

## FINAL REPORT

**Title:** Health Benefits of Organic, Conventional, and No-Till Wheat

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**Key Words:** Wheat, nutrition, wheat quality, crop rotation, organic, no-till, sustainable.

### Abstract:

This is the final report for our two-year study on nutritional and functional qualities of wheat grown under organic, conventional and no-till cropping systems. Considering the known effects of environmental conditions on grain yield and quality, we hypothesized that no-till and organic cropping systems alter the physical, chemical and nutritional characteristics of wheat grain.

Wheat samples from long-term cropping systems trials: Wheat was obtained from replicated field plots over two years in several long-term cropping systems studies. Soft white (SW) wheat was obtained from three no-till trials vs. conventional trials in Pendleton and Moro, Oregon. Hard red (HR) and SW wheat were obtained from organic vs. conventional trials in Pullman, WA. HR wheat was obtained from organic vs. conventional trials in Bozeman, MT. In addition, one year of HR wheat was obtained from a no-till vs. conventional trial in Bozeman.

Analyses conducted: (1) Kernel characteristics: weight, diameter, test weight, hardness; (2) whole meal flour composition and characteristics: protein content, protein quality, ash (total mineral) content, phenolic content, antioxidant content, and mineral analyses (Ca, Cu, Fe, Mg, Mn, P, Zn); (3) milling, flour, and end-use characteristics: flour yield, solvent retention capacity tests, dough and bread characteristics (HR wheat), and cookie and cake characteristics (SW wheat).

Organic vs. Conventional Observations: Organically-produced grain of SW winter and HR spring wheat from Pullman was higher in test weight, kernel diameter and kernel weight than grain produced in conventional cropping systems, while those differences were not evident in HR spring wheat grown in Bozeman, MT. Organic wheat of both soft and hard wheat grown in Pullman was significantly higher in ash content (indicator of total mineral content), but tended to be lower in protein content. Despite low protein content, organic HR wheat exhibited comparable protein strength determined by SDS sedimentation test. No differences were observed in protein content and quality between organic and conventionally grown wheat from Bozeman, MT. Differences in mineral content, polyphenol content and antioxidant activities of grain between organic and conventional cropping systems were either not significant or inconsistent among two wheat classes and two growing locations. There were no significant effects of organic management practices on flour yield, flour composition, cookie diameter, sponge cake volume and bread loaf volume.

No-Till vs. Conventional Observations: SW wheat produced with no-till exhibited significantly greater test weight, kernel diameter and weight, and lower kernel hardness than the grain of conventionally tilled SW. No-till management practices provided lower ash, protein

content, phenolic content, antioxidant capacity and higher cookie diameter (desirable) in SW wheat, whereas it imparted no significant effects on composition and baking quality of HR wheat (one year, one location for HR results). It is clear from these results that the organic and no-till cropping system environments influenced physical kernel characteristics and chemical composition of SW wheat.

Synopsis: Nutritional characteristics, including mineral analyses and antioxidant assays, don't suggest any consistent benefit for wheat produced under no-till or organic systems. End-use quality was generally similar among cropping systems. However, protein tended to be lower in both organic and no-till systems. This is generally undesirable for hard wheat products (bread) but is desirable for many soft wheat products (cookies, cake). Protein strength (quality) was generally similar among cropping systems, and end-use qualities were also generally similar.

Implications: One of the most important observations of this research is the tendency for lower protein under both organic and no-till systems. Lower protein was not surprising for organic wheat; however, this is, to the best of our knowledge, the first time lower protein has been reported in long-term no-till studies. In the case of soft wheat marketing, low protein is not a problem, but it is a problem for hard wheat marketing and products, and this is of special importance to no-till producers, such as those associated with Shepherds Grain, who produce hard red wheat for bread. Further studies are needed to confirm the lower protein of grain from no-till systems over years and locations, and to obtain additional data for hard wheat because almost all of our no-till data was from soft white wheat. This would help inform growers of the potential impact of their cropping systems on protein content and quality and may help them in their choice of wheat classes to produce and fertilization practices.

## **Project Description**

### *Introduction:*

Whole wheat is well established as an excellent source of dietary fiber, phytochemicals, and antioxidants such as phenolics and tocopherols, which are recognized to provide health benefits of protecting against diabetes, heart disease and certain cancers (Fardat, 2010). The nutritional merits of whole wheat are primarily due to the bran and germ components of the grain (which are absent in white flour), which in turn are associated with reduced glycemic index and reduced risk of colorectal and gastric cancer (Jacobs et al. 1995; Gao et al., 2002).

In some cases, organically-produced foods have been reported to have superior nutrient composition compared to conventional foods but this finding is not universal (Dangour et al., 2009). Organic wheat has been shown, in one study, to have slightly higher content of specific minerals compared to conventional wheat (Murphy, 2007). We are not aware of any such nutritional studies on no-till wheat. Under organic cropping systems, wheat is subjected to abiotic and biotic stresses and limitations, usually including altered nitrogen fertility and increased pressure from weeds, pests and diseases. In general, wheat yields are lower (Entz et al 2001) and grain protein content is lower (David et al 2005) under organic than conventional conditions. Comparatively severe stresses under organic cropping systems might also increase the accumulation of secondary metabolites including phenolic anti-oxidants.

Karl Kupers, John Aeschliman, and others associated with Shepherd's Grain have indicated a strong interest in knowing whether no-till wheat may also have nutritional advantages over

conventional till wheat. No-till cultural practices result in significant improvements in topsoil quality, properties, and microbial communities (including mycorrhizae), as well as soil moisture storage and fertility practices. It is quite possible that these changes lead to improved plant nutrition and growth, leading to improved nutritional value of the harvested grain.

*Justification:*

This proposal addresses the BIOAg priority, “Sustainable farming, processing, or marketing practices to increase food quality, nutrition, safety or access”. There is growing consumer demand for foods perceived as being safe, healthy and sustainable. Organic and no-till wheat are often perceived as safe and sustainable and are well-positioned to gain market share if nutritional or quality advantages can be identified. This project also has potential cross-over applications to conventional systems where there may be alternatives to the high, soil-degrading rates of chemical fertilizers that artificially increase protein content but not necessarily protein quality or nutritional value.

*Objective:*

The objective of this proposal is to quantify differences in bioactive constituents and properties of organic, no-till, and conventional wheat, including total dietary fiber, antioxidant activity, phenolic compounds, and glycemic index.

*Procedures:*

Wheat grain was roller-milled and the bran and shorts fractions ground to produce whole grain flour. The following grain and flour characteristics were determined:

- (1) Dietary fiber content (AACCI Approved Method 32-07).
- (2) Phenolic content
- (3) Starch digestibility was expressed using the proportion of rapidly digestible starch, slowly digestible starch and resistant starch (Englyst et al. 1992).
- (4) Antioxidant activity was determined using three methods: (A) a direct measurement of the total antioxidant capacity of flour using the ABTS reagent (Serpen et al. 2008); (B) iron chelating activity (Liyana-Pathirana and Shahidi, 2006); and (C) inhibition of lipid peroxidation (Burits and Bucar, 2000; Pieroni et al., 2002).
- (5) Mineral content was analyzed by Dr. Lin Yan, USDA-ARS, Grand Forks ND. The following minerals will be analyzed: Ca, Cu, Fe, Mg, Mn, P, and Zn.
- (6) Standard wheat quality evaluations including kernel protein and moisture content, seed size, test weight, and kernel hardness, and SDS-sedimentation.

**Outputs:**

A total of 119 wheat grain samples were collected and analyzed for this study. Wheat grain samples for comparison of organic and conventional cropping systems included: HR spring wheat grown in Bozeman, MT in 2006 and 2010, and Pullman, WA in 2011; SW winter wheat was grown in Pullman, WA in 2009 and 2010. Wheat grain samples for comparison of no-till and conventional tillage included: SW winter wheat samples obtained from three long-term studies in 2010 and 2011 by Drs. Machado and Gollany at Oregon State University; HR spring wheat samples of tillage and no-till comparison were also obtained in 2010 from Dr. Perry Miller in Bozeman, Montana.

**Organic vs. Conventional Results (Tables 1-8)**

Organic SW (Brundage 96) and HR (Kelse) wheat grown in Pullman exhibited greater kernel weight and diameter than conventionally grown wheat (Table 1). No differences in kernel weight and diameter between organic and conventional cropping systems were observed in wheat grown in Bozeman. Ash content of organic SW and HR wheat grown in Pullman was higher than that of conventionally grown wheat (Table 2). Organic HR wheat tended to be lower in protein content than conventionally grown wheat, but no differences in protein quality of HR wheat determined using SDS sedimentation volume were observed between organic and conventional grown wheat grains. Differences in mineral content, phenolic content and antioxidant capacity between organic and conventional wheat grain were mostly insignificant, and small or inconsistent among classes and varieties (Tables 3 & 4). Effects of organic cropping system on milling, flour functional properties and baking quality were relatively small. Organic wheat exhibited similar milling properties, flour composition and baking quality to conventionally grown wheat in both SW and HR wheat (Tables 5, 6, 7 & 8). Organic wheat tended to be lower in flour protein content than conventionally grown wheat, but produced comparable loaf volume of bread.

**No-Till vs. Conventional Results (Tables 9-16)**

SW wheat grain produced with no-tillage exhibited greater test weight, kernel weight and diameter, and lower ash, calcium and copper, phenolic content and radical scavenging capacity than grain produced with conventionally tillage (Tables 9, 10, 11 & 12). HR wheat grain, on the other hand, exhibited little differences in physical and compositional characteristics between two tillage systems. Higher iron, magnesium, phosphorus and zinc content of wheat grain was observed with no-tillage than conventional tillage.

Tillage practice had little influence on milling properties of grain and flour ash content of SW and HR wheat, and protein content, dough mixing properties and bread baking quality of HR wheat (Tables 13, 14, 15 & 16). SW wheat grown with no-tillage was lower in protein content, SDS sedimentation volume (weaker protein) and lactic and sucrose solvent retention capacity, and consequently produced cookie of larger diameter than wheat grown with conventional tillage.

### Organic vs. Conventional Results (Tables 1-8):

Table 1. Physical kernel characteristics of wheat grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Test Weight (lb/bu)	Kernel Hardness	Kernel Weight (mg)	Kernel Diameter (mm)
Soft wheat	Brundage 96	Organic	59.7	28.5	32.7 <sup>a</sup>	2.74 <sup>a</sup>
		Conventional	58.6	28.4	28.8 <sup>b</sup>	2.62 <sup>b</sup>
Hard wheat	Kelse	Organic	64.3 <sup>a</sup>	66.4	40.0 <sup>a</sup>	3.04 <sup>a</sup>
		Conventional	63.7 <sup>b</sup>	68.8	36.3 <sup>b</sup>	2.91 <sup>b</sup>
	Hank	Organic	57.8	68.0	30.5	2.74
		Conventional	57.5	67.5	31.9	2.77
Vida	Organic	63.0 <sup>a</sup>	73.6 <sup>a</sup>	33.4	2.79	
	Conventional	61.1 <sup>b</sup>	64.7 <sup>b</sup>	34.4	2.79	

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 2. Composition of wheat grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Ash (%)	Protein (%)	SDS Sedimentation Volume (ml)
Soft wheat	Brundage 96	Organic	1.51 <sup>a</sup>	10.26	44.3
		Conventional	1.34 <sup>b</sup>	10.83	51.9
Hard wheat	Kelse	Organic	1.39 <sup>a</sup>	11.94 <sup>b</sup>	77.3
		Conventional	1.26 <sup>b</sup>	13.01 <sup>a</sup>	76.7
	Hank	Organic	1.68	13.93	69.1
		Conventional	1.73	14.64	66.6
Vida	Organic	1.23 <sup>b</sup>	12.23	68.8	
	Conventional	1.48 <sup>a</sup>	12.35	65.5	

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 3. Mineral content of wheat grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Mineral (ug/g)						
			Ca	Cu	Fe	Mg	Mn	P	Zn
Soft wheat	Brundage 96	Organic	378	4.50	46.8	1189	42.4	3166 <sup>a</sup>	23.4 <sup>a</sup>
		Conventional	375	4.47	47.9	1139	40.8	2577 <sup>b</sup>	19.8 <sup>b</sup>
Hard wheat	Kelse*	Organic	395	4.66	41.1	1200	39.9	2670	21.6
		Conventional	375	5.07	40.2	1181	39.0	2599	25.5
	Hank	Organic	397 <sup>b</sup>	6.20	38.7	1460	41.0 <sup>b</sup>	3375	27.6
		Conventional	441 <sup>a</sup>	6.40	37.9	1506	47.9 <sup>a</sup>	3341	26.7
	Vida	Organic	309	4.56	36.7 <sup>b</sup>	1357	40.3 <sup>b</sup>	2677 <sup>b</sup>	22.9
		Conventional	323	4.60	42.3 <sup>a</sup>	1422	46.9 <sup>a</sup>	3239 <sup>a</sup>	24.1

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 4. Phenolic content and antioxidant capacity of wheat grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Phenolic content (mg Gallic acid/g)	Iron chelating capacity (mg EDTA Eq./g)	Radical scavenging capacity, TEAC (mmol Trolox/g)
Soft wheat	Brundage 96	Organic	4.45	4.27 <sup>a</sup>	25.41 <sup>b</sup>
		Conventional	4.58	3.65 <sup>b</sup>	27.20 <sup>a</sup>
Hard wheat	Kelse	Organic	5.93 <sup>b</sup>	6.09	30.07 <sup>b</sup>
		Conventional	6.17 <sup>a</sup>	5.85	32.25 <sup>a</sup>
	Hank	Organic	6.47	6.12	32.57
		Conventional	6.31	6.11	32.69
	Vida	Organic	4.78	3.49 <sup>b</sup>	28.91
		Conventional	4.75	5.15 <sup>a</sup>	28.46

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 5. Milling properties of wheat grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Flour yield (%)	Break flour yield (%)	Mill score
Soft wheat	Brundage 96	Organic	71.7	48.3	85.0
		Conventional	71.5	47.8	86.8
Hard wheat	Kelse	Organic	68.1	34.6 <sup>b</sup>	81.2 <sup>b</sup>
		Conventional	68.2	37.2 <sup>a</sup>	84.1 <sup>a</sup>
	Hank	Organic	69.4 <sup>b</sup>	42.3	78.9 <sup>b</sup>
		Conventional	70.6 <sup>a</sup>	42.7	80.7 <sup>a</sup>
Vida	Organic	68.2	34.2 <sup>b</sup>	85.2	
	Conventional	67.8	36.5 <sup>a</sup>	83.5	

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 6. Composition and protein quality of wheat flour milled from grain produced under organic and conventional cropping systems

Class	Variety	Cropping System	Ash (%)	Protein (%)	SDS Sedimentation Volume (ml)
Soft wheat	Brundage 96	Organic	0.43 <sup>a</sup>	7.75	10.1
		Conventional	0.40 <sup>b</sup>	8.43	12.2
Hard wheat	Kelse	Organic	0.43	10.68 <sup>b</sup>	22.3 <sup>b</sup>
		Conventional	0.37	11.76 <sup>a</sup>	25.7 <sup>a</sup>
	Hank	Organic	0.50	11.91	25.2
		Conventional	0.49	12.69	26.1
Vida	Organic	0.35	10.34	12.8	
	Conventional	0.38	10.49	13.0	

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Brundage 96 (3 field replications, Pullman, 2009 and 2010), Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).

Table 7. Biochemical properties and baking quality of refined soft wheat flour milled from grain of Brundage 96 produced under organic and conventional cropping systems

Cropping System	Solvent Retention Capacity (%)				Cookie diameter (mm)	Cake volume (ml)
	Carbonate	Lactic	Water	Sucrose		
Organic	72.0	92.2	53.3	89.3	9.19	1174
Conventional	72.3	101.9	52.9	88.9	9.26	1195

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Values for Brundage 96 were means of three field replications in 2009 and 2010.

Table 8. Bread baking quality of refined hard wheat flour milled from grain produced under organic and conventional cropping systems

Variety	Cropping System	Bread dough absorption (%)	Bread dough mixing time (min.)	Bread Loaf Volume (ml)
Kelse	Organic	64.7	4.2	1084
	Conventional	65.9	3.8	1120
Hank	Organic	64.8 <sup>b</sup>	5.7 <sup>a</sup>	1136
	Conventional	67.9 <sup>a</sup>	5.2 <sup>b</sup>	1142
Vida	Organic	65.8 <sup>a</sup>	3.3	914
	Conventional	64.3 <sup>b</sup>	3.5	965

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Shown are mean values for Kelse (3 replications, Pullman, 2011), Hank (4 replications, Bozeman, 2000) and Vida (3 replications, Bozeman, 2010).



### No-Till Results (Tables 9-16):

Table 9. Physical kernel characteristics of wheat grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Test Weight (lb/bu)	Kernel Hardness	Kernel Weight (mg)	Kernel Diameter (mm)
ORCF 102	No-till	61.2 <sup>a</sup>	33.1 <sup>b</sup>	39.3 <sup>a</sup>	2.86 <sup>a</sup>
	Conventional	60.4 <sup>b</sup>	34.9 <sup>a</sup>	37.1 <sup>b</sup>	2.79 <sup>b</sup>
Vida	No-till	61.2	66.6	33.1	2.78
	Conventional	61.1	64.7	34.4	2.79

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 10. Composition and protein quality of wheat grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Ash (%)	Protein (%)	SDS Sedimentation Volume (ml)
ORCF 102	No-till	1.41 <sup>b</sup>	8.26 <sup>a</sup>	28.3 <sup>b</sup>
	Conventional	1.45 <sup>a</sup>	8.26 <sup>a</sup>	31.7 <sup>a</sup>
Vida	No-till	1.41	12.26	68.2
	Conventional	1.48	12.26	65.5

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 11. Mineral content of wheat grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Mineral (ug/g)						
		Ca	Cu	Fe	Mg	Mn	P	Zn
ORCF 102	No-till	232 <sup>b</sup>	2.34 <sup>b</sup>	27.5	960	37.7 <sup>a</sup>	2352	13.4
	Conventional	249 <sup>a</sup>	2.54 <sup>a</sup>	28.5	946	33.6 <sup>b</sup>	2270	13.7
Vida	No-till	322	4.56	39.4 <sup>a</sup>	1434 <sup>a</sup>	44.9	2996 <sup>a</sup>	23.6 <sup>a</sup>
	Conventional	338	4.40	32.9 <sup>b</sup>	1116 <sup>b</sup>	45.1	2577 <sup>b</sup>	18.5 <sup>b</sup>

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 12. Phenolic content and antioxidant capacity of wheat grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Phenolic content (mg Gallic acid eq./g)	Iron chelating capacity(mg EDTA Eq./g)	Radical scavenging capacity, TEAC (mmol Trolox/g)
ORCF 102	No-till	4.51 <sup>b</sup>	4.76	22.74 <sup>b</sup>
	Conventional	4.63 <sup>a</sup>	4.62	24.21 <sup>a</sup>
Vida	No-till	4.77	4.45 <sup>b</sup>	28.97
	Conventional	4.75	5.14 <sup>a</sup>	28.46

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 13. Milling quality parameters of wheat grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Flour yield (%)	Break flour yield (%)	Mill score
ORCF 102	No-till	68.5	45.2	83.5
	Conventional	68.8	45.5	83.4
Vida	No-till	68.3	36.6	84.6
	Conventional	67.8	36.5	83.5

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 14. Composition and protein quality of wheat flour milled from grain produced under no-tillage and conventional tillage systems

Variety	Tillage	Ash (%)	Protein (%)	SDS Sedimentation Volume (ml)
ORCF 102	No-till	0.39	6.56 <sup>b</sup>	7.3 <sup>b</sup>
	Conventional	0.40	7.25 <sup>a</sup>	8.9 <sup>a</sup>
Vida	No-till	0.37	10.58	13.6
	Conventional	0.38	10.49	13.0

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ).

Values for ORCF102 were means of three field replications grown in Pendleton, OR in 2010 and 2011, while values for Vida were means of three replications grown in Bozeman, MT in 2010.

Table 15. Biochemical properties and baking quality of soft wheat flour milled from grain of var. ORCF 102 produced under no-tillage and conventional tillage systems

Tillage	Solvent Retention Capacity (%)				Cookie diameter (mm)	Cake volume (ml)
	Carbonate	Lactic	Water	Sucrose		
No till	69.5	78.3 <sup>b</sup>	53.5	84.1 <sup>b</sup>	9.24 <sup>a</sup>	1237
Conventional	70.8	82.3 <sup>a</sup>	53.7	85.1 <sup>a</sup>	9.19 <sup>b</sup>	1224

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Values were means of three field replications grown in Pendleton, OR in 2010 and 2011.

Table 16. Mixing and baking quality of hard wheat flour milled from grain of var. Vida produced under no-tillage and conventional tillage systems

Tillage	Mixograph				Dough Mixing time (min.)	Bread Loaf Volume (ml)
	Absorption (%)	Peak time (min.)	Peak width	Absorption (%)		
No till	61.5	4.3	200.7	65.3	3.4	939
Conventional	61.4	4.2	196.2	64.3	3.5	965

Values with different letters within each wheat class are significantly different ( $P < 0.05$ ). Values were means of three replications grown in Bozeman, MT in 2010.

**Abstracts and Publications:**

Park, E.Y., E.P. Fuerst, P.R. Miller, S. Machado, I.C. Burke, and B.-K. Baik. 2011. Functional and nutritional characteristics of wheat grown in organic, no-till, and conventional cropping systems. Abstract and poster for 2011 meeting of American Association of Cereal Chemists, International. Poster also presented at the 20<sup>th</sup> Anniversary of the WSU Center for Sustaining Agriculture Natural Resources December 6, 2012.

E. P. Fuerst, E.Y. Park, C.F. Morris, S. Machado, P. . Miller, I.C. Burke, E. Wegner, and B.-K. Baik 2011. End-Use Quality and Nutritional Aspects of Organic, No-till, and Conventional Dryland Wheat. Poster presented 11/11/2011 at the Washington Tilth 'Dryland Organic Farming Conference' in Yakima, WA. Poster also presented at the 20<sup>th</sup> Anniversary of the WSU Center for Sustaining Agriculture Natural Resources December 6, 2012.

This research has been written in two draft manuscripts, one comparing organic vs. conventional and the other comparing no-till vs. conventional. They are part of Eun Young Park's dissertation, tentative defense date December, 2013, with the intent that they will be published in *Cereal Chemistry*. Funding from BIOAg and Shepherd's Grain will be acknowledged.

**Outreach:**

The results obtained from the current study were presented (above) at the 2011 meeting of American Association of Cereal Chemists, at the conference "*Dryland Organic Farming in the Pacific Northwest*" in Yakima November 10-11, 2011 and at the CSANR 20<sup>th</sup> Anniversary celebration in 2012. Results will be published in a refereed journal and in grower and industry publications such as *Wheat Life* and *Cereal Foods World*.

**Impacts:**

This research demonstrates that both organic and no-till cropping systems affect the physical grain characteristics and composition with no apparent negative influences on functional and end-product quality. Organic and no-till cropping systems tend to lower protein content of grain, which is desirable for SW wheat, but not for HR. Even with generally lower protein content of grain, HR wheat grown under organic and no-till cropping systems still possesses comparable bread baking quality to HR wheat grown under conventional systems. This could partially defray our concern on low protein content of organic HR wheat compared to conventionally grown wheat. Organic and no-till cropping systems had limited effects on nutritional characteristics of wheat grain, including mineral content, phenolic content and anti-oxidant capacity.

**Additional Funding Applied for / Secured**

Shepherd's Grain provided \$6,000 in 2010 to support this project. The information gathered and results obtained on whole grain characteristics while conducting this project were essential for us to procure an international collaborative research project (Dr. Baik, \$110,000) on whole grain wheat quality and processing for extended food uses and enhanced product quality with the Rural Development Administration-Korea. Following publication of these results, we will be in a good position to contribute to AFRI and OREI (Organic Research and Extension Initiative) proposals.

### **Graduate Students Funded**

This BioAg-supported project provided support for Eun Young Park as Ph.D. candidate in School of Food Science over a two-year period.

### **Recommendations for future research**

One of the most important observations of this research is the tendency for lower protein under both organic and no-till systems. In the case of soft wheat marketing, this is not a problem, but it is a problem for hard wheat marketing and products, and this is of special importance to no-till producers, such as those associated with Shepherd's Grain. Further studies are needed to confirm the lower protein of grain from no-till systems over years and locations, and to obtain additional data for hard wheat because almost all of our data for no-till was from soft white wheat. This would help inform growers of the potential impact of their cropping systems on protein content and quality and may help them in their choice of wheat classes to produce and fertilization practices.

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