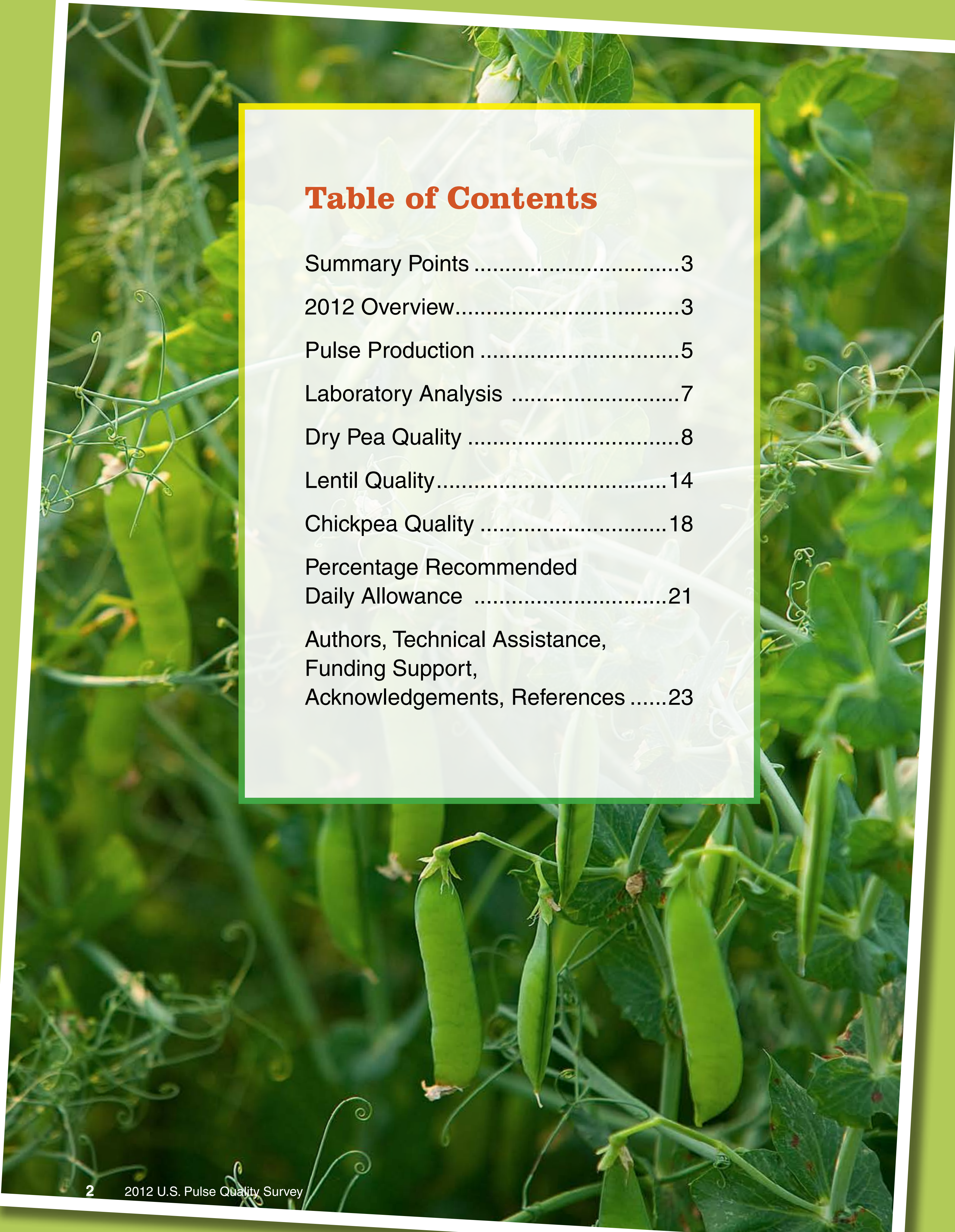
2012 U.S. Pulse Quality Survey

Northern Pulse Growers Association

USA Dry Pea & Lentil Council

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION



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2012 Overview

Summary Points

1. This 2012 report is based on 243 samples, a higher number than in 2011 and representing all pulse growing regions in the USA.
2. A large suite of physical and nutritional quality parameters were tested.
3. The quality of pulse crops, especially with respect to protein, starch, and micronutrients, was better in 2012 than in 2011.
4. Pulse quality and nutritional data from 2012 were evaluated and compared with other sources of published data.
5. A recommendation for increased pulse consumption is included, highlighting the superior nutritional profiles of US-grown pulse crops.

Diets based on pulse crops as nutrient-rich whole food are gaining attention with respect to combating non-communicable diet-related diseases, including obesity, diabetes, cardiovascular diseases, and different types of cancer. Non-communicable diseases are a global health concern that affects more than one in every ten adults (World Health Organization, 2012). In the United States, over 35% of adults are obese (Flegal et al., 2012). In short, healthy food approaches to reduce non-communicable diseases are required on a national and global scale.

Pulses are a part of the daily diet of many vegetarians around the world. Pulses are rich in protein (20-30%) and an excellent source of dietary fiber, low molecular weight carbohydrates, essential amino acids, polyunsaturated fatty acids, and a range of micronutrients. With an increasing global population, US-grown pulses are becoming an important part of the global food supply. The majority of US-grown pulses are exported to international markets in Asia, South America, and Europe. Moreover, local demand for pulses has recently increased due to greater pulse consumption by Americans.

Pulse quality is an indication of seed quality characteristics that are acceptable to consumers. Generally, quality characteristics are based on physical, nutritional, and consumer preference related to different market classes. As both the supply and demand of pulses are forecast to grow, pulse quality information is vital to continued efforts by the US pulse industry to produce higher quality products. Collaborative efforts by the USA Dry Pea Lentil Council (USADPLC), the Northern Pulse Growers Association (NPGA), and the North Dakota State University (NDSU) Pulse Quality and Nutrition laboratory resulted in the first US Pulse Survey published in 2011. This 2012 report is thus the second in the series, the intent of which is to become an annual technical communication. The US pulse quality survey provides data to aid growers with respect to production of high quality pulse crops, to assist processors and suppliers in assuring pulse quality, and to inform local and international consumers with respect to pulse quality and nutrition aspects.

The objectives of this report are to provide (1) proximate quality parameters (moisture, protein, total starch, water absorption, unsoaked seed, test weight, 1000 seed weight, starch properties, and color), (2) data on total micronutrient concentrations of iron, zinc, calcium, magnesium, potassium, manganese, copper, and selenium in dry pea, lentil, and chickpea varieties grown commercially in the USA, and (3) a technical summary of recent scientific publications on the nutritional quality of US-grown pulses as related to human health.

In 2012, a total of 243 pulse samples were collected from the major US pulse growing regions. Seeds representing 140 dry pea, 65 lentil, and 38 chickpea samples were acquired from industry representatives in pulse growing areas in North Dakota, South Dakota, Idaho, Montana, and Washington. In 2011, US pulse production was below the long-term annual average due to excess moisture and flooding (NPGA, 2011) and thus only 54 pulse samples were collected. Overall, the data in this report demonstrate that 2012 was a better year than 2011, with increased pulse acreage, production levels, and overall pulse quality including protein, starch, test weights, color, and starch properties.

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. In addition, average color quality (before and after soaking) was determined. The results of each quality parameter are provided for each pulse crop category. Physical quality parameters such as ash, water absorption, unsoaked seed percent, test weight, and 1000 seed weight of the 2012 samples were consistent with previous years, with the exception of low moisture and high protein and starch levels. Overall, pulses grown in 2012 have high levels of protein and starch.

Similar to the results reported in 2011, the pulses grown in 2012 are an excellent source of a wide range of micronutrients including iron (Fe), zinc (Zn), selenium (Se), and magnesium (Mg). In addition, phytic acid—an antinutrient in the seeds of pulses that has the potential to bind mineral micronutrients in staple food crops and reduce their bioavailability—was determined for only a few representative pulse samples in 2012. The results highlight the fact that US-grown pulses are low in phytic acid.

This report includes the percent recommended dietary allowance (RDA) of minerals from a 50 g serving of pulses for 19 to 50 year old adults. 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; this is especially noted in some cases for selenium, iron, zinc, and magnesium.

Pulse Production

Significant land area has recently been added to pulse crop in the Pacific Northwest with rapidly expanding production in the Northern Plains region of the USA. Over the last two decades, pulse production area in North Dakota, South Dakota, and eastern Montana has increased from less than 10,000 acres to nearly 900,000 acres. The USA is now the fourth largest pea exporter in the world and exports 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, 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.

In 2012, US pulse production acreage (1,278,392 acres) increased substantially from 2011 (917,015 acres) but was similar to 2010 (1,456,347). Despite the wet spring in the Pacific Northwest and dry summers in North Dakota and Montana, yields were above average with good physical and nutritional quality. Some hail damage was reported in the Northern Plains; however, grain yields were not affected (Pulse Pipe Line, 2012). Overall, total US pulse production was 891,869 MT in 2012 compared to 598,330 MT in 2011 (Table 1; Figure 1).

Table 1. US pulse acreage, average yield, and production summary for 2012.

Pulse crops	Acres	lbs/acre	Metric tons (MT) harvested
Green Pea	282,960	1,787	229,328
Yellow Pea	344,596	1,886	294,802
Austrian Winter Pea	12,416	1,983	11,169
Lentil	444,595	1,136	229,171
Chickpea	193,825	1,449	127,399
Total	**1,278,392**	**1,538**	**891,869**

Data from USA Dry Pea and Lentil Council, 2012 production report, Sep. 30, 2012.

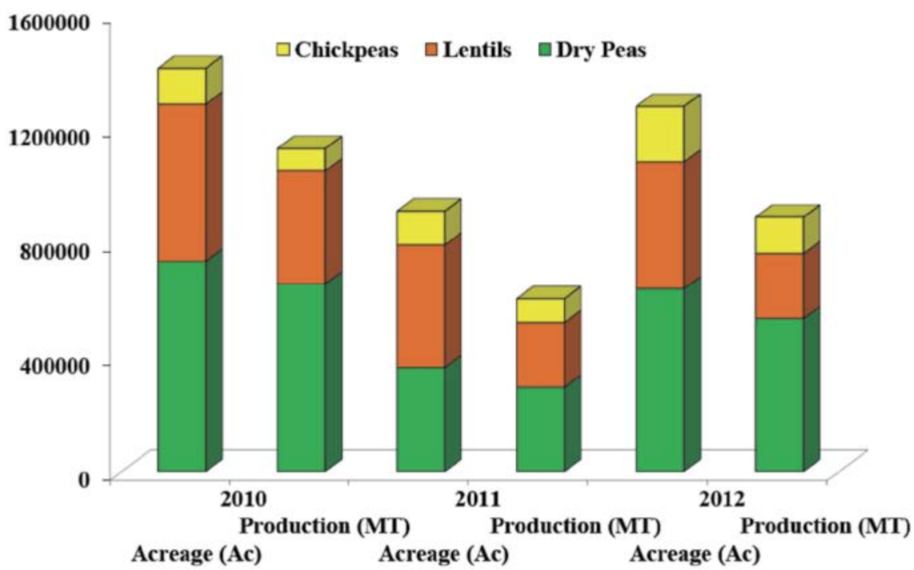
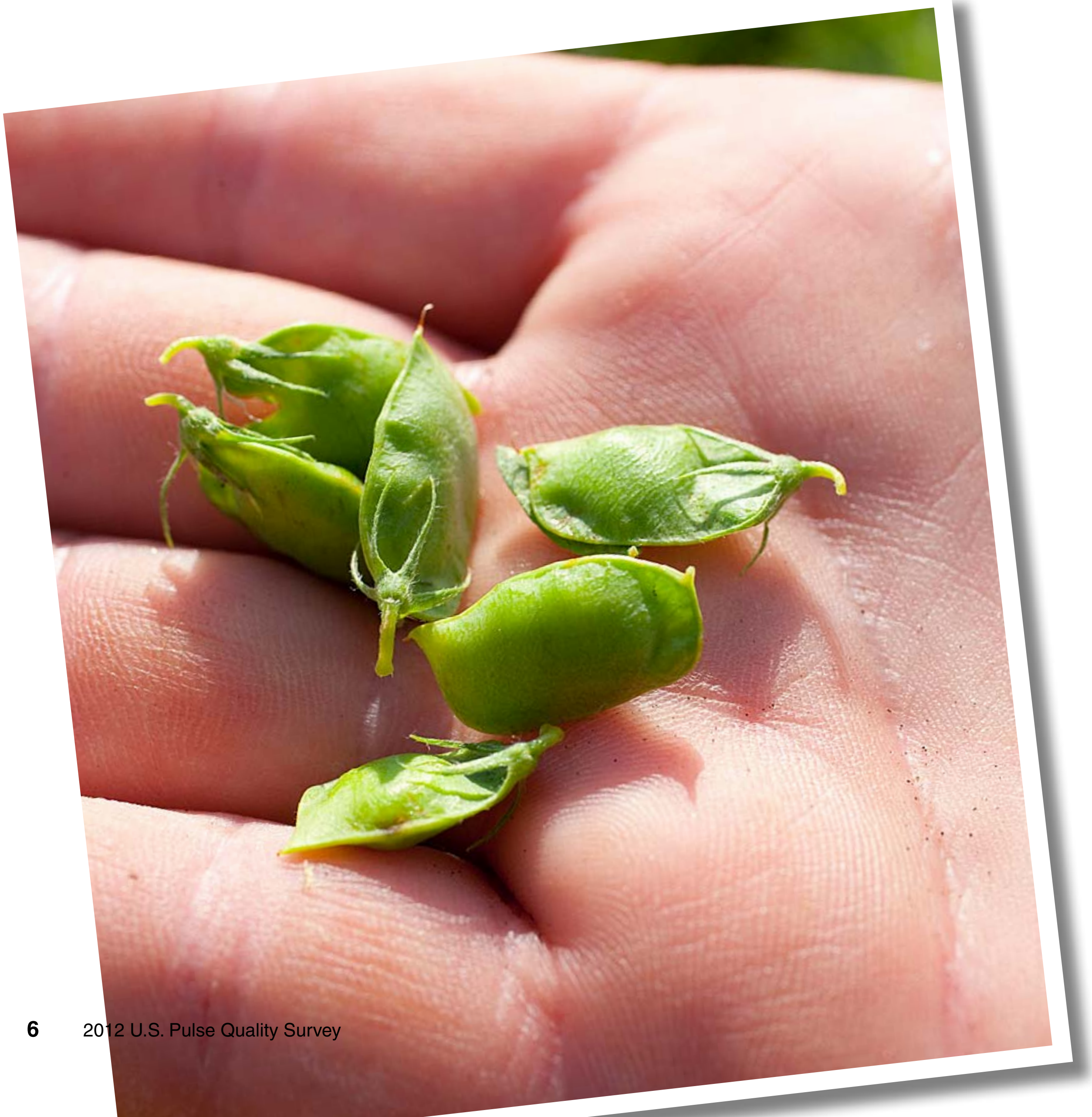


Figure 1. USA dry pea, lentil, and chickpea acreage and production (MT) in 2010, 2011 and 2012 (based on USA Dry Pea Lentil Council data)**.**

Dry Pea: Total green pea acreage increased to 282,960 acres in 2012 compared to 169,872 acres in 2011, representing a 67% increase. Total green pea production was 229,328 MT in 2012 and 140,007 MT in 2011. Yellow pea acreage and production was 344,596 acres and 294,802 MT, respectively, in 2012 compared to total acreage of 190,650 acres and production of 142,276 MT in 2011 (USA Dry Pea Lentil Council, 2012). Total US pea production including green, yellow, and Austrian winter pea was 535,962 MT in 2012. Most production came from Montana and North Dakota followed by Washington.

Lentil: Lentil acreage was 444,595 in 2012 and 425,893 acres in 2011; production was 229,171 in 2012 MT and 223,763 MT in 2011. Approximately 44% of total lentil production was from North Dakota, 32% from Montana, 15.9% from Washington, and 7.9% from Idaho (USA Dry Pea Lentil Council, 2012).

Chickpea: Chickpea acreage was 193,825 in 2012 compared to 117,050 in 2011; production was approximately 127,339 MT in 2012 and 83,358 MT in 2011. More than 41% of total chickpea production was from Washington, 35% from Idaho, 9.1% from California, 7.3% from Montana, and 4.3% from North Dakota.



Laboratory Analysis

Similar to 2011, standard methods were followed for the determination of each pulse quality attribute in 2012. Table 2 includes the reference for each analytical method employed.

Table 2. Quality attribute, analytical method, and remarks for analyses conducted for this 2012 Pulse Quality Survey.

Quality Attribute	Method	Remarks
1. Moisture (%)	AACC method 44-15A	Indicator of post-harvest handling, milling yield
2. Protein (%)	AACC method 46-30	Indicator of nutritional quality and processing
3. Ash (%)	AACC method 08-01	Indicator of total mineral content
4. Total starch (%)	Johnson et al., 2012	Indicator of nutritional quality and processing
5. Water absorption (%)	AACC method 56-35.01	Indicator of cooking quality/uniformity and canning
6. Unsoaked seed (%)	AACC method 56-35.01	Indicator of cooking quality/uniformity and canning
7. Test weight (lb/bu)	AACC method 55-10	Indicator of sample density, size, and shape
8. 1000 seed weight	100-kernel sample weight times 10	Indicator of grain size and milling yield
9. Starch properties	Rapid Visco Analyzer	Indicator of texture, firmness, and gelatinization of starch
10. Color	Konica Minolta CR-310 Chroma meter	Indicator of visual quality and processing
11. Micronutrients	Thavarajah et al., 2008, 2009a	Micronutrient analysis and malnutrition/cancer protection
12. Phytic acid	Thavarajah et al., 2009b	Phytic acid analysis and phytic acid levels in foods

Dry Pea Quality

Sample distribution

A total of 140 dry pea samples were collected from Montana, North Dakota, Idaho, and Washington from September to November 2012. Growing location, number of samples, market class, and genotype details of these dry peas samples are described in Table 3. The majority of the dry pea samples were received from North Dakota, followed by Montana, Washington, and Idaho. Only 30 field pea samples were collected in the 2011 quality survey, so 2012 represented a 367% increase in the number of samples.

Table 3. Description of dry pea samples used in the 2011 pulse quality survey.

State	No. of samples	Market class	Cultivars
Montana	26	Yellow	Universal, CDC Meadows
		Green	Aragon, Banner, Cruiser, Cooper
North Dakota	87	Yellow	DS Admiral, CDC Meadow, Thunderbird, Spider, CDC Golden
		Green	CDC Striker, K-2, Aragon, Shamrock, Arcadia
Idaho	7	Green	Aragon, Ariel, Banner
Washington	20	Yellow	Carousal, Universal
		Green	Aragon, Ariel, Banner, Columbian, Pro 081-7116, Pro 191-7137
Total	140		

Proximate analysis of dry pea (Table 4)

Moisture

The moisture content of dry pea ranged from 7.0-10.8% in 2012. The average moisture content of the 140 samples was 9.1%, which is lower than the 4-year average of 11.3%. However, average moisture content increased compared to 2011.

Protein

The protein content of dry pea ranged from 18.6-29.2% with an average of 24.9%. Interestingly, the average protein content of dry peas grown in 2012 was higher than the 4-year average of 23.9%. This is mainly due to the favorable weather conditions experienced in 2012 compared to 2011.

Ash

The ash content of dry pea ranged from 2.1-3.5% with an average of 2.6%. The average ash content of dry peas grown in 2012 was equal to the 4-year average of 2.6%. Ash content is an indication of minerals present in pulses.

Total starch

Total starch content of dry pea ranged from 30-67% with an average of 52%. The average total starch content of dry peas grown in 2012 was higher to the 4-year average of 45%.

Table 4. Proximate analysis of dry pea grown in the USA, 2012.

Characteristics*	2012 range	2012 mean (SD)	Mean 2011	Mean 2010	Mean 2009	Mean 2008	4--year mean
Physical Quality							
1. Moisture (%)	7.0-10.8	9.1 (0.7)	7.3	13.2	11.9	12.8	11.3
2. Protein (%)	18.6-29.2	24.9 (2)	22.5	27.1	24.1	21.9	23.9
3. Ash (%)	2.1-3.5	2.6 (0.2)	2.6	2.6	2.5	2.6	2.6
4. Total starch (%)	30-67	52 (7)	41	45	43	51	45
5. Water absorption (%)	94-125	103 (5)	101	98	94	98	98
6. Unsoaked seed (%)	0-16	0.8 (2)	0.6	1.1	3.9	-	1.9
7. Test weight (lb/Bu)	57-65	61 (2)	61	63	63	63	63
8. 1000 seed weight (g)	145-361	206 (28)	203	241	225	235	226
Starch Properties							
1. Peak viscosity (RVU)	95-238	123 (15)	215	126	117	118	144
2. Hot paste viscosity (RVU)	95-188	117 (11)	165	118	108	96	122
3. Break down (RVU)	0-50	6.3 (7)	41	8	9	22	20
4. Cold paste viscosity (RVU)	150-454	213 (34)	355	204	184	180	231
5. Setback (RVU)	56-266	96 (25)	200	87	76	84	112
6. Peak time (min)	7.8-13.0	9.2 (1.4)	8.2	8.6	8.3	14	10

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

Water absorption

Water absorption of dry pea ranged from 94-125% with an average of 103%. This range of values brackets the 4-year average of 98%.

Unsoaked seed

Unsoaked seed percentage ranged from 0-16% with an average of 0.8%, which was lower than the 4-year average of 1.9%.

Test weight

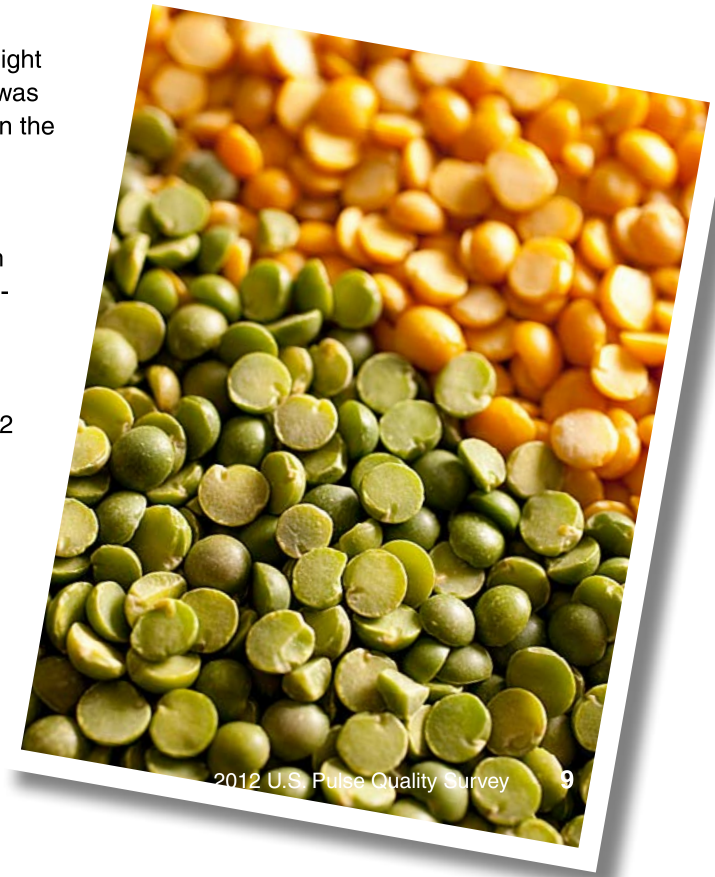
Test weight ranged from 57-65 lb/Bu with an average of 61 lb/Bu. These values bracket the 4-year average of 63 lb/Bu.

1000 seed weight

The average 1000 seed weight of dry peas grown in 2012 was 206 g, which was lower than the 4-year average of 226.

Starch properties

Average values of all starch properties in 2012 were significantly lower than values reported in 2011. The average values of 4-year starch properties bracket with 2012 values, indicating good quality of starch for food processing.



Proximate analysis of dry pea market classes (Table 5)

For yellow peas, levels of moisture, protein, total starch, water absorption, and unsoaked seeds percent were higher in 2012 than values reported in 2011. Ash content and test weights were similar to 2011 values. For green peas, all physical quality parameters except unsoaked seed percent were higher in 2012 than in 2010. Both yellow and green dry pea market classes showed similar proximate analysis for protein, test weights, and 1000 seed weights. In addition, US yellow peas showed lower ash content, total starch and water absorption compared to green peas grown in 2012; however, moisture content and unsoaked seed percent were higher in yellow peas compared to green peas. Both green and yellow peas had similar starch properties and, for both market classes, average starch properties decreased from 2011 and were similar to 2010.

Starch properties were similar to the 2010 values as a result of the adequate moisture content observed in the dry pea crop in 2012. Therefore, starch properties of both dry pea market classes are better for the Asian noodle market, for example, which prefers a medium to high peak viscosity flour product as it gives better textural characteristics. Also, flour from both dry market classes can be used as a thickening agent due to moderate peak viscosity values.

Proximate analysis of pea market classes (Table 6)

For the yellow market class, Spider (26.4%) and Agassi (25.4%) had the highest protein content and Treasure had the highest total starch content (59.8%). For the green market class, SGDP (27.6%) and Viper (27.3%) had the highest protein content and K-2 had the highest total starch content (60.4%). Overall, K-2 had high starch and moderate levels of protein. In addition, new cultivars Pro 081-7116, Pro 091-7137, and Pro 7040 showed high starch and average protein content.

Table 5. Proximate analysis of dry pea market classes.

	Mean (SD) of yellow pea			Mean (SD) of green pea		
Characteristics*	**2012**	**2011**	**2010**	**2012**	**2011**	**2010**
Physical Quality						
1. Moisture (%)	9.3 (0.6)	7.3 (0.1)	13.6 (2)	8.9 (0.7)	7.4 (0.4)	12.8 (2)
2. Protein (%)	24.9 (1.3)	22.8 (2)	27.2 (2)	24.8 (2.6)	22.4 (2)	27.0 (2)
3. Ash (%)	2.6 (0.2)	2.7 (0.2)	2.7 (0.5)	2.7 (0.2)	2.6 (0.2)	2.4 (0.5)
4. Total starch (%)	50 (8)	44 (4)	45 (3)	53 (6)	40 (6)	45 (3)
5. Water absorption (%)	102 (8)	99 (4)	99 (8)	104 (5)	101 (4)	99 (8)
6. Unsoaked seed (%)	2 (3)	0.8 (0.9)	1 (2)	0.5 (1)	0.5 (1.3)	1.1 (2)
7. Test weight (lb/Bu)	62 (2)	62 (1)	63 (1)	62 (1)	61 (1)	63.3 (1)
8. 1000 seed weight (g)	212 (23)	225 (22)	248 (27)	201 (31)	195 (22)	232 (36)
Starch Properties						
1. Peak viscosity (RVU)	126 (17)	192 (14)	127 (14)	120 (12)	223 (120)	124 (19)
2. Hot paste viscosity (RVU)	119 (11)	152 (12)	120 (13)	115 (10)	169 (62)	115 (16)
3. Break down (RVU)	8 (8)	41 (5)	7 (5)	5 (5)	41 (13)	9 (7)
4. Cold paste viscosity (RVU)	211 (38)	331 (33)	204 (29)	215 (31)	365 (72)	204 (35)
5. Setback (RVU)	93 (28)	179 (23)	85 (17)	100 (22)	209 (57)	89 (21)
6. Peak time (min)	9 (1)	8 (0.2)	9 (0.7)	9 (2)	8 (0.4)	9 (1)

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

Table 6. Mean protein and starch content for different field pea cultivars grown in the USA, 2012.

Market Class	Cultivar	Protein (%)*	Total Starch (%)#
Yellow	Agassi	25.4	50.1
	Carousel	21.9	56.2
	CDC Golden	24.9	50.0
	CDC Meadows	24.9	47.0
	DS Admiral	24.4	48.4
	Spider	26.4	49.4
	Treasure	24.9	59.8
	Universal	24.9	55.7
	Unknown	25.0	50.2
Green	Aragorn	24.7	53.2
	Ariel	23.3	50.7
	Banner	23.0	50.3
	CDC Striker	26.7	51.9
	Columbian	24.3	50.9
	Cooper	25.4	51.8
	Cruiser	26.6	57.9
	K2	23.9	60.4
	Majorette	23.7	49.1
	Orka	24.1	54.7
	Pacifica	18.9	52.1
	Pro 081-7116	19.0	58.1
	Pro 091-7137	20.2	59.4
	Pro 7040	19.1	57.0
	SGDP	27.6	57.9
	Shamrock	26.0	56.7
	unknown	26.8	51.4
	Viper	27.3	51.1

*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 7 and 8)

Color is an important quality attribute for the dry pea food industry. Color quality was measured 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 2012 was fairly similar to results reported in 2011 and 2010. The higher negative value for red-green (axis a) in 2012 indicates a greener color than 2011. For the yellow pea market class, lightness did not change after soaking but increased red-green and yellow-blue values. For green pea market class, soaking decreased lightness but increased red-green and yellow-blue values.

Among the genotypes, Shamrock had the highest a axis value (greenest color) before soaking and Colombian and Pro 7040 had 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 Shamrock, Pacifica, and Pro 7040 had the greenest color compared to other cultivars.

Table 7. Color quality of yellow and green peas grown in 2012 before and after soaking.

	Mean (SD) of yellow pea						Mean (SD) of green pea					
	Before soaking			After soaking			Before soaking			After soaking		
Color scale	2012	2011	2010	2012	2011	2010	2012	2011	2010	2012	2011	2010
L (lightness)†	65 (1)	65 (2)	63 (1)	65 (1)	66 (2)	67 (1)	60 (2)	61 (2)	59 (4)	54 (2)	55 (2)	57 (2)
a (red-green)±	4.7 (1)	4.7 (0.3)	5.6 (1)	5.4 (1)	5.6 (1)	5.5 (1)	-1.9 (1)	-0.9 (3)	-1.7 (1)	-8.4 (1)	-8.7 (1)	-6.7 (1)
b (yellow-blue)*	14 (1)	14 (0.4)	15 (1)	30 (1)	30 (0.4)	28 (2)	9 (1)	10 (2)	9 (1)	18 (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

Table 8. Mean color quality of green pea cultivars grown in the USA, 2012.

Cultivars	a*(red-green) 2012 Whole seed color	a*(red-green) 2012 Seed color ater soaking	a*(red-green) 2011 Whole seed color	a*(red-green) 2011 Seed color after soaking
Aragorn	-1.6	-8.6	-2.4	-8.8
Arcadia	-0.4	-5.1	-	-
Ariel	-1.8	-9.1	-2.5	-9.1
Banner	-2.5	-8.9	-3.1	-9.1
CDC Striker	-1.6	-8.2	-1.5	-8
Columbian	-2.4	-9.2	-2.3	-9.5
Cooper	-0.2	-3.5		
Cruiser	-1.8	-8.7	-1.5	-8.3
K2	-1.5	-7.1	-0.9	-7.5
Majorette	-0.9	-6.7	-	-
Orka	-1.3	-6.8	-	-
Pacifica	-2.9	-9.1	-	-
Pro 081-7116	-2.2	-9.1	-	-
Pro 091-7137	-2.1	-8.9	-	-
Pro 7040	-2.9	-9.5	-	-
SGDP	-2.0	-8.6	-	-
Shamrock	-3.1	-8.4	-	-
Unknown	-1.7	-8.3	-	-
Viper	-1.4	-8.3	-	-

*negative values are green and zero is neutral.
Note 2011 values are missing for several cultivars.

Mineral Micronutrients

Dry pea micronutrients (Table 9)

Mineral micronutrients are essential for general well-being, for maintenance of healthy immune systems, and for protection against diseases and several cancers. Essential nutrients can be classified as macronutrients (carbohydrates, lipids, proteins, and water), which are consumed in large quantities, and micronutrients (minerals and vitamins), which are consumed in smaller quantities. Both are equally important for human health.

Mineral micronutrients include elements; some are required in large quantities while others such as selenium (Se), iodine (I), copper (Cu), iron (Fe), and zinc (Zn) are required in smaller quantities. Micronutrient malnutrition has a negative influence on the cognitive abilities of school-aged children, decreasing their educational achievements and increasing mortality and morbidity rates.

Table 9. Mean micronutrient concentration of dry pea grown in the USA, 2012.

Micronutrient	Market class† Yellow 2012	Yellow 2011	Green 2012	Green 2011
Calcium (mg/kg)	390 (99)	529 (68)	345 (167)	507 (114)
Copper (mg/kg)	3.8 (2)	7.8 (1)	-*	-*
Iron (mg/kg)	50 (10)	42 (7)	41 (9)	39 (6)
Magnesium (mg/kg)	579 (68)	821 (35)	440 (98)	769 (58)
Manganese (mg/kg	10 (3)	12 (2)	-*	-*
Potassium (mg/kg)	7490 (743)	5830 (312)	9004 (601)	6000 (320)
Selenium (µg/kg)	500 (300)	700 (400)	600 (500)	326 (288)
Zinc (mg/kg)	35 (7)	22 (3)	38 (6)	25 (4)

† mean values with standard deviation. *Data not reported.

Pulses are naturally rich in minerals. Across dry pea market classes, Fe, Zn, and K levels were higher in 2012 than in 2011. However, Ca, Mg, and Se levels were lower in 2012 than in 2011. US-grown dry peas are also containing significant amounts of copper and manganese.

Mineral nutrient levels of dry pea cultivars (Table 10)

Dry pea cultivars vary with respect to seed mineral levels. Among different yellow pea cultivars, CDC Meadows showed the highest Se content and Carousel the lowest. For green market class, Cruiser, Orka, SGDP, and Viper showed the highest Se levels compared to other cultivars. Details for different cultivars are shown in Table 10.

Table 10. Mean mineral micronutrient of dry pea cultivars grown in the USA, 2012.

		Concentration (mg/kg)								(µg/kg)
Market Class	Cultivar	Ca	Cu	Fe	K	Mg	Mn	P	Zn	Se
Yellow	Agassi	235	2.0	41	6923	528	6	2507	33	470
	Carousel	435	6.7	49	8653	485	12	3257	32	200
	CDC Golden	156	1.6	54	7535	533	6	2800	38	320
	CDC Meadows	396	3.5	57	7778	605	12	2750	35	570
	DS Admiral	414	3.2	49	7095	596	10	2776	33	490
	Spider	327	3.4	50	7597	549	9	2818	34	312
	Treasure	404	3.9	52	7107	582	10	2974	35	530
	Universal	400	6.6	38	8405	525	12	2960	34	280
	Unknown	415	4.6	45	7739	568	12	2994	37	1000
Green	Aragorn	402	9	47	8666	422	13	3276	41	395
	Arcadia	321	11	47	9980	521	17	3239	39	838
	Ariel	411	6	53	8739	430	13	3195	31	173
	Banner	342	8	41	9100	465	11	3185	32	597
	CDC Striker	207	9	40	8807	376	12	3061	40	856
	Columbian	420	8	51	8793	545	14	3272	34	150
	Cooper	258	8	29	8949	367	9	3292	48	925
	Cruiser	215	8	42	9956	382	12	3441	44	1788
	K-2	245	8	34	9527	477	12	3077	37	906
	Majorette	260	7	25	8727	289	12	2952	35	901
	Orka	249	8	32	9679	430	12	2933	38	1193
	Pacifica	772	8	44	8503	564	13	3129	41	160
	Pro 081-7116	638	8	41	8669	553	14	3750	38	260
	Pro 091-7137	450	7	43	8877	510	11	3328	30	237
	Pro 7040	699	8	42	8919	504	13	3941	39	203
	SGDP	226	8	32	9121	438	9	2944	43	1001
	Shamrock	281	7	36	9907	482	12	3603	45	601
	Viper	207	9	34	8669	343	9	3272	43	1152

Lentil Quality

Sample Distribution

A total of 65 lentil samples were collected from Montana, North Dakota, Idaho, and Washington. Similar to dry peas, lentil samples were also collected from September to November in 2012. Growing location, number of samples, market class, and genotypes for the 2012 quality survey are described in Table 11.

Table 11. Description of lentil genotypes used in 2012 pulse quality survey.

State	No. of samples	Market class	Genotype
Idaho	13	Green	Merrit
		Green	CDC Viceroy
		Red	Red Chief
		Spanish Brown	Morena
		Spanish Brown	Pardina
Montana	32	Green	Greenland
		Green	Laird
		Green	CDC Richlea
		Green	Viceroy
		Red	Impala
		Red	CDC Redberry
North Dakota	13	Green	CDC Meteor
		Green	CDC Richlea
		Green	Viceroy
		Red	Impala
Washington	7	Green	Brewer
		Green	Merrit
		Spanish Brown	Pardina
Total	65		

Proximate analysis of lentils (Table 12)

Moisture

Moisture content of lentils ranged from 6.8-10% in 2012. The average moisture content of the 65 samples was 8.3%, which is lower than the 4-year average of 9.7%.

Protein

Protein content ranged from 19.0-28.3% with an average of 24.9%. The average protein content of 2012 grown lentils was similar to the 4-year average of 24.5%.

Ash

Ash content of lentils ranged from 2.3-3.5% with an average of 2.8%. The average ash content of lentils grown in 2012 was slightly higher than the 4-year average of 2.7%.

Total starch

Total starch content ranged from 39.9-59.4% with an average of 51.9%. This average was significantly higher than the 4-year average of 46%.

Water absorption

The average water absorption of lentils ranged from 97-151% with an average of 94%. These values bracketed the 4-year average of 93%.

Unsoaked seed

The average unsoaked seed percentage was 7%, which was lower than the 4-year average of 4.0%.

Test weight

Test weight of lentils ranged from 56-64 lb/Bu with an average of 61 lb/Bu. These values bracket the 4-year average of 61 lb/Bu.

1000 seed weight

The average seed density of lentils grown in 2012 was 45 g, which was relatively low compared to the 4-year average of 48 g.

Starch properties

The average values of starch properties of lentils grown in 2012 were lower than the 4-year average values with the exception of peak time.

Table 12. Proximate analysis of lentils grown in the USA, 2012.

Characteristics	2012 range	2012 Mean (SD)†	Mean 2011	Mean 2010	Mean 2009	Mean 2008	4-year mean
Physical Quality							
1. Moisture (%)	6.8-10.0	8.3 (0.7)	7.1	11.5	10.5	9.8	9.7
2. Protein (%)	19.0-28.3	24.9 (2)	22.2	26.9	25.2	23.5	24.5
3. Ash (%)	2.3-3.5	2.8 (0.2)	2.7	2.8	2.6	2.6	2.7
4. Total Starch (%)	39.9-59.4	51.9 (4)	40	43	47	52	46
5. Water Absorption (%)	97-151	94 (23)	88	96	93	94	93
6. Unsoaked Seed (%)	0-33	7 (9)	6	2	3	-*	4
7. Test Weight (lb/Bu)	56-64	61 (2)	60	61	62	62	61
8. 1000 Seed Weight (g)	24-76	45 (11)	49	46	49	-*	48
Starch Properties							
1. Peak Viscosity (RVU)	119-146	119 (15)	185	124	121	122	138
2. Hot Paste Viscosity (RVU)	80-132	112 (12)	145	112	110	86	113
3. Break Down (RVU)	5-24	7 (6)	41	12	10	36	25
4. Cold Paste Viscosity (RVU)	138-260	208 (25)	323	205	190	169	222
5. Setback (RVU)	52-133	96 (15)	178	93	80	83	109
6. Peak time (min)	7.9-13.0	9.9 (1.4)	8.1	8.9	8.8	12.6	9.6

* Data not reported.
† SD, Standard deviation.

Proximate analysis of lentil market classes (Table 13)

For red market class, average moisture, protein, ash, and starch levels increased from 2011 values. Test weights and water absorption were similar to 2011 values; however, unsoaked seed levels and 1000 seed weight were lower than 2011 values. Similar to red market class, moisture, protein, total starch, water absorption, unsoaked seed percent, and test weights of the green market class increased from 2011 values. For both market classes, average starch properties decreased from 2011 values. Overall, lentil protein and starch quality was better compared to the 2011 crop.

Color quality of lentils (Table 14)

Color quality for both market classes was improved compared to results reported in 2011.

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 15. For both red and green market classes, levels of iron, potassium, selenium, and zinc increased from 2011 values. The red market class had higher iron, zinc, magnesium, potassium, and calcium levels. US-grown 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 of beta-carotene, a vitamin A precursor (data not shown).

Table 13. Summary of proximate analysis of red and green lentils grown in the USA, 2012.

Characteristics*	Red		Green	
	2012	2011	2012	2011
Physical Quality				
1. Moisture (%)	8.2 (0.3)	7.1 (1)	8.5 (1)	7.1 (0.1)
2. Protein (%)	25.3 (2)	22.4 (2)	25.1 (2)	22.3 (2)
3. Ash (%)	3.0 (0.2)	2.5 (3)	2.7 (0.2)	2.7 (0.2)
4. Total Starch (%)	53 (4)	41 (5)	52 (3)	40 (5)
5. Water Absorption (%)	85 (51)	86 (20)	98 (17)	91 (14)
6. Unsoaked Seed (%)	2 (3)	9 (8)	6 (7)	3.4 (4)
7. Test Weight (lb/Bu)	61 (1)	61 (2)	60 (2)	59 (2)
8. 1000 Seed Weight (g)	39 (11)	42 (11)	47 (11)	56 (9)
Starch Properties				
1. Peak Viscosity (RVU)	99 (13)	174 (27)	121 (14)	191 (19)
2. Hot Paste Viscosity (RVU)	96 (12)	138 (16)	114 (11)	147 (13)
3. Break Down (RVU)	4 (5)	36 (14)	7 (7)	44 (7)
4. Cold Paste Viscosity (RVU)	180 (30)	310 (49)	212 (3)	326 (45)
5. Setback (RVU)	84 (20)	171 (34)	98 (15)	44 (7)
6. Peak time (min)	10.8 (1.8)	8.2 (0.3)	9.9 (1.4)	7.9 (0.3)

* Mean values with standard deviation.

Table 14. Color quality of yellow and green lentils before and after soaking.

Color scale	Mean (SD) of red lentils						Mean (SD) of green lentils					
	Before soaking			After soaking			Before soaking			After soaking		
	2012	2011	2010	2012	2011	2010	2012	2011	2010	2012	2011	2010
L (lightness)†	55(2)	54(1)	51(7)	52(3)	52(2)	54(1)	60(1)	60(1)	60(1)	59 (2)	60 (1)	62(2)
a (red-green)‡	3.9(1)	4.3(1)	3.9(1)	7.7(1)	7.3(2)	6.9(2)	1.1(1)	2.1(0.4)	1(0.6)	-0.4 (1)	1 (0.6)	-0.2(1.5)
b (yellow-blue)*	9(2)	9(2)	8(2)	19(1)	18(1)	16(2)	14(1)	15(1)	24(1)	23 (2)	24(1)	22(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

Table 15. Micronutrient concentrations of lentils grown in the USA, 2012.

	Market class*			
	Red		Green	
Micronutrient	2012	2011	2012	2011
Calcium (mg/kg)	418 (85)	569 (99)	293 (79)	501 (62)
Iron (mg/kg)	79 (18)	67 (6)	69 (39)	53 (6)
Magnesium (mg/kg)	482 (43)	720 (47)	367 (109)	761 (40)
Potassium (mg/kg)	7243 (896)	6108 (463)	6954 (709)	6255 (447)
Selenium (µg/kg)	503 (174)	495 (158)	726 (403)	698 (273)
Zinc (mg/kg)	40 (4)	33 (6)	34 (8)	29 (4)

* 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 16.

Mineral levels of lentils are known to vary with growing location and soil conditions. Lentils grown in North America are rich in iron, zinc, magnesium, potassium, and selenium. Lentils are also 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 an adequate daily amount of minerals. For this reason, lentil can be considered a biofortified whole food source of selenium, iron, and zinc for lentil consumers (Thavarajah et al., 2011). CDC Greenland had higher selenium content with low iron and zinc content compared to Merrit. However, Red Chief was low in selenium and high in iron, zinc, calcium, and potassium compared to the other cultivars. Spanish brown cultivar Pardina was rich in iron and zinc but low in selenium as it was mostly grown in low selenium soils. Generally, green lentil cultivars were low in iron and zinc compared to selenium. However, growing location soil, weather, and other environmental conditions affect mineral levels in lentils.

Table 16. Mean nutritional quality of lentil cultivars grown in the USA, 2012.

		Concentration (mg/kg)					
Market Class	Genotype	Fe	Zn	Ca	Mg	K	Se (µg/kg)
Green	CDC Greenland	45	30	169	293	7617	2038
	Laird	46	27	193	193	6788	893
	Merit	95	37	373	364	8034	193
	CDC Meteor	70	33	316	503	6476	469
	CDC Richlea	59	32	287	381	6840	855
	CDC Viceroy	59	39	281	317	6544	598
Red	CDC Impala	84	40	344	533	6986	606
	Red Chief	102	48	494	411	9161	188
	CDC Redberry	71	36	436	482	6959	513
Spanish Brown	Pardina	102	38	381	294	7344	114

Chickpea Quality

Sample distribution

A total of 38 chickpea samples were collected from Montana, North Dakota, South Dakota, Idaho, and Washington. Samples of approximately 100-250 g were received by the NDSU Pulse Quality and Nutrition Laboratory from September to November, 2012. Chickpea growing location, number of samples, market class, and genotypes used in 2012 quality survey are described in Table 17.

Table 17. Description of chickpea cultivars used in 2012 pulse quality survey.

State	No of samples	Market class	Cultivar
Idaho	20	Kabuli	Billy Bean
			Bronic
			Dwelley
			Sawyer
			Sierra
			Troy
Montana	5	Kabuli	B-90
			CDC Frontier
North Dakota	6	Kabuli	B-90
			CDC Frontier
South Dakota	3	Kabuli	B-90
			CDC Frontier
Washington	4	Kabuli	Dylan
			CDC Frontier
			Sierra
Total	**38**		

Proximate analysis of chickpea (Table 18)

Moisture

The moisture content of US grown chickpea ranged from 7.2-9.4% in 2012. The average moisture content of chickpea was 8.0%. Moisture content increased from 2011.

Protein

Protein content of chickpea ranged from 18.3-25.8% with an average of 20.9%. Billy Bean, B-90, and CDC Frontier had the highest protein content compared to the other cultivars (Table 19). Average protein content was similar to 2011.

Ash

The ash content of chickpea ranged from 1.8-3.1% with an average of 2.9%. Average ash content was similar to 2011 values.

Total starch

Total starch content ranged from 38.2-59.7% with an average of 49.7%. Total starch values were significantly higher than in 2011. Dylan had the highest total starch content compared to the other cultivars (Table 19). Overall, the 2012 crop demonstrated high starch content.

Water absorption

The average water absorption of chickpea ranged from 93-123% with an average of 101%. The average value was similar to 2011 values.

Unsoaked seed

All tested seeds were properly soaked thus no unsoaked seed percentage was recorded, similar to 2011.

Test weight

Test weight ranged from 56-65 lb/Bu with an average of 61 lb/Bu.

1000 seed weight

The seed density of chickpea grown in 2011 ranged from 248-613 g with an average of 403 g.

Starch properties

The average values of starch properties were similar to dry peas but values were lower than 2011.

Color quality of chickpea

(Table 20)

Color is an important quality attribute for the chickpea flour and humus 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

The lightness of chickpea did not change after soaking. In addition, soaking increased red-green and yellow-blue values.

Table 18. Summary of proximate analysis of chickpea grown in USA, 2012.

	2011		2012	
Characteristics*	**range**	**Mean (SD)**	**range**	**Mean (SD)**
Physical Quality				
1. Moisture (%)	7.2-9.4	8.0 (1)	4.6-8.7	6.9 (1)
2. Protein (%)	18-3.25.8	20.9 (2)	17.4-23.8	20.7 (2)
3. Ash (%)	1.8-3.1	2.9 (0.2)	2.5-3.0	2.8 (0.1)
4. Total Starch (%)	38.2-59.7	49.7 (5)	23.2-59.8	41 (7)
5. Water Absorption (%)	92-123	101 (46)	93-118	103 (7)
6. Unsoaked Seed (%)	0	0	0	0
7. Test Weight (lb/Bu)	56-65	61 (2)	57-64	61 (20)
8. 1000 Seed Weight (g)	248-613	403 (99)	268-556	387 (82)
Starch Properties				
1. Peak Viscosity (RVU)	92-138	119 (10)	143-202	178 (15)
2. Hot Paste Viscosity (RVU)	89-129	110 (8)	139-179	156 (11)
3. Break Down (RVU)	1-30	9 (6)	6. 47	23 (11)
4. Cold Paste Viscosity (RVU)	114-186	161 (16)	237-392	292 (46)
5. Setback (RVU)	25-78	50 (12)	85-213	136 (40)
6. Peak time (min)	8.7-13.0	10.3 (1)	8.8-12.5	9.9 (1)

Table 19. Mean protein and starch content for different chickpea cultivars grown in the USA, 2012.

	2012		2011	
Cultivar	**Protein (%)**	**Total starch (%)**	**Protein (%)**	**Total starch (%)**
Billy Bean	22	47	23	36
Bronic	19	51	24	38
B-90	22	47	-*	-
Dwelley	20	52	-	-
Dylan	20	57	-	-
CDC Frontier	22	52	21	46
Sawyer	19	49	-	-
Sierra	20	49	21	39
Troys	18	49	20	44

* Data not reported.

Chickpea micronutrients

US grown chickpeas are a significant source of iron, zinc, and selenium. Concentrations of each mineral micronutrient are given in Table 21. Similar to dry pea and lentils, chickpea is also low in phytic acid and a good source of beta-carotene. Potassium, selenium, and zinc levels in 2012 grown chickpeas were higher than 2011 values. Total iron values were similar to last year.

Mineral nutrient levels of chickpea cultivars

(Table 22)

All genotypes had different levels of mineral micronutrients. CDC Frontier had higher selenium content compared to the other cultivars. Billy Bean and Bronic were high in iron, zinc, potassium, and calcium. B-90 was high in magnesium.

Table 20. Color quality of kabuli chickpea before and after soaking

	Mean (SD) of kabuli chickpea	
Color scale	Before soaking	After soaking
L (lightness)†	61 (2)	62 (1)
a (red-green)‡	6.2 (0.8)	6.6 (0.6)
b (yellow-blue)*	14.6 (1.2)	25.5 (2.0)

† 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 21. Mean micronutrient concentrations in chickpea grown in the USA, 2012.

Micronutrient	2012	2011
Calcium (mg/kg)	503 (158)	645 (82)
Iron (mg/kg)	43 (7)	43 (7)
Magnesium (mg/kg)	693 (97)	906 (72)
Potassium (mg/kg)	7627 (1382)	6611 (406)
Selenium (µg/kg)	599 (504)	361 (280)
Zinc (mg/kg)	30 (7)	24 (2)

Table 22. Mean nutritional quality of chickpea cultivars grown in the USA, 2012.

Cultivar	Fe (mg/kg)	Zn (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Se (µg/kg)
B-90	36	28	426	838	6839	370
Billy Bean	56	32	839	620	8659	163
Bronic	56	31	672	577	8714	176
Dylan	44	26	618	803	6909	237
Dwelley	45	30	522	721	8132	186
Frontier	39	30	404	683	7320	1036
Sierra	47	31	492	705	7661	191

Percentage Recommended Daily Allowance

The percent recommended daily allowance (%RDA) provides an indication of the nutrient concentration of a food item. The %RDA for US-grown pulses from 2012 for adults ages 19-50 years are given in Table 23. However, the actual levels of each mineral nutrient vary based on growing location, genotype, year, and number of samples used to determine mineral micronutrient levels.

Table 23. 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)†								
	Se	Fe		Zn		Ca	Mg		K*
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	52	31	14	17	23	2	6	8	9
Lentil	53	48	21	16	22	2	4	6	8
Chickpea	54	27	12	14	19	3	8	11	8

†%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)

Why Pulses Are Good For You

According to scientific journal publications, US-grown pulses are whole foods. Consumption of pulses as a part of an individual's daily diet can improve health and general well-being.

Prebiotic carbohydrates

- US grown lentils are rich in prebiotic carbohydrates. Prebiotic carbohydrates support beneficial hindgut microflora.
- Johnson et al. (2012) report that a 100 g serving of US-grown lentils could provide 13 g of prebiotics, including fructooligosaccharides, raffinose family oligosaccharides, sugar alcohols, and resistant starch.

Proteins

- Pulses are high in protein (20-30%) (Bhatty, 1988).

Lipids

- Lentil seeds contain <1% lipids, chickpea contains 6% and field pea contains about 0.4% (Jukanti et al., 2012).
- Linoleic acid is the major fatty acid forming 37% of the total fatty acids (Bhatty, 1988).
- No cholesterols

Micronutrients

- Iron
  - Lentils: a 100 g serving of lentils provides 5.6-7.0 mg of iron, 4.4-5.4 mg of zinc, 42-70 µg of selenium, and 300-500 µg of folate (Thavarajah, Johnson, and Sen Gupta unpublished data).
  - Dry Peas: a 100 g serving of dry peas provides 4.6-5.4 mg of iron, 3.9-6.3 mg of zinc, 40-50 µg of selenium, and 300-500 µg of folate (Amarakoon et al., 2012; Thavarajah and Amarakoon unpublished data)
  - Chickpea: a 100 g serving of lentils provides 4.6-6.7 mg of iron, 3.7-7.4 mg of zinc, 15-56 µg of selenium, and 150-556 µg of folate (Thavarajah and Thavarajah, 2012; Jukanti et al., 2012).

Phytic acid

- Pulses including lentils, dry peas, and chickpeas are low in phytic acid (Amarakoon et al., 2012; Thavarajah and Thavarajah, 2012; Jukanti et al., 2012; Buecket et al., 2011).
- Low phytic acid increases mineral bioavailability.

Overall, pulses are a whole food high in protein, low in fat, rich in prebiotics, and contain no cholesterol and abundant low glycemic index carbohydrates. Pulses are valuable nitrogen fixing crops (approximately 150 kg/ha) that emit low levels of greenhouse gases. Incorporation of pulses into both daily diets and agricultural production may provide food-based solutions to healthy living and a means to sustainable development.

Eating 100 g of pulses could provide beneficial amounts of protein, iron, zinc, selenium, and folic acid and no cholesterol. *We should eat more US grown pulses!!*

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