean 2008	3-year mean
Physical Quality						
1. Moisture (%)	5.5-8.6	7.1 (0.5)	11.5	10.5	9.8	10.6
2. Protein (%)	19.0-25.4	22.2 (2)	26.9	25.2	23.5	25.2
3. Ash (%)	1.9-3.0	2.7 (0.3)	2.8	2.6	2.6	2.7
4. Total starch (%)	28.7-52.7	40 (5)	43	47	52	47
5. Water absorption (%)	59-123	88 (17)	96	93	94	94
6. Unsoaked seed (%)	0-22	6 (6.5)	2	3	-*	3
7. Test weight (lb/Bu)	56-65	60 (2)	61	62	62	62
8. 1000 seed weight (g)	22-75	49 (14)	46	49	-*	48
Starch Properties						
1. Peak viscosity (RVU)	133-222	185 (24)	124	121	122	122
2. Hot paste viscosity (RVU)	109-165	145 (15)	112	110	86	103
3. Break down (RVU)	24-58	41 (11)	12	10	36	19
4. Cold paste viscosity (RVU)	224-427	323 (65)	205	190	169	188
5. Setback (RVU)	115-263	178 (35)	93	80	83	85
6. Peak time (min)	7.6-8.9	8.1 (0.4)	8.9	8.8	12.6	10.1

* Data not reported.
† SD, Standard deviation.

Proximate analysis of lentil market classes (Tables 15 and 16)

Both red and green lentil market classes had similar proximate analyses except for 1000 seed weight and starch properties. Red lentils had higher unsoaked seed percentages than green lentils. For both market classes, average moisture, protein, and starch levels decreased from 2010 values. In addition, green lentils had higher starch properties compared to red lentils, with the exception of setback value and peak time. For both market classes, average starch properties increased from 2010 values. CDC Redberry and CDC Maxim had the highest protein content compared to CDC Impala. In the red market class, CDC Redberry had the highest protein content and CDC Maxim had the highest starch content. For green lentils, CDC Richlea had the highest protein content and CDC Meteor had the highest starch content compared to the other genotypes.

Color quality of lentils (Table 17)

Color quality for both market classes was similar to results reported in 2010.

Table 15. Summary of proximate analysis of red and green lentils grown in the USA, 2011.

	Red		Green	
Characteristics*	**2011**	**2010**	**2011**	**2010**
Physical Quality				
1. Moisture (%)	7.1 (1)	11.7 (2)	7.1 (0.1)	11.4 (2)
2. Protein (%)	22.4 (2)	27.6 (2)	22.3 (2)	26.3 (2)
3. Ash (%)	2.5 (3)	2.9 (1)	2.7 (0.2)	2.8 (1)
4. Total starch (%)	41 (5)	45 (7)	40 (5)	42 (5)
5. Water absorption (%)	86 (20)	93 (7)	91 (14)	99 (9)
6. Unsoaked seed (%)	9 (8)	2.1 (5)	3.4 (4)	1.7 (4)
7. Test weight (lb/Bu)	61 (2)	63 (3)	59 (2)	60 (3)
8. 1000 seed weight (g)	42 (11)	37 (7)	56 (9)	52 (11)
Starch Properties				
1. Peak viscosity (RVU)	174 (27)	122 (16)	191 (19)	126 (21)
2. Hot paste viscosity (RVU)	138 (16)	113 (14)	147 (13)	112 (13)
3. Break down (RVU)	36 (14)	9 (6)	44 (7)	14 (10)
4. Cold paste viscosity (RVU)	310 (49)	207 (32)	326 (45)	204 (35)
5. Setback (RVU)	171 (34)	94 (20)	44 (7)	93 (23)
6. Peak time (min)	8.2 (0.3)	9.4 (2)	7.9 (0.3)	8.5 (1)

* Mean values with standard deviation.

Table 16. Mean protein and starch content for different lentil cultivars grown in the USA, 2011.

Market class	Genotype	Protein (%)	Total starch (%)
Red	CDC Impala	19.1	39.3
	CDC Redberry	25.4	41.2
	CDC Maxim	24.4	52.7
Spanish brown	Pardina	20.8	38.3
Green	CDC Richlea	27.1	41.1
	Laird	22.2	41.2
	CDC Meteor	22.0	43.8
	Riveland	20.8	28.7

Table 17. Color quality of yellow and green lentils before and after soaking.

	Mean (SD) of red lentils				Mean (SD) of green lentils			
	Before soaking		After soaking		Before soaking		After soaking	
Color scale	2011	2010	2011	2010	2011	2010	2011	2010
L (lightness)†	54(1)	51(7)	52(2)	54(1)	60(1)	60(1)	60(1)	62(2)
a (red-green)±	4.3(1)	3.9(1)	7.3(2)	6.9(2)	2.1(0.4)	1.1(1)	1(0.6)	-0.2(1.5)
b (yellow-blue)*	8.6(2)	8.2(2)	17.7(1)	15.7(2)	15(1)	15(1)	23.6(1)	21.9(2)

† Zero is black, 100 is white.
± Positive values are red, negative values are green, and zero is neutral
* Positive values are yellow, negative values are blue, and zero is neutral

Lentil Micronutrients

Micronutrients levels of different market classes

Levels of mineral micronutrients iron, zinc, calcium, magnesium, potassium, and selenium in lentil are given in Table 18. The red market class has higher iron, zinc, and calcium levels. Lentils have low levels of phytic acid, a mineral antinutrient for which low levels are a positive factor for increased mineral bioavailability. Lentils are also a good source beta-carotene, a vitamin A precursor.

Table 18. Micronutrient concentrations of lentils grown in the USA, 2011.

	Market class*	
Micronutrient	Red	Green
Iron (mg/kg)	67 (6)	53 (6)
Zinc (mg/kg)	33 (6)	29 (4)
Calcium (mg/kg)	569 (99)	501 (62)
Magnesium (mg/kg)	720 (47)	761 (40)
Potassium (mg/kg)	6108 (463)	6255 (447)
Selenium (µg/kg)	495 (158)	698 (273)
Phytic acid (mg/g)	5.2 (1.7)	5.2 (1.3)
Beta-carotene (µg/100g)	264 (189)	349 (106)

* mean values with standard deviation.

Mineral nutrient levels of lentil cultivars

Mineral micronutrient levels vary with lentil genotype. The levels of iron, zinc, calcium, magnesium, potassium and selenium are given in Table 19. With the exception of Pardina and Beluga genotypes with respect to selenium concentrations, all lentil genotypes have high level of mineral micronutrients. All lentil genotypes have low phytic acid concentrations.

Please note that due to the small number of lentil samples, no location details are provided for lentil mineral micronutrients. However, mineral levels of lentils are known to vary with growing location and soil conditions. Lentils grown in North America are a rich source of iron, zinc, magnesium, potassium, and selenium. Lentils are naturally low in phytic acid (PA), and low PA is a favorable factor for improving mineral bioavailability. Lentil is also a good source of beta-carotene, the presence of which also favors increased mineral bioavailability. A single 50-100 g serving of lentil could potentially provide adequate daily amount of minerals. For this reason, lentil can be considered as a biofortified whole food source of selenium, iron, and zinc for lentil consumers (Thavarajah et al., 2011).

CDC Maxim had higher iron and zinc content with low phytic acid levels compared to CDC Impala and CDC Redberry. However, CDC Maxim was low in selenium compared to CDC Impala and CDC Redberry. Spanish brown cultivar Pardina was rich in iron and zinc but low in selenium. Generally, green lentil cultivars were low in iron and zinc compared to selenium.

Table 19. Mean nutritional quality of lentil cultivars grown in the USA, 2011.

Market Class	Genotype	Iron mg/kg	Zinc mg/kg	Calcium mg/kg	Magnesium mg/kg	Potassium mg/kg	Selenium µg/kg	Phytic acid mg/g
Red	CDC Impala	68	35	430	773	6736	560	8.2
	CDC Redberry	71	35	709	755	6342	579	6.5
	CDC Maxim	72	38	569	699	5810	212	5.6
Spanish Brown	Pardina	72	30	470	682	6112	80	4.7
Black	Beluga	49	35	415	696	5989	143	4.1
Green	CDC Richlea	52	29	530	748	6098	644	5.2
	Laird	54	34	507	743	6076	697	4.3
	CDC Meteor	54	28	494	789	6398	786	4.9
	Riveland	53	31	375	761	6786	702	6.5

Chickpea Quality

Sample Distribution

A total of 16 chickpea samples were collected from Montana, North Dakota, South Dakota, Idaho, and Washington State. Samples of approximately 100-250 g were received by the NDSU Pulse Quality and Nutrition Laboratory from January to March, 2012. Chickpea growing location, number of samples, market class, and genotypes used in 2011 quality survey are described in Table 20.

Table 20. Description of chickpea cultivars used in 2011 pulse quality survey.

State	No of samples	Market class	Genotype
Montana	1	Kabuli	Not available
North Dakota	4	Kabuli	Frontier
South Dakota	1	Kabuli	Frontier
Idaho	2	Kabuli	Bronic
		Kabuli	Billy Bean
Washington	8	Kabuli	Frontier
			Sierra
			Pedro
			HB-14
			Troys
Total	**16**		

Proximate analysis of chickpea (Table 21)

Moisture

The moisture content of US grown chickpea ranged from 4.6-8.7% in 2011. The average moisture content of chickpea was 6.9%.

Protein

Protein content of chickpea ranged from 17.4-23.8% with an average of 20.7%. Bronic had the highest protein content compared to the other cultivars (Table 22).

Ash

The ash content of chickpea ranged from 2.5-3.0% with an average of 2.8%.

Total starch

The total starch content ranged from 23-60% with an average of 41%. CDC Frontier had the highest total starch content compared to the other cultivars (Table 22).

Water absorption

The average water absorption of chickpea ranged from 93-118% with an average of 103%.

Unsoaked seed

All tested seeds were properly soaked. No unsoaked seed percentage was observed.

Test weight

Test weight ranged from 57-64 lb/Bu with an average of 61 lb/Bu.

1000 seed weight

The seed density of chickpea grown in 2011 ranged from 268-556 g with an average of 387 g.

Starch properties

The average values of starch properties were similar to dry peas.

Canning quality (Table 23)

Color quality of canned chickpea was measured using an L, a, and b type scale. Other quality characters were measured as followed:

- Clumping: 1 = no clumping, 5 = highest clumping
- Splitting: 1 = no splitting, 5 = highest splitting
- Turbidity: 1 = no turbidity or clear, 5 = highest or cloudy
- Overall acceptance: 1 = very good, 5 = very poor

Sierra had the highest overall acceptance compared to CDC Frontier.

Table 21. Summary of proximate analysis of chickpea grown in USA, 2011.

	2011	
Characteristics*	**range**	**Mean (SD)**
Physical Quality		
1. Moisture (%)	4.6-8.7	6.9 (1)
2. Protein (%)	17.4-23.8	20.7 (2)
3. Ash (%)	2.5-3.0	2.8 (0.1)
4. Total starch (%)	23.2-59.8	41 (7)
5. Water absorption (%)	93-118	103 (7)
6. Unsoaked seed (%)	0	0
7. Test weight (lb/Bu)	57.4-63.9	61 (20)
8. 1000 seed weight (g)	268-556	387 (82)
Starch Properties		
1. Peak viscosity (RVU)	143-202	178 (15)
2. Hot paste viscosity (RVU)	139-179	156 (11)
3. Break down (RVU)	6 47	23 (11)
4. Cold paste viscosity (RVU)	237-392	292 (46)
5. Setback (RVU)	85-213	136 (40)
6. Peak time (min)	8.8-12.5	9.9 (1)

Table 22. Mean protein and starch content for different chickpea cultivars grown in the USA, 2011.

Genotype	Protein (%)	Total starch (%)
CDC Frontier	21	46
Pedro	19	39
Troys	20	44
HB-14	19	40
Bronic	24	38
Billy Beans	23	36
Sierra	21	39

Chickpea Micronutrients

US grown chickpea are a good source of iron, zinc, calcium, magnesium, potassium, and selenium. Concentrations of each mineral micronutrient are given in Table 24. Similar to dry pea and lentils, chickpea is also low in phytic acid and a good source beta-carotene.

Mineral nutrient levels of chickpea cultivars
(Table 25)

All genotypes had similar levels of mineral micronutrients, phytic acid, and beta-carotenes, with the exception of selenium levels in cultivar Troys. CDC Frontier had higher iron and selenium contents compared to the other cultivars.

Please note that due to the small number of samples, no location details are provided for chickpea mineral micronutrients.

Table 23. Mean canning quality of USA grown chickpeas.

Quality Attributes	Sierra	CDC Frontier	Unknown-Kabuli type
L*	53.4	52.5	53.4
a*	4.7	5.7	6.0
b*	15.5	15.2	16.6
Clumping (1-5)	0	0	0
Splitting (1-5)	0	1	1
Turbidity (1-5)	2	2	2
Overall (1-5)	1	1	1

Table 24. Mean micronutrient concentrations in chickpea grown in the USA, 2011.

Micronutrient	Chickpea
Iron (mg/kg)	43 (4)
Zinc (mg/kg)	24 (2)
Calcium (mg/kg)	645 (82)
Magnesium (mg/kg)	906 (72)
Potassium (mg/kg)	6611 (406)
Selenium (µg/kg)	361 (280)
Phytic acid (mg/g)	4.8 (1)
Beta-carotene (µg/100 g)	294 (213)

Table 25. Mean nutritional quality of chickpea cultivars grown in the USA, 2011.

Genotype	Iron mg/kg	Zinc mg/kg	Calcium mg/kg	Magnesium mg/kg	Potassium mg/kg	Selenium µg/kg	Phytic acid mg/g
CDC Frontier	47	25	651	947	6848	582	5.0
Pedro	38	25	561	882	6675	179	5.0
Troys	42	24	779	900	6742	82	5.1
HB-14	39	22	651	834	6271	122	4.5
Bronic	42	26	500	839	6084	204	5.4
Billy Bean	38	20	706	783	5822	165	4.8
Sierra	40	24	701	949	6724	117	5.0

Percentage Recommended Daily Allowance

The percentage recommended daily allowance (%RDA) provides an indication of the nutrient concentration of a food item. Based on a 50 g serving for both adult males and females 19-50 years of age, US grown field pea, lentil, and chickpea could be considered good sources of selenium, iron, zinc, and magnesium. This conclusion is based on 64 samples grown in 2011. The actual levels of each nutrient vary based on growing location, genotype, year, and number of samples used to determine mineral micronutrient levels. The %RDA for US grown dry pea, lentil, and chickpea from 2011 for adults ages 19-50 years are given in Table 26.

Table 26. Percent recommended daily allowance (RDA) of minerals in a 50 g serving of pulses.

	%RDA in a 50 g of serving of pulses for adults (19-50 yrs)†								
	Selenium	Iron		Zinc		Calcium	Magnesium		Potassium*
Crop	Male/ Female (55 µg)	Male (8 mg)	Female (18 mg)	Male (11 mg)	Female (8 mg)	Male/ Female (1000 mg)	Male (410 mg)	Female (310 mg)	Male/ Female (4.7 g)
Field pea	36	25	11	11	15	2	9	13	6
Lentil	49	36	16	13	18	3	9	12	6
Chickpea	33	27	12	11	15	3	11	15	7

†%RDA and AI were calculated based on www.nap.edu (Food and Nutrition Board, Institute of Medicine and National Academies; http://fnic.nal.usda.gov)
*Adequate Intake (AI)

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