Composition and Functionality of Peas Grown in South Dakota

Technical Bulletin

By

Clifford Hall
Christopher Graham

Contents

Funding Sources

Funding was made possible by the U.S. Department of Agriculture's (USDA) Agricultural Marketing Service via the South Dakota Department of Agriculture and Natural Resources through sub-recipient award 2020SDSU07. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.

Additional Funding through the South Dakota Agricultural Experiment Station

South Dakota State University
College of Agriculture, Food and Environmental Sciences

Overview of Project

The protein and starch composition and functional properties of spring and winter peas grown in 2021 at the Western Trial location near Sturgis, SD was the source material highlighted in this report. The data is based on the evaluation of nearly 200 individual samples with approximately 16 winter (Figure 1) and 30 spring (Figure 2) pea varieties being included in the analysis. The data presented are the mean values of the four plots where the pea samples were grown. In a few cases, mean values were the outcome of pea obtained from two plots. Agronomic data regarding the pulses used in this report can be found at the South Dakota State University Extension website (https://extension.sdstate.edu/field-pea-variety-trial-results). Prior to analyses, all samples were hand cleaned to remove any broken seeds and the cleaned seeds were then milled through a 0.5 mm screen on a Udy mill. Analytical methods were based on the approaches used by the Pulse Quality and End Use Laboratory at South Dakota State University to determine pulse quality data. The composition analyses completed on the samples included protein and starch percentage, and amylose percentage on a selected number of samples. Functionality tests included pasting properties as measured by the rapid visco analyzer (RVA), oil and water holding capacities and foaming properties. In addition, application of pea starch in pudding and yogurt is presented as an example of the properties of pea starch.

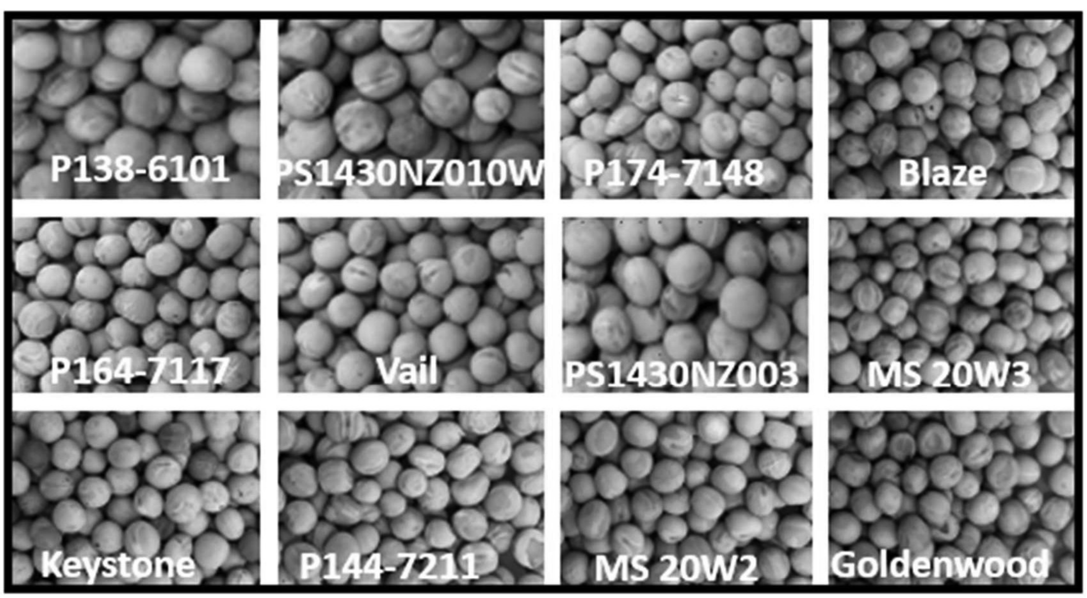


Figure 1. Example varieties of winter peas used in the study.

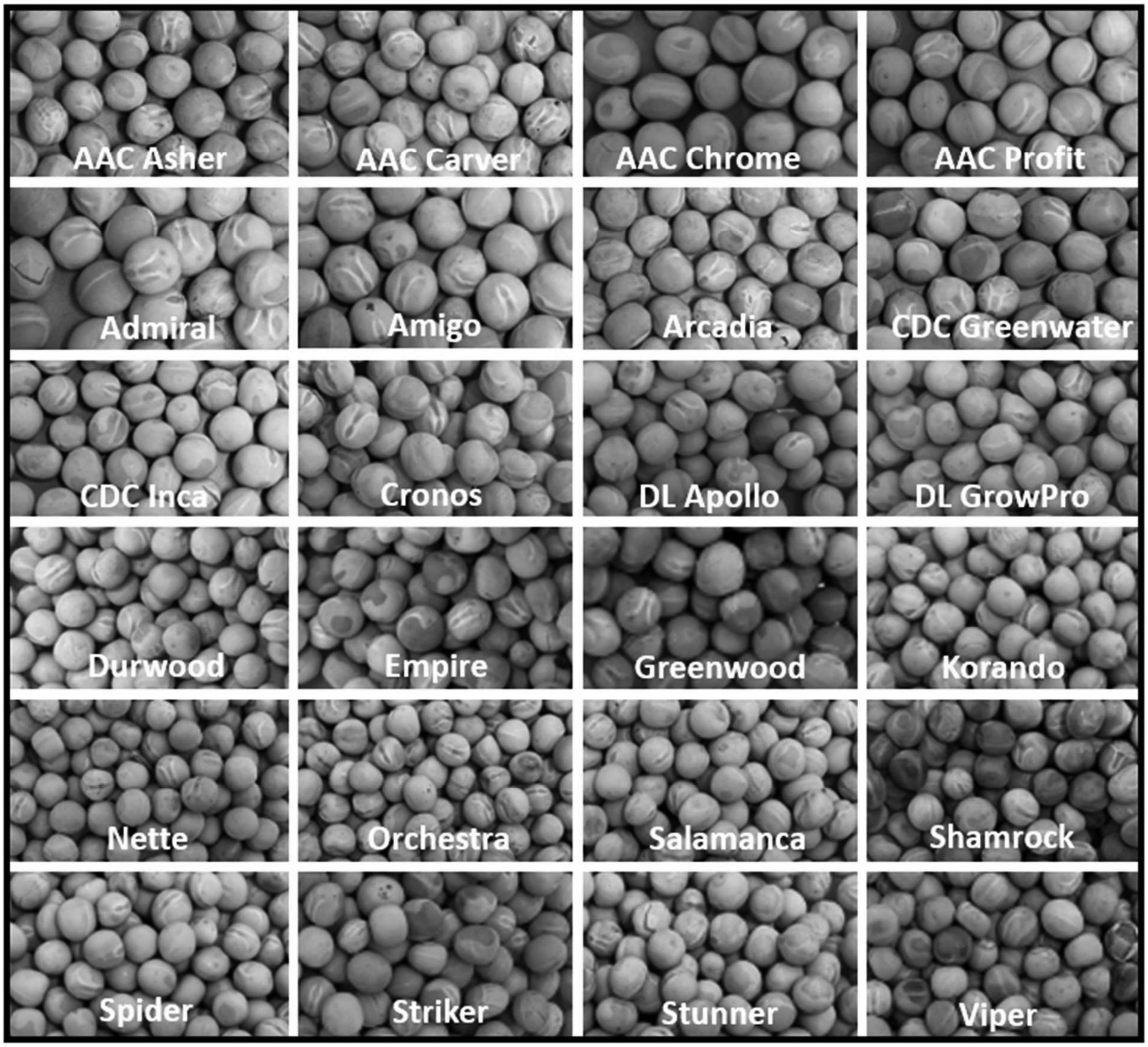


Figure 2. Example varieties of spring peas used in the study.

Composition Results

The protein and starch (Tables 1-2) represent the mean values of samples obtained from the four plots where the samples were grown. In a few cases, the data is representative of samples from two plots. The protein content of the winter peas ranged from 24.6% to 26.8% in the experimental lines P144-7211 and PS1430NZ010W, respectively (Table 1). In the commercial varieties tested, Goldenwood and Blaze had the highest (26.0%) and lowest (25.4%) protein content, respectively. In spring varieties, the mean protein was 26.1% among all samples tested (Table 2), which is slightly higher than the 25.6% mean protein content for the winter varieties. The protein content of spring peas ranged from 24.7% in AAC Carver to 27.1% in Striker. With few exceptions, the standard deviation (StDev) tended to be less than 0.5 percentage points and thus support the minimal variability in protein contents within a variety. As expected, variability in protein content between varieties was observed.

The mean starch content was 40.9% for the winter peas with a range from 39.3% to 42.1% for varieties P154-7225 and PS1430NZ010W, respectively. Like protein, these were experimental lines. Blaze and Keystone had the highest (41.7%) and lowest (40.3%) protein content among commercial varieties, respectively. The mean starch content of spring peas was 41.0%, with a range of 39.0% to 44.0% in the Viper and Nette 2010 varieties, respectively. Unlike protein, the starch content was slightly more variable based on StDev. The mean StDev within a variety was approximately 0.8 and 1.3 percentage points for winter and spring categories, respectively. The higher StDev likely is partly attributed to the analytical protocol. The amylose content is represented as the percentage amylose in the total starch value. The amylose content ranged from 21.8% to 37.4 in winter pea lines P174-7148 and line P144-7211, respectively. In spring peas, Durwood had an amylose content of 39.5% while Salamanca had the lowest (21.1%) amylose content. The majority of the other samples had amylose

Table 1. Protein and starch content (%) of winter pea varieties.

	Protein Content (%)		Starch Content (%)	
Variety	Mean	StDev	Mean	StDev
Blaze	25.4	0.47	41.7	1.65
Goldenwood	26.0	0.49	41.2	1.55
Keystone	25.5	0.28	40.3	0.75
MS 20W2	25.1	0.22	40.5	0.89
MS 20W3	25.2	0.30	40.7	0.77
MS 20WIL	25.9	0.24	39.7	0.63
P144-7211	24.6	0.37	41.4	0.26
P154-7225	26.1	0.54	39.3	1.20
P164-7117	25.3	0.55	41.6	1.43
P174-7148	25.2	0.79	40.9	0.60
PS1430NZ003	25.6	0.20	41.8	0.13
PS1430NZ010W	26.8	0.25	42.1	0.41
PS1430NZ011W	26.0	0.10	40.2	0.00
Vail	25.8	0.43	40.9	1.31

contents between 26 and 33%.

Functionality Results

Table 2. Protein and starch contents (%) of spring pea varieties.

	Protein Content (%)		Starch Content (%)	
Variety	Mean	StDev	Mean	StDev
AAC Asher	25.0	0.31	41.2	0.55
AAC Carver	24.7	0.33	40.2	0.15
AAC Chrome	25.4	0.31	40.5	0.83
AAC Profit	26.0	0.29	42.6	0.47
Admiral	25.6	0.64	41.2	0.60
Amigo	26.2	0.11	41.2	1.54
Arcadia	25.5	0.36	41.9	1.83
CDC Greenwater	26.4	0.36	40.8	1.92
CDC Inca	26.3	0.75	41.6	1.74
CDC Saffron	25.7	0.50	41.5	0.55
CDC Spectrum	26.0	0.31	41.1	0.63
Cronos	26.8	0.29	40.2	0.62
DL Apollo	26.8	0.37	41.6	1.17
DL GrowPro	26.2	0.38	40.7	0.83
Durwood	26.0	0.73	41.7	1.82
Empire	26.8	0.43	39.8	2.68
Greenwood	26.2	0.47	39.1	0.71
Korando	26.2	0.47	42.0	2.08
MS-19YP3	26.2	0.46	41.3	1.81
MS-20GP5	25.9	0.30	41.4	1.87
MS-20YP4	26.5	0.66	41.2	2.03
Nette 2010	25.5	0.49	44.0	1.73
Orchestra	26.7	0.61	39.9	0.67
Salamanca	26.3	0.75	39.3	2.25
Shamrock	26.6	0.30	40.7	1.12
Spider	26.2	0.49	40.6	1.42
Striker	27.1	0.89	40.6	2.84
Stunner	26.1	0.21	42.0	1.27
Viper	26.6	0.47	39.0	1.63

The lack of information about the functional properties of pulse relative to variety warranted the current investigation. The water holding capacity and oil holding capacities are an indicator of how much water, usually measured in grams (g), can bind to one gram of dry flour. These properties are important as they indicate how much water may be needed to fully hydrate the flour. This is an important measure in baking and batter applications, where insufficient water hydration leads to dry products. Oil holding capacity may indicate, for example, how much oil is taken up by a batter during frying. While there is no specific target number for water or oil holding capacity, defining these can provide industry with values that can be targeted for applications such as gluten free cookies.

The oil holding capacity of the winter peas ranged from 0.05 to 0.39 g oil/g flour with a mean value of 0.21 g oil/g flour (Table 3). Blaze and MS20W2 had the highest and lowest mean oil holding capacities at 0.27 and 0.11 g oil/g flour, respectively. The mean oil holding capacity for the spring peas was 0.19 g oil/g flour. Stunner and CDC Spectrum had the lowest and highest oil holding capacities, respectively (Table 4). The water holding capacities were higher for both winter and spring peas compared to oil holding capacities. The mean water holding capacities for winter and spring peas were 1.27 and 1.28 g water/g flour, respectively. The Goldenwood and Vail had the lowest and highest values at 1.04 and 1.61 g water/g flour, respectively (Table 3). However, the mean value water holding capacity of Vail was the same as PS1430NZ011W even though Vail had the highest single water holding capacity. In spring peas, the single lowest (0.99 g water/g flour) and highest (1.62 g water/g flour) water holding capacities were observed for Amigo/Viper and Nette 2010, respectively (Table 4). While Amigo and Viper had a single low water holding capacity values, AAC Carver had the lowest overall mean water holding capacity of the spring peas, indicating less variability for AAC Carver.

Table 3. Functional properties of winter peas.

	Oil Holding Capacity (g oil/g dry flour)		Water Holding Capacity (g water/g flour)		Foaming Capacity (%)		Foaming Stability (%)	
Variety	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
Blaze	0.27	0.09	1.27	0.03	214	23	54	6
Goldenwood	0.20	0.07	1.09	0.06	202	32	61	7
Keystone	0.20	0.04	1.29	0.04	170	17	54	0
MS 20W2	0.11	0.05	1.31	0.12	217	31	56	4
MS 20W3	0.22	0.07	1.30	0.12	186	28	61	5
MS 20WIL	0.15	0.04	1.30	0.19	222	21	49	10
P138-6101	0.19	0.06	1.18	0.01	220	7	56	10
P144-7211	0.21	0.07	1.30	0.11	193	19	57	8
P154-7225	0.23	0.08	1.28	0.12	170	40	55	13
P164-7117	0.22	0.08	1.19	0.10	178	46	48	11
P174-7148	0.19	0.06	1.29	0.09	167	31	56	8
P188-6101	0.28	0.00	1.09	0.00	180	0	57	0
PS1430NZ003	0.25	0.03	1.14	0.09	225	25	66	1
PS1430NZ010W	0.15	0.08	1.23	0.05	207	7	53	6
PS1430NZ011W	0.17	0.06	1.40	0.08	193	37	76	7
Vail	0.23	0.07	1.40	0.13	198	24	50	6

Foaming capacity is a functionality that indicates how well a material will foam under a stress such as whipping. Foam capacity generally exceeds 100%. Stability is done in tandem with foaming capacity and is indicative of the retention of the volume of foam created initially during the shearing event. Stability is generally measured after 30 minutes and falls between a value of 0 and 100%. Ideally, both foaming capacity and foam stability would be high values. However, as foaming capacity increases, stability generally decreases. In the samples evaluated, this relationship was not observed and thus a random effect was noted between the foaming capacity and foam stability.

Table 4. Functional properties of spring peas.

	Oil Holding Capacity (g oil / g flour)		Water Holding Capacity (g water / g flour)		Foaming Capacity (%)		Foaming Stability (%)	
Variety	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
AAC Asher	0.18	0.07	1.23	0.03	247	32	59	6
AAC Carver	0.15	0.01	1.15	0.00	235	22	60	1
AAC Chrome	0.19	0.06	1.39	0.14	242	10	62	14
AAC Profit	0.19	0.07	1.31	0.11	222	9	68	11
Admiral	0.18	0.05	1.16	0.13	203	62	62	8
Amigo	0.23	0.10	1.21	0.16	215	13	62	2
Arcadia	0.23	0.03	1.21	0.11	249	13	68	3
CDC Greenwater	0.14	0.04	1.23	0.11	233	14	51	13
CDC Inca	0.20	0.05	1.29	0.10	254	21	62	11
CDC Saffron	0.20	0.05	1.17	0.04	230	22	56	5
CDC Spectrum	0.26	0.13	1.32	0.12	252	29	57	7
Cronos	0.11	0.01	1.26	0.14	243	5	54	12
DL Apollo	0.19	0.02	1.28	0.05	220	26	76	5
DL GrowPro	0.18	0.05	1.36	0.11	253	17	65	11
Durwood	0.17	0.06	1.20	0.10	200	18	57	17
Empire	0.19	0.05	1.30	0.17	232	30	65	6
Greenwood	0.23	0.04	1.30	0.19	230	16	60	4
Korando	0.23	0.02	1.37	0.15	223	19	62	5
MS-19YP3	0.14	0.03	1.22	0.13	198	26	66	6
MS-20GP5	0.21	0.07	1.37	0.12	218	51	70	9
MS-20YP4	0.21	0.04	1.28	0.05	229	30	64	13
Nette	0.23	0.04	1.45	0.15	257	25	51	7
Orchestra	0.20	0.04	1.23	0.05	247	14	51	9
Salamanca	0.17	0.07	1.29	0.09	230	31	65	17
Shamrock	0.23	0.02	1.21	0.10	193	27	73	1
Spider	0.20	0.06	1.24	0.08	212	49	55	4
Striker	0.14	0.01	1.24	0.04	266	26	56	13
Stunner	0.17	0.09	1.33	0.09	242	19	62	16
Viper	0.23	0.03	1.24	0.22	215	35	69	8

The foaming capacity of the winter peas ranged from 110 to 247% with a mean value of 196% (Table 3). P164-7117 and Goldenwood were the varieties associated with the lowest and highest individual foaming capacities, respectively. However, the highest and lowest mean foaming capacities were observed in PS1430NZ003 and P174-7148, respectively (Table 3). The mean foaming capacity of the spring peas was 231% with a range of 100 to 297%. Admiral and AAC Asher had the lowest and highest foaming capacities for individual samples. However, Shamrock and Striker had the lowest (193%) and highest (266%) mean values, respectively (Table 4). The high standard deviation of the Admiral variety suggests greater variability in the foaming capacity while less variability in foaming capacity was observed in samples from the Cronos variety.

The mean foaming stability of the winter and spring peas was 56 and 62%, respectively, and indicates a moderate foam stability. The foaming stability of individual samples ranged from 33 to 83% and 31 to 84% for the winter and spring peas, respectively. The high (83 to 84%) foaming stability suggests that the PS1430NZ011W and DL Apollo were excellent foam stabilizers. These varieties also had overall mean foam stabilities that were higher than other samples (Tables 3 and 4).

The pasting properties of a flour are generally driven by the starch component of the flour. However, other components can impact the pasting properties. Matching a desired pasting property is an effective approach to target ingredient replacement during product improvement. The rapid visco analyzer or RVA is one tool to assess pasting properties of a flour. This instrument heats the sample and water, under slight agitation, in a stepwise fashion until a temperature of 95°C is reached. During this phase the peak viscosity is often reached. Peak viscosity occurs when the intact starch granules absorb a maximum amount of water, resulting in maximum swelling of the intact granules. Continued heating at 95°C eventually leads to the disruption of the granules and a drop in viscosity is observed. The trough or hot paste viscosity results during this phase of the test and is usually the lowest viscosity observed during the test. The difference between the peak and hot paste viscosity is referred to as breakdown. Breakdown is the resistance to granule disruption and thus the lower the breakdown, the more resistant the granules are to disintegration. At the end of the 95°C holding period, the temperature is gradually cooled to 50°C and then held at 50°C for a predetermined time. At the end of the cycle, a final viscosity is established. In many cases, this viscosity will be the highest among the viscosities recorded. The difference between final viscosity value and the hot paste viscosity value is referred to as the total setback (this was recorded in the current research) and is indicative of ability of the paste to form a gel. The setback is understood to be the result of a reassociation (i.e., recrystallization) of amylose in the starch. Thus, higher setback is attributed to higher amylose in the sample. In this research, pasting viscosities were different between variety (Tables 5 and 6; Figures 3-5).

The mean peak viscosity of all winter pea samples was 1251 cP, with a range in values from 1008 to 1517 cP. The individual samples from P174-7148 and P164-7117 had the lowest and highest peak viscosities, respectively. However, the PS1430NZ010W and PS1430NZ011W had the highest and lowest peak viscosity mean values, respectively (Table 5). Of the commercial varieties tested, Blaze had the highest mean peak value. The spring samples had a higher mean peak viscosity value (1529 cP) compared to the winter samples. The Spider and Cronos varieties had the lowest (1100 cP) and highest (2011 cP) peak viscosities on an individual sample basis and followed the same trend on a mean basis (Table 6).

The hot paste viscosity of all winter pea samples was 1186 cP, with a range in values from 1000 to 1372 cP. Like the peak viscosities, individual samples from P174-7148 and P164-7117 had the lowest and highest hot paste viscosities, respectively. Furthermore, the PS1430NZ010W and PS1430NZ011W lines had the highest and lowest hot paste viscosity mean values, respectively (Table 5). The Spider and Cronos had the lowest (1026 cP) and highest (1802 cP) hot paste viscosities on an individual sample basis while AAC Carver and Shamrock had the lowest and highest hot paste viscosities on a mean basis (Table 6). Overall, the mean hot paste viscosity (1358 cP) was higher in spring pea samples than winter peas (1186 cP).

The mean final viscosity value for winter peas was 1719 cP, where P144-7211 and Blaze had the lowest (1422 cP) and highest (2059 cP) final viscosities on an individual basis. On a mean basis, Blaze had the highest (1823 cP) final viscosity while PS1430NZ011W had the lowest (1588 cP) (Table 5). Like the other viscosity measures, spring peas had an overall mean final viscosity that was higher (2028 cP) than that of the winter varieties. The Spider and Cronos varieties had the lowest (1412 cP) and highest (2504 cP) final viscosities on an individual basis, respectively. AAC Carver and Shamrock had the lowest (1807 cP) and highest (2385 cP) final viscosities on a mean basis, respectively (Table 6).

Table 5. Pasting properties of winter peas obtained using a rapid visco analyzer (RVA).

	Peak Viscosity (cP)		Hot Paste Viscosity (cP)		Final Viscosity (cP)		Pasting Temp. (°C)	
Variety	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
Blaze	1285	140	1223	116	1823	181	81.3	0.7
Goldenwood	1337	29	1250	26	1804	17	80.8	0.6
Keystone	1197	72	1162	56	1706	92	81.6	1.8
MS 20W2	1279	66	1184	53	1696	91	80.0	0.1
MS 20W3	1121	54	1091	50	1610	75	80.7	0.8
MS 20WIL	1212	86	1143	67	1672	91	80.0	1.3
P138-6101	1226	68	1155	29	1656	44	82.0	0.4
P144-7211	1213	77	1179	90	1652	174	80.1	0.3
P154-7225	1252	103	1175	68	1667	121	81.2	0.7
P164-7117	1285	179	1213	132	1775	175	80.7	0.5
P174-7148	1202	194	1167	167	1737	212	80.4	2.0
P188-6101	1282	0	1243	0	1879	0	81.6	0.0
PS1430NZ003	1317	35	1192	38	1795	101	80.4	0.4
PS1430NZ010W	1407	59	1291	80	1756	99	79.6	0.3
PS1430NZ011W	1108	53	1086	52	1588	70	81.1	0.4
Vail	1343	21	1264	25	1800	38	80.2	0.4

Table 6. Pasting properties of spring peas obtained using a rapid visco analyzer (RVA).

	Peak Viscosity (cP)		Hot Paste Viscosity (cP)		Final Viscosity (cP)		Pasting Temp. (°C)	
Variety	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
AAC Asher	1408	31	1347	25	2030	120	80.1	0.3
AAC Carver	1367	50	1280	62	1807	85	79.1	0.1
AAC Chrome	1417	94	1341	106	1934	188	80.8	0.0
AAC Profit	1530	48	1426	31	2114	135	80.6	0.3
Admiral	1543	67	1418	119	2025	145	79.6	0.9
Amigo	1577	10	1421	100	1964	69	79.4	0.4
Arcadia	1551	52	1386	92	1917	113	80.3	0.5
CDC Greenwater	1566	109	1467	140	2192	176	79.5	0.7
CDC Inca	1536	49	1403	112	1976	114	79.8	0.3
CDC Saffron	1510	8	1418	57	2062	80	79.2	0.0
CDC Spectrum	1566	33	1473	81	2170	88	79.9	0.5
Cronos	1604	257	1440	218	2059	308	79.6	0.5
DL Apollo	1580	81	1440	114	2023	31	79.2	0.1
DL GrowPro	1503	17	1361	87	1926	79	79.4	0.6
Durwood	1519	57	1350	66	1861	90	79.2	0.6
Empire	1445	61	1344	46	1962	35	79.9	1.0
Greenwood	1524	54	1413	108	2051	62	79.3	0.3
Korando	1524	90	1381	113	1955	170	78.8	0.4
MS-19YP3	1599	34	1448	83	2090	32	79.0	0.3
MS-20GP5	1567	70	1444	96	2117	98	80.2	0.4
MS-20YP4	1539	103	1474	100	2296	120	80.2	0.6
Nette	1564	56	1401	105	2032	103	78.9	0.4
Orchestra	1488	66	1313	92	1976	222	79.1	1.1
Salamanca	1510	134	1354	212	1935	197	79.4	0.8
Shamrock	1745	96	1596	92	2385	61	79.9	0.0
Spider	1426	189	1319	134	1913	319	80.1	0.7
Striker	1560	53	1446	106	2156	169	79.8	0.7
Stunner	1573	109	1417	177	2023	243	78.7	0.4
Viper	1534	15	1377	95	1960	108	79.4	0.4

Pasting temperature is the temperature associated with the peak viscosity and indicates resistance to rupture of the starch granule. The mean pasting temperature for winter and spring peas were 80.7 and 79.6°C, respectively. Keystone had the highest (83.3 °C) pasting temperature among all peas tested. In general, little variability in pasting temperatures was observed (Tables 5 and 6).

Breakdown and setback are important properties because they provide information regarding how resistant the starch is to granule breakdown and if the reassociation of starch polysaccharides will result in a gel. The breakdown associated with the winter peas was lower (65 cP) than the breakdown associated with the spring peas (171 cP). This data indicates that the starch granules from the winter peas were more resistant to breakdown than spring peas. The breakdown values ranged from 8 to 145 cP and 55 to 289 cP in winter and spring samples, respectively (Figures 3 and 4). On an individual sample basis, the P174-7148 and P164-7117 had the lowest and highest breakdown values, respectively. However, the mean (represented by an x on bars in Figure 3) breakdown value (22 cP) was lowest for variety PS1430NZ011W when considering all values for the specific variety. In contrast, PS1430NZ003 had the highest mean breakdown (125 cP). This indicates that PS1430NZ011W starch granules tended to be more resistant (i.e., lower value) to breakdown than starch granules of other varieties. The breakdown in spring peas was lowest (55 cP) and highest (289 cP) for AAC Asher and Salamanca based on individual samples. These same varieties also had the lowest and highest breakdowns on a mean comparison basis (Figure 4) and supports that AAC Asher starch granules were more resistant to breakdown.

The setback values for the winter peas were 533, 360, and 698 cP for the mean, and individual lowest and highest values, respectively. Recall that setback implies a strong reassociation of amylose in starch and results in a firmer paste (i.e., high value). The blaze and PS1430NZ003 varieties had the highest mean setback values while PS1430NZ010W had the lowest setback (Figure 3). The mean setback value for the spring peas was 670 cP, where the highest (921 cP) and lowest (373 cP) values were in CDC Greenwater and Durwood varieties on an individual sample basis, respectively. On a mean basis, MS-20YP4 and Durwood had the highest (853 cP) and lowest (557 cP) setback values among the spring peas (Figure 4). While setback value can often indicate an association with gel firmness, the relationship may not always be affirmed.

The mean gel firmness tended to be slightly higher for the spring peas (262 g) compared to winter peas (190 g). This generally supports the observation that higher setback values for the spring peas translated into higher gel firmness. For winter peas, the firmness values ranged from 139 g (P154-7225) to 273 g (Blaze) on an individual sample basis. On a mean basis, Blaze (234 g) and P144-7211 (160 g) had the highest and lowest mean values, respectively (Figure 5). The gel firmness for spring peas ranged from 175 g (Spider) to 321 g (Striker) on an individual sample basis. On a mean basis, Nette 2010 (295 g) and CDC Saffron (226 g) had the highest and lowest mean values, respectively (Figure 5).

The strongest relationship between the RVA properties evaluated was between gel firmness and final viscosity. This was expected because the higher the final viscosity generally means a greater reassociation of amylose during the holding phase at cool temperatures. More reassociation results in a polymeric material such as a gel. Although peak viscosity and amylose are negatively correlated based on literature, the samples tested support a moderate relationship between peak viscosity and amylose. In this research, we utilized an enzyme kit and not a more sensitive assay such as high-performance liquid chromatography. Thus, if using this equipment, the data may show stronger relationships between peak value and amylose content.

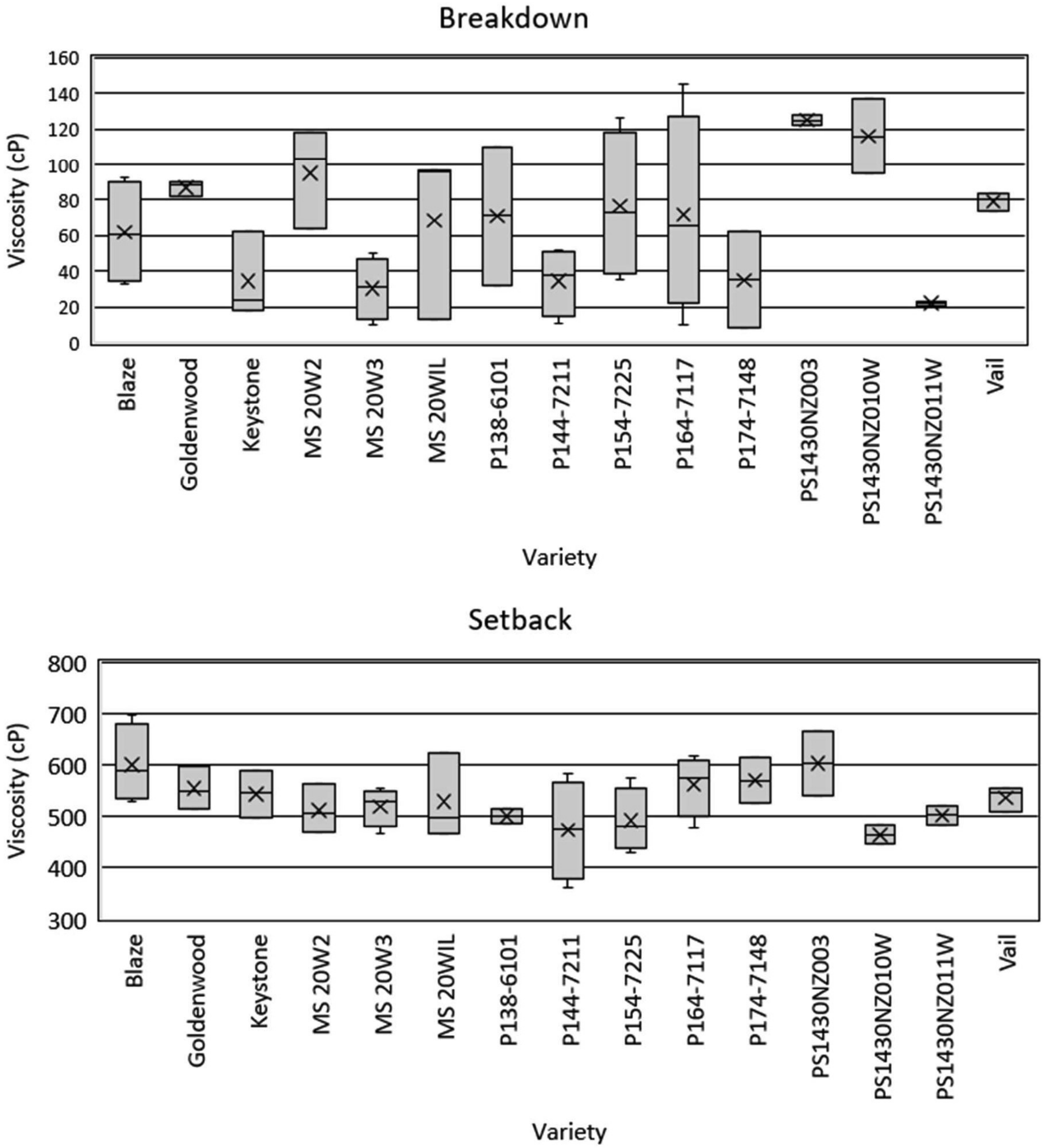


Figure 3. The breakdown and setback viscosities of winter peas obtained from the rapid visco analyzer (RVA). The mean value is represented by an X with the box.

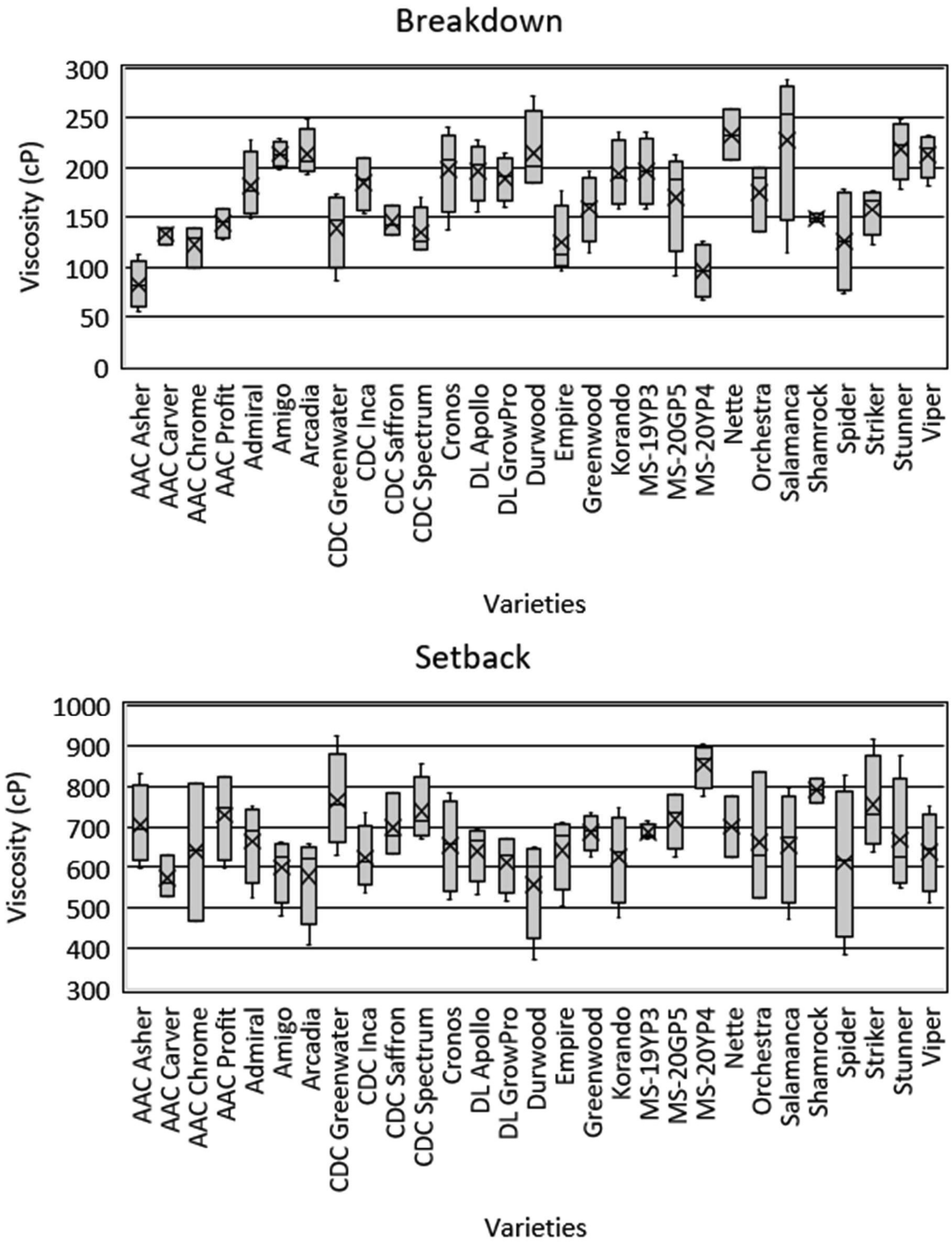
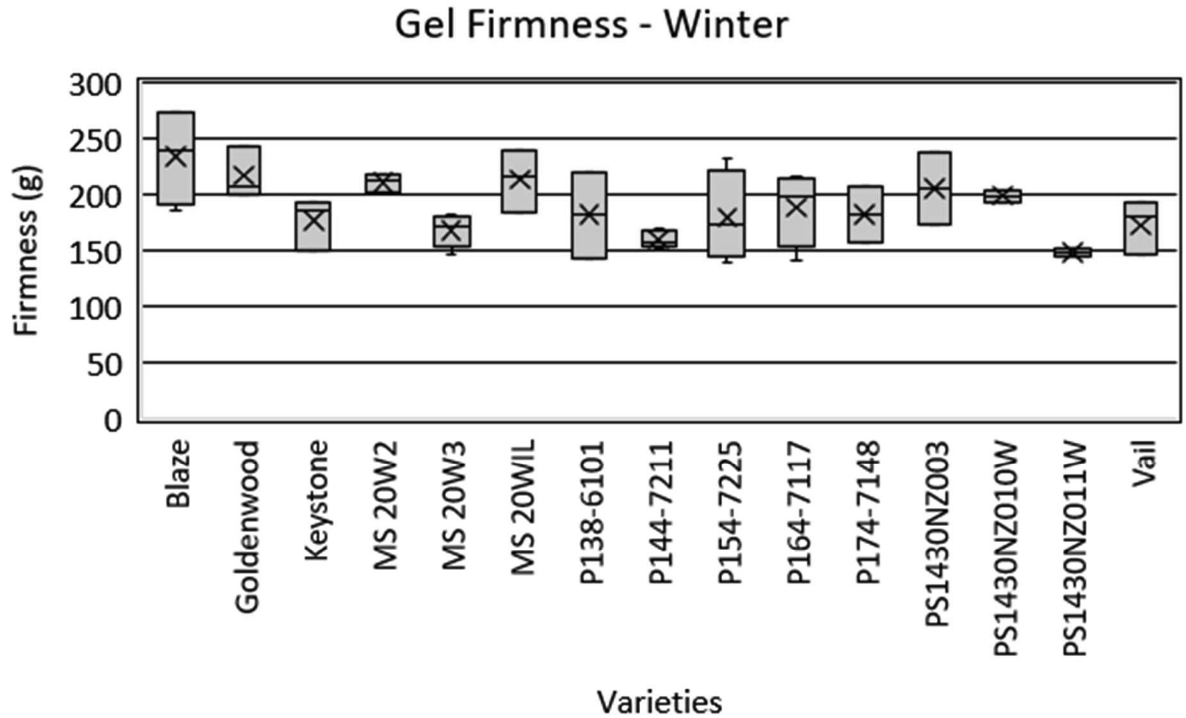


Figure 4. The breakdown and setback viscosities of spring peas obtained from the rapid visco analyzer (RVA). The mean value is represented by an X with the box.



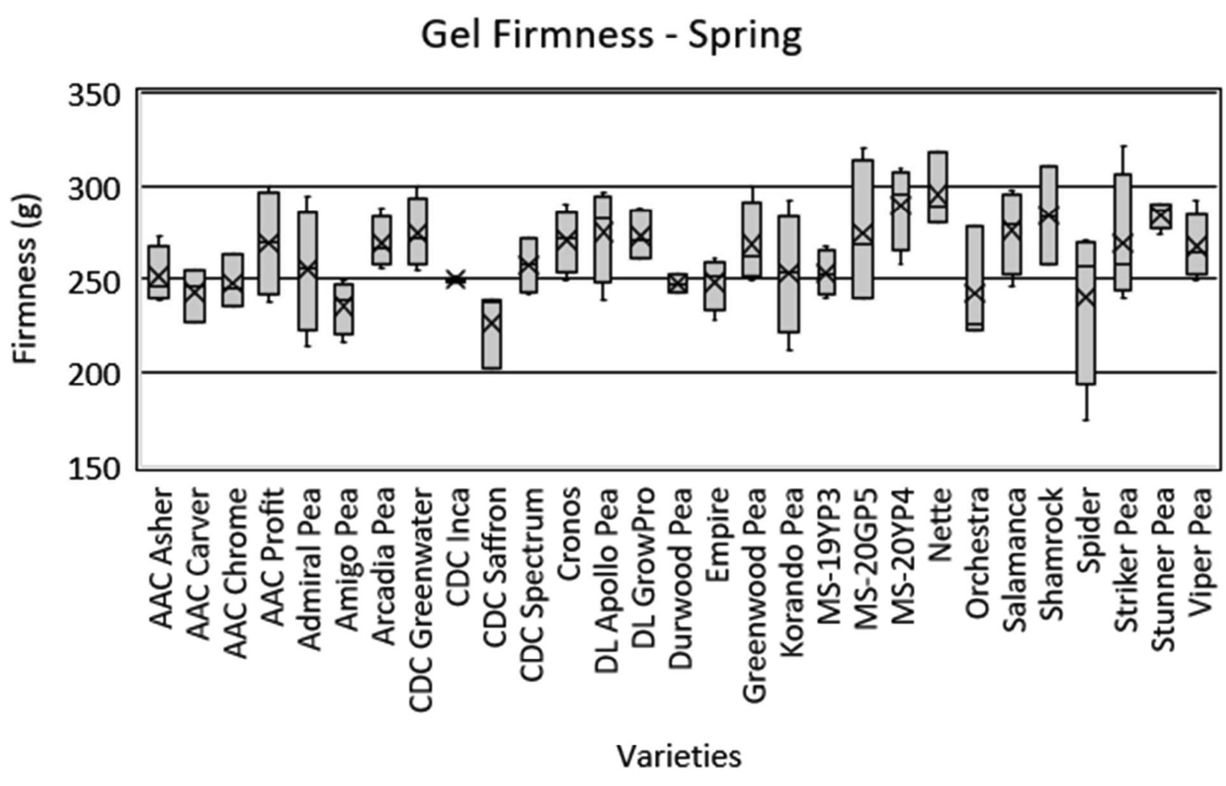


Figure 5. Firmness of the gels formed after the rapid visco analyzer (RVA) run for winter and spring peas. The mean value is represented by an X with the box.

Application of Starch

Part of the funded projects was to demonstrate the utilization of pea starch in food applications. The funded project also included activities related to extraction of the starch using supercritical fluid extraction (SFE treated pea starch). This method utilizes liquid carbon dioxide with a small amount of ethanol under pressure. Additionally, ethanol extraction of starch (ethanol treated pea starch) was evaluated in this research activity. The treated starch samples, including a non-extracted starch (i.e., control starch), were analyzed for functional and pasting properties. Starch samples were applied to the food products (yogurt and pudding), and syneresis and hardness were determined.

Significantly lower peak and hot paste viscosities were observed for the SFE treated pea starch (Figure 6) while this same starch had breakdown and setback viscosities that were higher than the control pea starch and ethanol treated pea starch samples. The ethanol treatment did not impact the pasting properties based on the similarity of pasting viscosities to that of the control starch (Figure 6). The reason for the difference among samples was related to the impact of the SFE process on the integrity of the granule and polysaccharides (i.e., amylose and amylo-pectin) structures. The slightly lower final viscosity of the SFE treated starch likely is due to an inadequately assembled network during the reassociation of amylose and amylopectin chains during cool down and storage. In particular, the amylose reassociation leads to higher final viscosities, as observed with control pea starch and the ethanol treated starch (Figure 6). The differences in the pasting properties likely were impacted by the water binding characteristics of the samples.

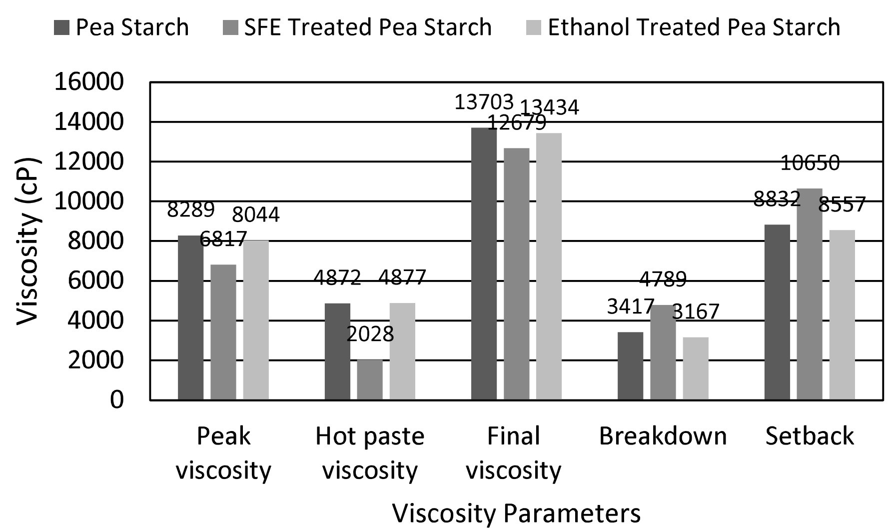


Figure 6. Viscosity properties of pea starch, SFE treated pea starch and ethanol treated pea starch as determined by rapid visco analyzer.

Water and oil holding capacities among the starch samples were slightly different. The

SFE treatment had lower water and oil holding capacities compared to the control pea starch sample (Figure 7). The ethanol treated sample had higher water holding capacities than the other starches. In contrast, the oil holding capacities were lower than the other starches. The lower water holding capacity might be related to the loss of hydrophilic sites the starch has available to interact with water via hydrogen bonding. This loss of hydrophilic site could be due to increased interactions between starch polysaccharides. The resulting viscosity parameters and the water holding capacities observed likely contributed to properties observed in puddings and yogurt.

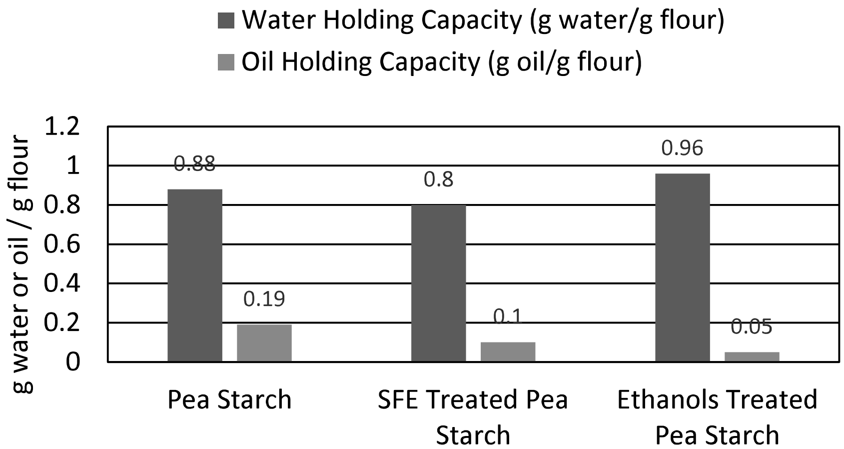


Figure 7. Water and oil holding properties of pea starch, SFE treated pea starch and ethanol treated pea starch.

Pudding is a starch-based product that incorporates dairy and sugar as the main ingredients. In this project, several starch ingredients were used to develop pudding formulas (Figure 8). As a general observation, precooked pea starch as an ingredient for pudding was discarded since the pudding remained very thin. This would be a good option for beverages that need viscosity enhancement but not gelling characteristics. The corn starch control at 3% produced the same gel characteristics as the formulas with 9% pea starch. Dropping the pea starch to 3%, resulted in a soft textured pudding that still retained a good gel structure (Figure 8). The SFE treated starch had good texture but was thinner than the pea starch sample at the same usage level and did not form a gel structure like the pea starch. From this initial research, a formulation of approximately 5% starch was utilized in additional pudding research.

Physical results of pudding (Figure 9) and yogurt (Figure 10) showed an increase in the syneresis and firmness with the storage time. This is expected due to be due to chemical interaction, such as hydrogen bonding and ionic interaction, that exist during the storage of food. The interactions between protein and starch, for example can lead to a displacement of water from a matrix (i.e., syneresis). The same trend was observed in both pudding and yogurt where the ethanol treated starch

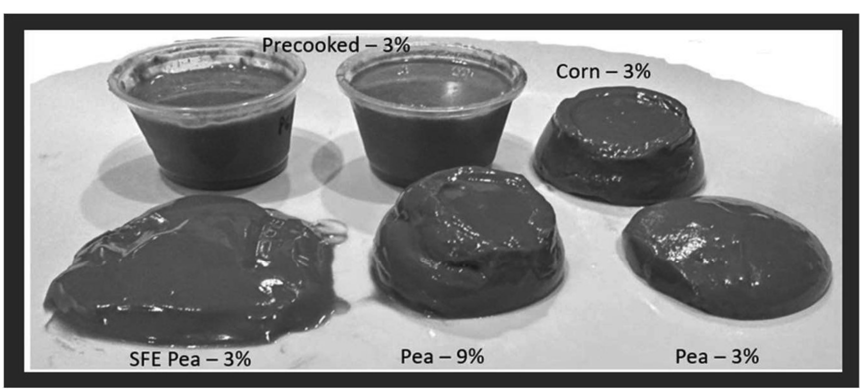


Figure 8. Chocolate pudding made with pea starch, SFE treated pea starch, precooked starch and corn starch.

controlled (i.e., lower values) syneresis better than the other two starches (Figure 9 and 10). The pudding made with ethanol treated pea starch was less firm (softer texture) than the puddings made with the other pea starches (Figure 9). However, it was not as soft as the commercial control sample. We use a commercial control to assess how the current formulas compare in physical parameters. Thus, in this study the samples made with pea starches formed firmer textured products. However, formulation changes (i.e., less starch) may help to reduce firmness. In yogurt, the increase in firmness follows the same trends as in the pudding. However, the difference between the three pea starches was not significant as was the case with pudding. Overall, the firmness was less in the yogurt products compared to pudding. The presence of protein in yogurt likely contributed to less firmness due to the protein preventing the starch polysaccharide interactions.

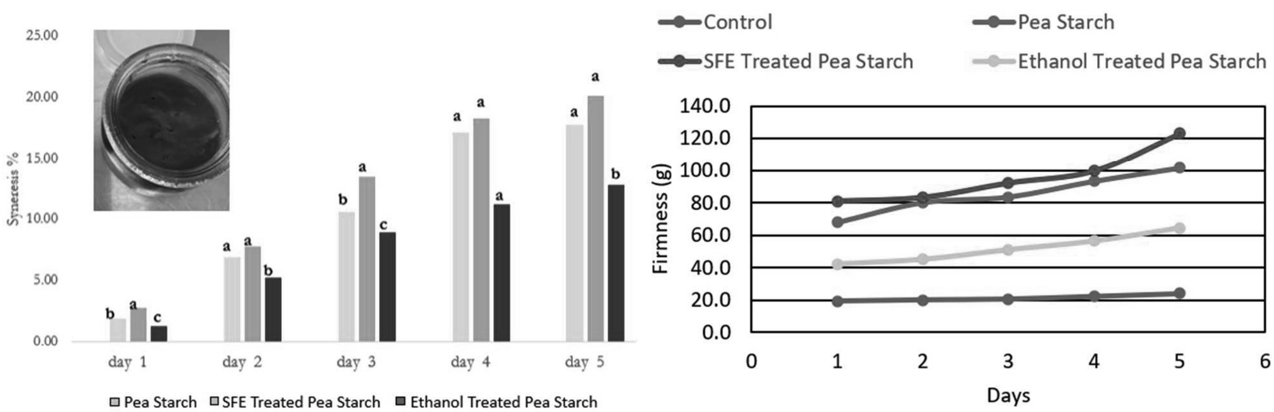


Figure 9. Syneresis (left) and firmness (right) of chocolate pudding made with pea starch, SFE treated pea starch, precooked starch. Different letters above bars indicate significant difference between starches at specific day.

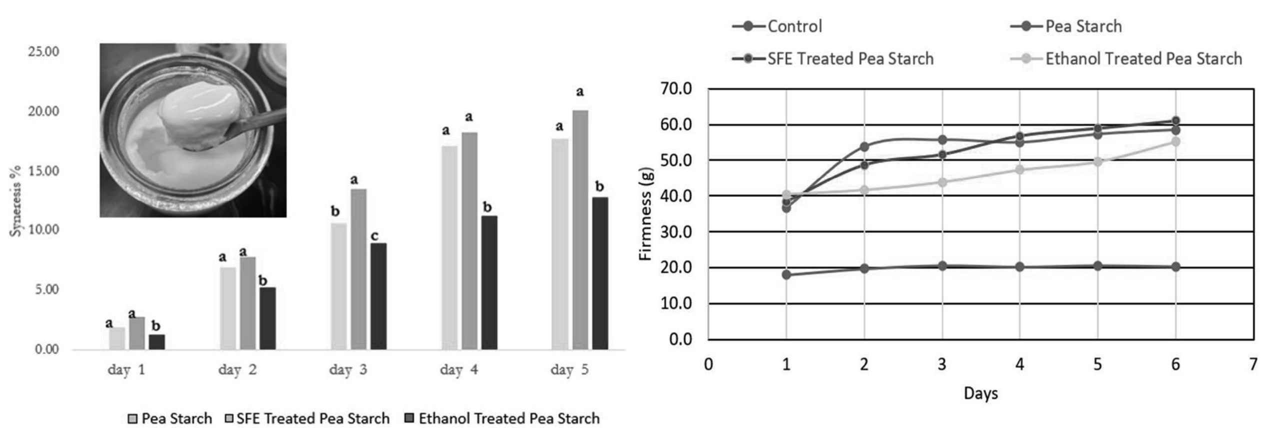


Figure 10. Syneresis (left) and firmness (right) of yogurt made with pea starch, SFE treated pea starch, precooked starch. Different letters above bars indicate significant difference between starches at specific day.

Summary

The composition and functionality of peas were different among the varieties. Growing the peas at the Sturgis, SD field site and applying the same agronomic practices helped minimize the influence of environment and agronomic factors on composition and functionality of peas. Thus, the focus on variety could be assessed. There was a weak correlation between composition and pasting properties. For example, PS1430NZ010W had the highest starch content and the highest peak and hot pastes viscosities, however it was in the top 30% in terms of final viscosity. The Blaze variety had the second highest starch content and had intermediate values for peak and hot paste varieties, but the final viscosity was highest among samples. Furthermore, Blaze had the highest gel firmness, which supports the relationship between firmness and final viscosity observed among the varieties. Overall, there was not one specific variety that was deemed to be the best in all tests performed. Thus, selection of a variety based on the desired composition, viscosity and functional properties can be made following the data presented in this bulletin.

In addition to varieties, application of pea starch should target the desired outcome. For example, SFE produced starches with less viscosity enhancing properties but could form gels at high concentrations. The SFE treated pea starch had lower double helix structure based on our previous research and thus the resulting lower viscosity is likely the outcome of structural changes in the starch. The viscosity properties between ethanol treated peas starch and native pea starch indicates that the ethanol treatment had limited impact on structure. However, ethanol treated starch had higher water holding capacity than native pea starch and the SFE treated pea starch, which may be the reason for the lower syneresis in both pudding and yogurt observed in the samples made with ethanol treated starch. The data supports the use of pea starch in non-traditional uses and that the appropriate selection of variety can provide specific properties desired by food manufacturers.

Acknowledgement

Pulse quality technical team for completing the analyses.
Abdulmalik Albu Tuwaybah
Prakriti Dhakal
Shirin Kazemzadehpournaki,
Hojjat Abdollahikhamene
Mastaneh Shokri