# Smooth and Wrinkled Peas. 1. General Physical and Chemical Characteristics

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Twelve smooth pea cultivars contained less crude protein, free lipid, ash, glucose, and sucrose and more starch than four wrinkled pea cultivars. Lipid content was correlated ($p < 0.001$) with starch, and ash was correlated ($p < 0.01$) with compression hardness. Wrinkled seeds with a lower starch content were higher in starch amylose content than smooth peas. Starch gelatinization temperature by differential scanning calorimetry ranged from 72.0 to 74.7 °C in smooth and from 89.5 to 89.8 °C in wrinkled cultivars and was 82.8 °C in a cross between the two types. The transition enthalpy was positively correlated with amylopectin content of pea flours. Crushing hardness was higher for small-seeded than for large-seeded cultivars ($p < 0.001$). The yield of abrasively dehulled wrinkled seeds (84.1%) was smaller than the yield of dehulled smooth seeds (89.9%). The correlation between hardness tests of whole seeds (compression and abrasion) and of pea flour (particle size index) was highly significant.

## INTRODUCTION

Numerous original and review papers on the composition and nutritional value of smooth and wrinkled peas (FAO, 1970; Gueguen and Barbot, 1988; Bajaj and Dhillon, 1988; Adsule et al., 1989; Savage and Deo, 1989; Leterme et al., 1990; Owusu-Ansah and McCurdy, 1991) emphasize variations in seed components as affected by both genetic and environmental factors (Pandey and Gritton, 1975; Jaiswal et al., 1975). Twofold differences in protein and starch contents were reported (Reichert, 1981; Reddy et al., 1984).

Starch concentrations were higher in smooth peas than in wrinkled ones (Kooistra, 1962). Pea starches are of interest since their amylose spectrum covers a wide range from 20% in smooth pea starch (Kooistra, 1962) to over 90% in the starch of wrinkled cultivars (Stute, 1990). Thus far, due to many problems in isolation of starch from wrinkled peas—related to kernel shape, size, and granule structure (Colonna et al., 1980)—only the starch from smooth peas with plain, round-oval granules is produced on an industrial scale. Moreover, difficulties in seed dehulling make effective extraction of starch or protein from wrinkled peas complex.

Differential scanning calorimetry (DSC) is a valuable tool for investigation of physical properties of pea and other legume starches and proteins (Wright and Boulter, 1980; Sosulski et al., 1985; Califano and Anon, 1990). Practically all DSC studies on pea starches and proteins have been restricted to a small number of smooth types.

The objective of this study was to examine the effectiveness of abrasive dehulling of wrinkled and smooth peas. The yield, chemical composition, and color of dehulled seeds were analyzed. Four tests were used to compare the hardnesses of 16 smooth and wrinkled cultivars. The general chemical composition of pea seeds, including protein extractability, amylose content, and DSC of pea flour was studied.

## MATERIALS AND METHODS

Twelve smooth and four wrinkled pea cultivars (plant breeder samples) were obtained from Dr. F. Muehlbauer, ARS-USDA, Pullman, WA, or purchased from Crites Co., Moscow, ID (commercial seed samples). Flour for chemical analyses was prepared by grinding seeds with a Udy cyclone mill (Udy Corp., Fort Collins, CO) or Model L-2 Stein laboratory mill (Fred Stein Laboratories, Inc., Atchison, KS) to pass a sieve with 0.5-mm round openings. Moisture in seeds of smooth cultivars averaged 8.8% and in wrinkled seeds 7.6% (Table 1).

**Chemical Analyses.** Protein of whole pea flour was calculated from the nitrogen content (N × 6.25) determined by a Leco instrument (Leco Corp., St. Joseph, MI) equipped with a thermoconductivity detector. Nitrogen of soluble and insoluble fiber was assayed by the Kjeldahl method [AACC, 1983 (Method 46-11A)], moisture by oven-drying for 1 h at 130 °C [AACC, 1983 (Method 44-15A)], ash by dry combustion [AACC, 1983 (Method 08–01)], and free lipid by petroleum ether extraction, followed by evaporation to constant weight under vacuum [AACC, 1983 (Method 30–25)]. Dietary fiber was determined according to the procedure of Prosky et al. (1988). Starch was analyzed after its enzymatic conversion to glucose by successive treatment with α-amylase, protease, and amyloglucosidase as described for dietary fiber (Prosky et al., 1988). The released glucose was measured with the glucose oxidase–peroxidase reagent (Lloyd and Whelan, 1969). The amylose to amylopectin ratio was determined by two methods, according to the procedure of Hovenkamp-Hermelink et al. (1988) (method 1) and the procedure of Ruhl (1989) (method 2). Glucose and sucrose were extracted according to Method 80-50 (AACC, 1983) and assayed by the enzymatic–spectrophotometric method of Lloyd and Whelan (1969). Proteins were sequentially extracted from pea flour three times (each) by tap water or deionized water, by a 5% KCl solution, and by a 0.2% KOH solution. The extracts were freeze-dried and analyzed for moisture and protein. All chemical analyses were performed at least in duplicate, and all results were averaged.

**Physical Measurements.** Seed hardness was tested by four methods: (a) weight of seeds after abrasion for 30 s in a Strong-Scott barley pearler (Taylor et al., 1939); (b) minimum force required to break or crash single pea seeds placed between a fixed and moveable plate of a T-1200 G FTC texture test system (FTC, Rockville, MD) (at least 20 seeds of known weight of each cultivar were tested and the results expressed as newton per gram of seeds); (c) near-infrared reflectance spectroscopy (near-IRS) (Pomeranz et al., 1988) of pea flours from peas ground in a Udy mill (near-IRS I method) and Stein mill (near-IRS II method) as analyzed in the Technicon 400 InfraAlyzer (Technicon, Tarrytown, NY); and (d) particle size index (PSI) (Miller et al., 1982) of a 2.0-g sample of peas ground in a Stein mill, sifted, and pulsed on a U.S. No. 140 (106-μm openings) stainless steel sieve (PSI I method) or on a U.S. No. 70 (212-μm openings) sieve (PSI II method) using the Model L3 sonic sifter (ATM

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**Table 1. Chemical Composition of Whole Pea Seeds**

| | | | % as is | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| type and cultivar | 1000 kernel wt (g) | color | moisture | crude protein (N × 6.25) | starch | free lipids | ash | glucose | sucrose |
| smooth | | | | | | | | | |
| Alaska I[a] | 188.1 | G[c] | 9.0 | 24.7 | 43.3 | 0.87 | 3.10 | 0.07 | 2.01 |
| SS Alaska II[b] | 142.6 | G | 9.0 | 17.3 | 40.6 | 1.40 | 2.53 | 0.07 | 2.05 |
| Columbian I | 203.2 | G | 8.7 | 24.5 | 49.4 | 0.80 | 2.59 | 0.05 | 2.14 |
| Columbian II | 195.4 | G | 8.2 | 23.0 | 38.8 | 0.88 | 2.78 | 0.05 | 1.82 |
| Consort II | 246.2 | Y[d] | 9.0 | 20.3 | 39.7 | 1.05 | 2.54 | 0.04 | 1.96 |
| Latah I | 168.5 | Y | 9.0 | 27.7 | 42.1 | 0.56 | 2.71 | 0.06 | 1.73 |
| Melrose I | 106.9 | Y | 8.1 | 25.6 | 36.6 | 0.67 | 3.22 | 0.18 | 1.37 |
| Miranda I | 280.7 | Y | 9.1 | 24.2 | 44.6 | 0.78 | 2.38 | 0.08 | 1.41 |
| Renate I | 259.5 | Y | 8.9 | 23.6 | 42.0 | 0.79 | 2.46 | 0.11 | 2.07 |
| Ricardo I | 236.2 | Y | 8.8 | 24.1 | 45.2 | 0.73 | 2.50 | 0.09 | 1.24 |
| Solara I | 260.5 | G | 9.0 | 24.1 | 39.2 | 0.84 | 2.39 | 0.10 | 1.52 |
| Umatilla I | 230.9 | Y | 9.2 | 23.7 | 40.4 | 0.80 | 2.60 | 0.09 | 1.60 |
| mean | 209.9 | | 8.8 | 23.55 | 41.82 | 0.85 | 2.65 | 0.08 | 1.74 |
| wrinkled | | | | | | | | | |
| 4683 II | 158.7 | G | 7.6 | 25.2 | 25.2 | 2.74 | 2.92 | 0.24 | 1.78 |
| DSP II | 249.9 | Y | 7.4 | 26.3 | 27.2 | 1.61 | 3.21 | 0.18 | 2.12 |
| DSP I | 231.6 | Y | 7.6 | 24.7 | 30.9 | 1.83 | 2.62 | 0.14 | 2.27 |
| Scout II | 193.9 | Y | 7.7 | 24.9 | 27.0 | 1.70 | 2.82 | 0.15 | 2.57 |
| mean | 208.5 | | 7.6 | 25.28 | 27.56 | 1.97 | 2.89 | 0.18 | 2.19 |
| LSD (0.05) | 1.2 | | 0.06 | 0.29 | 2.30 | 0.03 | 0.04 | 0.01 | 0.07 |

[a] I, seed from plant breeder experimental plots (WA). [b] II, commercial seed (ID). [c] Green. [d] Yellow.

Corp., Milwaukee, WI). Seed color parameters—*L*, whiteness; *a*, greenness; *b*, yellowness; and *E*, total color (on a Hunter scale)—were determined by a CM-2002 spectrophotometer (Minolta Camera Co., Ltd., Japan).

**Differential scanning calorimetry** (DSC) characteristics of pea flours were determined with a DSC-4 instrument (Perkin-Elmer Corp., Norwalk, CT). An indium standard was used for temperature and enthalpy calibration. A 10-mg sample and 20 μL of distilled water were placed in a stainless capsule, sealed, and allowed to equilibrate for 30 min at room temperature. The samples were then heated from 20 to 180 °C at a scanning rate of 10 °C/min. A capsule with inert material ($Al_2O_3$) and water represented the reference sample. For each endotherm, temperatures of transition onset, peak, and completion were determined by data processing software. The transition enthalpy was calculated by software from the peak area and expressed as joules per gram (J/g) of dry matter. Physical and chemical data were analyzed by the system of SAS Institute (1985), and least significant differences were computed.

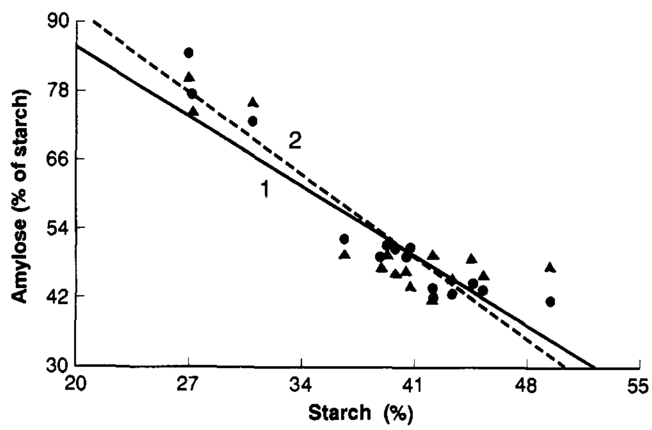


**Figure 1.** Linear regressions between total starch and amylose content of pea starch determined by two methods (see text): method 1, ▲, $r = 0.871$; method 2, ●, $r = 0.950$.

## RESULTS AND DISCUSSION

**Proximate Chemical Composition.** The thousand kernel weight, moisture, protein, starch, free lipid, ash, glucose, and sucrose contents of the 12 smooth pea cultivars and 4 wrinkled cultivars are listed in Table 1. Melrose is an Austrian feed cultivar, and 4683 is a cross between smooth-seeded SS Alaska and a wrinkled cultivar. Seeds of Melrose and 4683 were the smallest among the tested cultivars. As previously reported (Matthews and Arthur, 1985; Gueguen and Barbot, 1988), the average protein content of wrinkled peas was higher than that of peas from smooth genotypes. The protein content of smooth pea cultivars ranged from 17.25% to 27.69% and for wrinkled peas from 24.69% to 26.32%. The average protein content of smooth cultivars, 23.55%, is close to that listed in an FAO compilation (FAO, 1970). Starch content was much higher in smooth peas than in wrinkled seeds (Kooistra, 1962). Starch amylose contents, as determined by two methods, vary over a very wide range from 20% to 90% (Kooistra, 1962; Stute, 1990). There was a high negative correlation between pea total starch contents and starch amylose percentage; the linear correlation coefficients were $r = -0.871$ and $-0.950$ (Figure 1) for methods 1 and 2, respectively. Cv. 4683, a cross between smooth and wrinked peas with a low total starch content of 25.16% and a low starch amylose content of 33.20%, was excluded from those computations. Significantly higher amounts of free lipid and ash were found in wrinkled than in smooth peas (Table 1).

Glucose ranged between 0.04% and 0.18% in smooth and between 0.14% and 0.24% in wrinkled peas. Ranges of sucrose were 1.24–2.14% and 1.78–2.57% in smooth and wrinkled peas, respectively. The values are in agreement with those of Cerning-Beroard and Filiatre (1976) and Sosulski et al. (1982). The amounts of sugars are known to be affected by varietal differences, environmental conditions, and stage of maturity. For all peas, free lipid and starch contents was negatively correlated ($r = 0.820$, $p < 0.001$) (Table 2). Ash content was negatively correlated ($p < 0.05$) with starch and weight of 1000 seeds (1000 kernel wt), and positively correlated with compression hardness ($p < 0.01$). The highly significant negative correlation for smooth and wrinkled seeds between 1000 kernel wt and compression hardness ($r = -0.808$, $p < 0.001$) shows that crushing 1 g of smaller seeds (cv. Melrose, Latah, and Alaska) requires more force than crushing 1 g of bigger seeds (cv. Renate, Miranda, and Consort). A similar

**Table 2. Correlation Coefficients between Pea Characteristics[a]**

| | starch | protein | lipid | ash | 1000 kernel wt | hardness (compression) |
|---|---|---|---|---|---|---|
| | | | Smooth Cultivars | | | |
| starch | | 0.169 | 0.141 | −0.370 | 0.476 | −0.375 |
| protein | −0.267 | | −0.745*** | 0.333 | 0.009 | 0.398 |
| lipid | | 0.146 | | −0.511 | 0.046 | 0.407 |
| ash | −0.510* | 0.443 | 0.224 | | −0.756*** | 0.868*** |
| 1000 kernel wt | 0.228 | 0.010 | −0.196 | −0.560* | | −0.840*** |
| hardness (compression) | 0.011 | 0.302 | −0.143 | 0.635** | −0.808*** | |
| | | | Smooth and Wrinkled Cultivars | | | |

[a] ***, significant at $p < 0.001$; **, significant at $p < 0.01$; *, significant at $p < 0.05$.

**Table 3. Extractability of Pea Proteins**

| cultivar | | protein fraction[a] extracted with: water | 5% KCl | 0.2% KOH | residue | yield (%) |
|---|---|---|---|---|---|---|
| smooth | | | | | | |
| SS Alaska | DI[b] | 61.9 | 21.0 | 11.6 | 6.5 | 101.0 |
| | tap | 56.1 | 26.2 | 10.2 | 6.8 | 99.3 |
| Columbian II | DI | 69.0 | 18.7 | 7.7 | 6.0 | 101.5 |
| | tap | 70.2 | 15.4 | 10.1 | 5.0 | 100.6 |
| Consort | DI | 61.8 | 21.9 | 8.8 | 5.9 | 98.4 |
| | tap | 68.3 | 18.8 | 10.9 | 4.7 | 102.7 |
| Melrose | DI | 39.8 | 28.2 | 22.0 | 5.0 | 95.0 |
| | tap | 38.3 | 29.8 | 19.6 | 6.7 | 94.4 |
| Umatilla | DI | 59.6 | 29.6 | 8.5 | 3.8 | 101.4 |
| | tap | 55.9 | 26.1 | 10.1 | 3.5 | 95.6 |
| mean | DI | 58.43 | 23.86 | 11.7 | 5.4 | 99.44 |
| | tap | 57.75 | 23.27 | 12.2 | 5.3 | 98.52 |
| wrinkled | | | | | | |
| 4683 | DI | 46.9 | 37.3 | 10.6 | 5.8 | 100.7 |
| | tap | 50.1 | 29.5 | 11.0 | 4.7 | 95.2 |
| DSP II | DI | 74.4 | 14.9 | 7.3 | 4.3 | 100.9 |
| | tap | 69.4 | 17.6 | 9.5 | 4.2 | 100.7 |
| Scout | DI | 55.8 | 23.9 | 13.4 | 4.7 | 97.8 |
| | tap | 56.6 | 22.2 | 17.5 | 4.5 | 100.8 |
| mean | DI | 59.0 | 25.4 | 10.44 | 4.9 | 99.78 |
| | tap | 58.7 | 23.1 | 12.65 | 4.5 | 98.88 |

[a] As % of total protein. [b] Deionized water.

correlation ($r$ = −0.840, $p < 0.001$) was recorded when smooth seeds only are considered (Table 2).

Results of pea protein extractability in tap or deionized water, salt, and an alkaline solution are summarized in Table 3. Proteins were extracted from five smooth [two green (SS Alaska and Columbian) and three yellow (Consort, feed Melrose, and Umatilla)] and three wrinkled (DSP and Scout, and the cross 4683) varieties. There were no consistent differences in the amounts of proteins extracted by the three solutions from smooth and wrinkled peas. Similarly, the amounts of proteins extracted by deionized or tap water (from seeds of a given cultivar) were not consistently or significantly different. The feed cultivar Melrose is characterized by the lowest content of the water-soluble protein fraction and the highest level of the alkaline-soluble fraction. Among the wrinkled peas, the cross 4683 contained fewer water-soluble proteins than the other cultivars.

**Physical Characteristic of Seeds.** Assays by differential scanning calorimetry of two smooth pea flours (SS Alaska and Columbian) and three wrinkled peas (Scout, DSP, and the cross 4683) were conducted (Figure 2). Thermogram peaks correspond to the starch gelatinization temperature phase changes. The starch gelatinization temperatures of smooth peas were lower (72.0–74.7 °C) than for wrinkled peas (89.5–89.8 °C). The cross cv. 4683 had an intermediate starch gelatinization temperature of 82.8 °C. The transition enthalpies at maximum temperature of starch gelatinization—as shown in Figure 2—varied from 5.42 (for Columbian) to 1.15 J/g (for DSP). Both the transition enthalpy and the transition temperature of cv. 4683 were closer to those of wrinkled cultivars than to those of the smooth ones. Those results are in line with the fact that small differences in amylose content may have large effects on gelatinization temperatures and enthalpies. A high correlation between the amylopectin contents of pea starch and their transition enthalpies ($r$ = 0.985) was recorded. DSC could thus serve as a useful parameter to characterize the gelatinization characteristics and end-use properties of pea starches that vary in amylose contents.

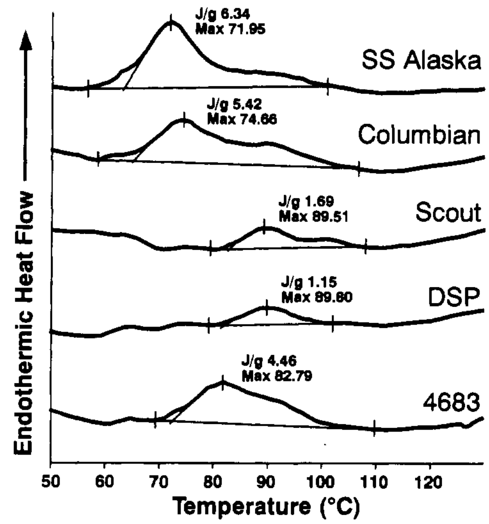


**Figure 2.** Differential scanning calorimetric thermograms of five pea varieties.

The hand-separated hulls represented 8.6–13.1% (av 10.3%) and 12.0–19.7% (av 14.6%) of the whole smooth and wrinkled peas, respectively. The yield of smooth seeds dehulled by abrasion was higher 86.9–95.3% (av 89.9%) than the yield of dehulled wrinkled seeds, 80.1–87.9% (av 84.1%), as the round shape of smooth seeds required a shorter time for dehulling. The feed cultivar Melrose among the smooth cultivars and the cross 4683 among the wrinkled seeds gave highest yields after abrasion dehulling. To follow the course of dehulling by abrasion, changes in protein and fiber contents of smooth seeds (SS Alaska) and wrinkled seeds (Scout) were studied (Figures 3 and 4). A plateau in protein and fiber contents was attained after 6 s for the smooth SS Alaska (Figure 3) and after 4 s for the wrinkled Scout (Figure 4). Those results were confirmed by changes in whiteness ($L$) and greenness ($a$) of smooth seeds and whiteness ($L$) and yellowness ($b$) of wrinkled peas (data not reported here). Differences in seed color during abrasion were related to different visual colors of hulls and cotyledons in both pea cultivars.

Seed hardness—as illustrated in Table 4—was measured by abrasion and compression tests on whole pea seeds and by near-infrared reflectance spectroscopy (near-IRS) and the particle size index test (PSI) on pea flours. The near-IRS test was run in two versions, using flour from the Udy

**Table 4. Hardness of Peas As Determined by Four Methods**

| | | compression | | near-IRS value[a] | | PSI[b] | |
|---|---|---|---|---|---|---|---|
| cultivar | abrasion | N/g | N/kernel (calcd) | I | II | I (%) | II (%) |
| smooth | | | | | | | |
| Alaska | 50.0 | 2296 | 432 | 48.0 | 80.6 | 89.4 | 80.9 |
| SS Alaska | 52.7 | 1921 | 274 | 35.7 | 53.5 | 89.9 | 80.7 |
| Columbian I | 48.0 | 2240 | 455 | 49.1 | 66.4 | 88.3 | 78.0 |
| Columbian II | 49.0 | 2170 | 424 | 47.6 | 64.6 | 88.9 | 80.5 |
| Consort | 45.0 | 1643 | 405 | 46.7 | 58.6 | 87.5 | 78.3 |
| Latah | 51.4 | 2398 | 404 | 63.1 | 83.2 | 88.6 | 77.6 |
| Melrose | 54.8 | 3233 | 346 | 46.8 | 67.7 | 91.0 | 80.8 |
| Miranda | 45.2 | 1471 | 413 | 55.5 | 69.2 | 87.8 | 77.3 |
| Renate | 45.0 | 1366 | 355 | 53.4 | 67.2 | 87.8 | 77.5 |
| Ricardo | 46.9 | 1887 | 446 | 55.3 | 69.2 | 87.6 | 76.2 |
| Solara | 45.0 | 1734 | 452 | 53.2 | 60.2 | 87.5 | 78.3 |
| Umatilla | 47.3 | 1897 | 438 | 53.6 | 72.6 | 87.8 | 77.9 |
| mean | 48.36 | 2021.3 | 403.7 | 50.67 | 67.75 | 88.51 | 78.67 |
| wrinkled | | | | | | | |
| 4683 | 45.2 | 2094 | 332 | 26.0 | 40.1 | 92.6 | 83.6 |
| DSP I | 35.6 | 1674 | 388 | 40.7 | 54.3 | 90.0 | 81.5 |
| DSP II | 37.4 | 1751 | 438 | 42.7 | 59.1 | 90.2 | 81.2 |
| Scout | 36.0 | 1865 | 361 | 44.1 | 53.9 | 89.2 | 81.0 |
| mean | 38.55 | 1846.0 | 379.8 | 38.38 | 51.85 | 90.50 | 81.83 |

[a] Near-Infrared reflectance spectroscopy of pea flours ground on the Udy mill (I) or the Stein mill (II). [b] PSI of pea flours; % passing through sieves with the following openings: I > 106 μm and II > 212 μm.

**Table 5. Correlation Coefficients between Pea Hardness Tests[a]**

| | abrasion | compression | near-IRS I | near-IRS II | PSI I | PSI II | dehulling time |
|---|---|---|---|---|---|---|---|
| | | | Smooth Cultivars | | | | |
| abrasion | | 0.852*** | −0.358 | 0.168 | 0.934*** | 0.679* | 0.461 |
| compression | 0.614* | | −0.127 | 0.309 | 0.804** | 0.557 | 0.434 |
| near-IRS I | 0.224 | −0.034 | | 0.683* | −0.525 | −0.715** | 0.200 |
| near-IRS II | 0.464 | 0.262 | 0.849*** | | 0.026 | −0.159 | 0.333 |
| PSI I | −0.020 | 0.467 | −0.787*** | −0.513* | | 0.825** | 0.272 |
| PSI II | −0.218 | 0.282 | −0.858*** | −0.610* | 0.901*** | | 0.122 |
| dehulling time | 0.435 | 0.141 | 0.419 | 0.395 | 0.586* | 0.591* | |
| | | | Smooth and Wrinkled Cultivars | | | | |

[a] *, significant at $p < 0.001$; ** significant at $p < 0.01$; ***, significant at $p < 0.05$.

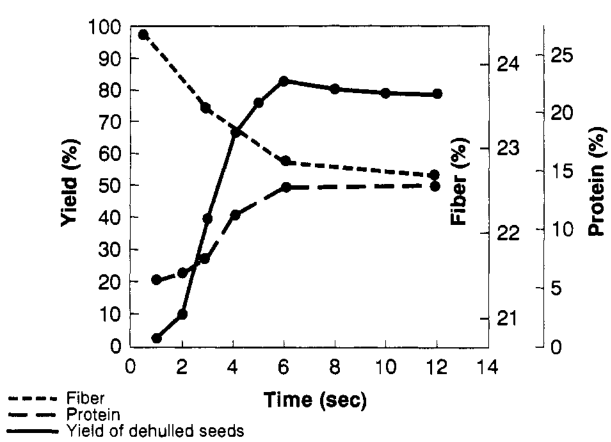


**Figure 3.** Effect of abrasive dehulling time on the yield and protein and fiber contents of pea seeds (cv. SS Alaska).

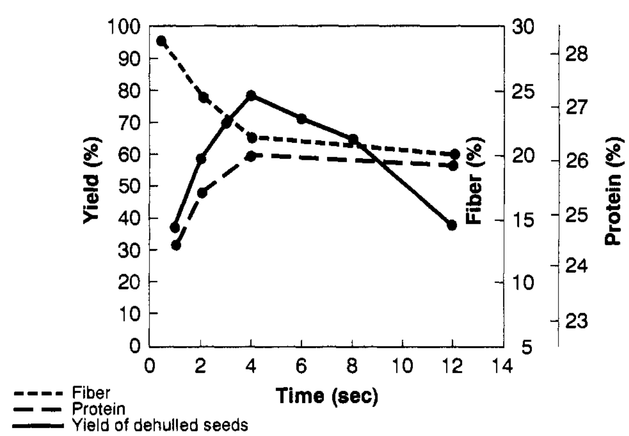


**Figure 4.** Effect of abrasive dehulling time on the yield and protein and fiber contents of pea seeds (cv. Scout).

cyclone mill (near-IRS I) and from the Stein laboratory mill (near-IRS II). Yields of pea flour fractions passing through sieves with >106- (PSI I) and >212-μm (PSI II) openings were measured. Flour from the Stein laboratory mill was used for the PSI test. Higher values of PSI and lower abrasion and near-IRS tests were obtained for wrinkled cultivars than for smooth ones. Variations in seed hardness among smooth and wrinkled cultivars were observed. The smooth feed cultivar Melrose, among the smooth peas, and the cross 4683, among the wrinkled peas, had the highest compression and abrasion hardness values. Intercultivar compression hardness values varied widely, as much as twice. Correlations between hardness tests run on whole seeds (compression and abrasion) and those run on pea flours (PSI) were significant for the smooth cultivars only ($p < 0.001$ and 0.01, respectively) (Table 5). When both smooth and wrinkled peas are considered, there were significant correlations between tests of the same type: abrasion and compression ($r = 0.614$, $p < 0.05$); near-IRS I and PSI II ($r = -0.858$, $p < 0.001$). Results of the PSI hardness test were correlated with the dehulling time of pea seeds ($p < 0.05$).

While the results in Tables 4 and 5 are all related to hardness, the specific assays test inherently different properties–characteristics of whole seeds (that varied widely in kernel size) and ground flours and were affected by various properties. One would expect the highest correlations between the two tests on whole kernels (abrasion and compression) and between the two tests that measure particle size (near-IRS and PSI). Examination of the results in Table 5 confirms those assumptions.

Our results show that abrasion of peas on a Strong-Scott barley pearler can effectively dehull peas, especially smooth ones. Effectiveness of dehulling, and associated changes in gross composition (proteins, lipids, and ash), is affected by pea type (smooth or wrinkled), kernel size, and kernel hardness. The course of dehulling can be followed routinely by changes in seed color parameters.

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