End-Use Quality of Soft Kernel Durum Wheat

Craig F. Morris, Jessica C. Murray, Alecia M. Kiszonas, Jeffrey D. Boehm, Jr.,
Maria Itria Ibba, Karsta Heinze, Valérie Lullien-Pellerin

CFM & AMK USDA-ARS Western Wheat Quality Laboratory, E-202 Food Quality Bldg., Washington State University, P.O. Box 646394, Pullman, WA, 99164, USA; JCM, JDB & MII Dept. Crop & Soil Sciences, Washington State Univ., KH & VL-P UMR IATE, CIRAD, INRA, Montpellier SupAgro, Univ. de Montpellier, Montpellier, France

Key Message:

Soft kernel durum wheat possessing the *Hardness* locus exhibits milling and baking characteristics consistent with soft hexaploid wheat. Various durum parents contribute significant variation to soft durum wheat end-use

Abstract:

Kernel texture is a major determinant of end-use quality of wheat. Durum wheat is known for its very hard texture, which influences how it is milled and for what products it is well suited. We developed soft kernel durum wheat lines via *Ph1b*-mediated homoeologous recombination with Dr. Leonard Joppa. The *Hardness* locus from Chinese Spring was successfully transferred to cv. Svevo durum wheat; Svevo was back-crossed 3 times to produce 'Soft Svevo'. Soft Svevo had SKCS kernel hardness, break flour yield, flour starch damage, and flour particle size similar to soft hexaploid wheat. Compared to Svevo, Soft Svevo had much reduced Solvent Retention Capacity (SRC) -water, -carbonate, and -sucrose; whereas SRC-lactic acid was similar to Svevo. Similarly, Mixograph, Farinograph and Alveograph results indicated much reduced water absorption, but similar gluten strength. Cookie diameter of Soft Svevo was markedly larger and similar to soft wheat. The energy required to produce flour was dramatically reduced: 624 ± 200 kJ/kg flour for Svevo vs. 146 ± 20 kJ/kg flour for Soft Svevo. When Soft Svevo was crossed to 10 CIMMYT durum parents, half-sib families and full-sib lines within families showed significant differences in SKCS hardness, break flour and total flour yields, starch damage, SRC-water, -carbonate, -sucrose, and -lactic acid, and flour SDS sedimentation volume. Cookie diameters ranged from 8.68 to 9.57 cm. Mean bread loaf volumes for families ranged from 680 to 838 cm^3. Results illustrate the significant effect of the *Puroindoline* genes and the *Hardness* locus on kernel texture and end-use quality, and demonstrate that soft kernel durum wheat has properties similar to soft hexaploid wheat. Further, the hard durum parent has a significant effect on end-use quality traits by contributing superior alleles for soft wheat milling, flour properties, dough and bread quality.

Introduction:

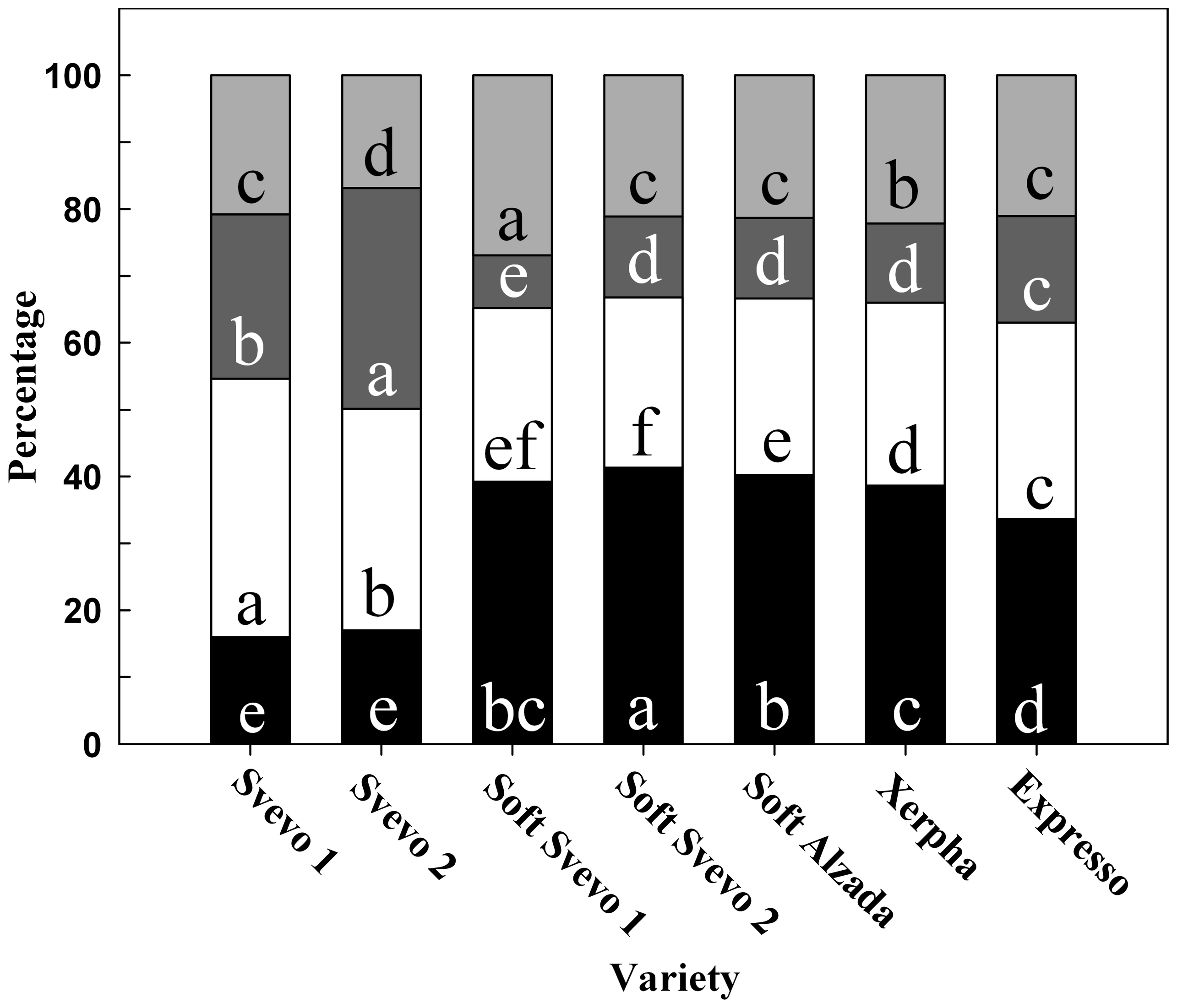
Approximately 33 million metric tons (mmt) of durum wheat are harvested worldwide, compared to 730 mmt of common wheat. Why this discrepancy? Durum is reportedly tolerant of drought, heat, and may possess a broader spectrum of resistances to biotic stresses. Indeed, in the Yaqui Valley, the birthplace of the Green Revolution, durum wheat routinely out-yields common wheat. We believe that durum production is limited in part due to its relatively narrower range of commercial applications as compared to common wheat. Due to the extremely hard texture of the kernels, durum wheat is typically milled into semolina, a coarse granular product, which is utilized in pasta, couscous, and some regional Mediterranean, Middle Eastern, and North African foods. Semolina differs from common wheat flour in that it has a much larger particle size and typically a higher yellow pigment concentration. Durum wheat grain is routinely processed on a 'dedicated' durum mill, which has the design and specialized equipment to deal with the hardness of the durum kernels, and the desire to produce semolina.

Development of Soft Kernel Durum Wheat:

A Langdon durum 5D(5B) disomic substitution line was crossed with a Langdon line ('47-1') that was heterozygous for *Ph1/ph1b*. Progeny were selected cytologically, and F_2s back-crossed to Langdon. Progeny were evaluated cytologically in subsequent crosses to confirm putative non-Robertsonian translocation(s). One of these putative Langdon translocation lines was subsequently used as a donor parent to transfer the *Hardness* locus to durum cv. Svevo. 'Soft Svevo' is a BC_3 derivative of this cross (1). Soft Svevo was then used in the production of several near-isogenic lines produced from commercial durum cultivars, and crossed to 10 durum lines from CIMMYT's 44th International Durum Yield Nursery (IDYN).

Results • Near-Isogenic Lines:

Kernel hardness, break flour yield, flour yield, starch damage and particle size of soft kernel durum varieties were similar-to-better than the soft white winter wheat cultivar 'Xerpha' (2,3). The figure below shows milling performance of durum (Svevo), soft durum (Soft Svevo), soft white winter (Xerpha), and hard red spring (Expresso) wheat varieties as mill stream distributions. Black bands, break flour yield, white, reduction flour, white + black = total flour, dark grey, middlings, and light grey, bran. At INRA, milling tests indicated a dramatic reduction in energy per unit of flour: 624 ± 200 kJ/kg Svevo vs. 146 ± 20 kJ/kg for Soft Svevo (4).

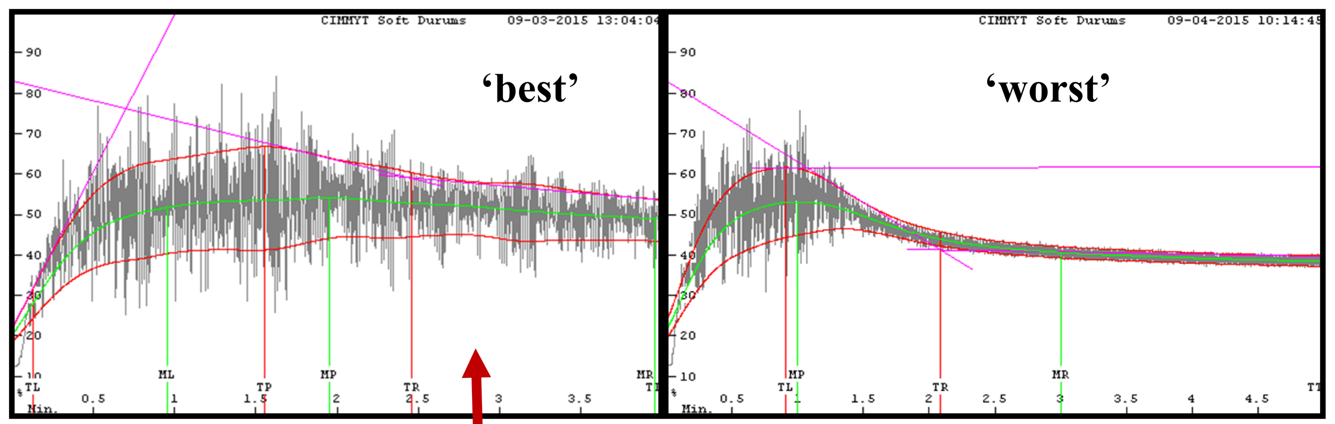


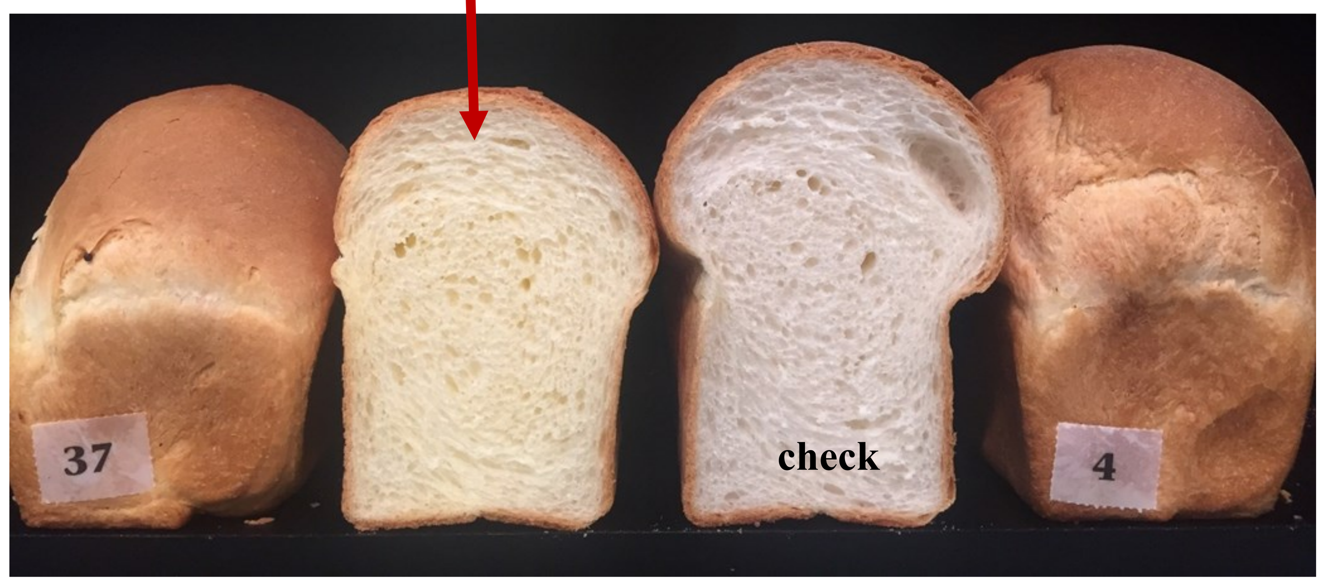
Results • CIMMYT Derived Lines:

Soft Svevo was crossed as female to 10 CIMMYT durum parents. F_2:F_5 half-sib families and full-sib lines within families showed significant differences in SKCS hardness (2.1-25.6), break flour yield (35.9-43.8%), total flour yield (58.9-65.8%), starch damage (1.11-1.77%), and SRC-water (49.4-57.0%). Values were consistent with soft kernel milling and flour quality characteristics. Flour SDS sedimentation, SRC-lactic acid, and Mixograph parameters are presented in the following table; two Mixograph curve examples are shown in the adjoining figure. Genotypes differed for all traits and indicated that 'gluten' characteristics were independent of kernel softness. Cookie diameters ranged from 8.68 to 9.57 cm, the latter being considered above average for soft wheat. Bread loaf volumes for families ranged from 680 to 838 cm^3, with individual genotypes ranging from 629-864 cm^3 (5,6). An example of soft durum bread vs. control is shown.

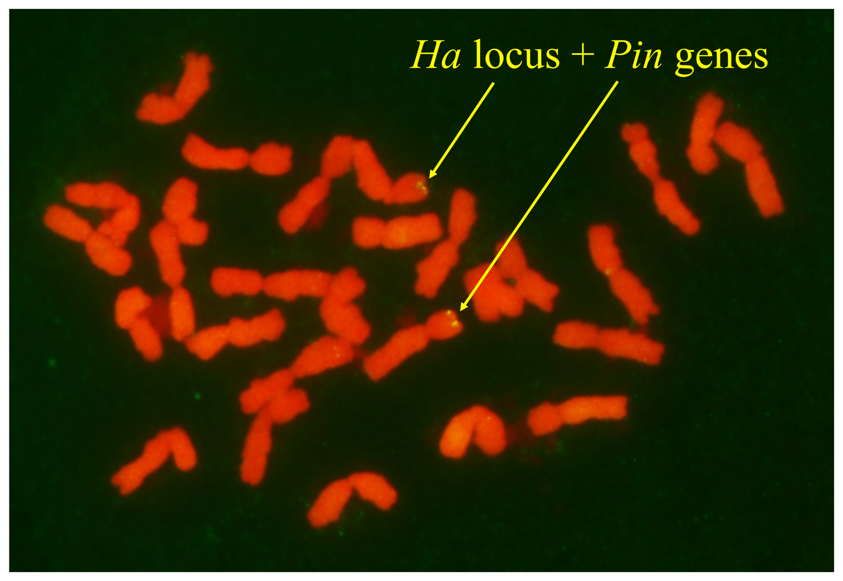
Family	Flour SDS volume	SRC lactic	Water absorption	Time to peak	Peak height	Peak width	Width 2 min after peak	Loaf volume	Bread crumb grain score
	mL g^{-1}	g 100 g^{-1}	g 100 g^{-1}	min	-	-	-	cm^{-3}	-
341	11.1 a †	104.2 a	62.4 b †	2.4 bc	50.5 ab	103.0 b	12.4 a	838 a †	5.4 fg
635	9.6 bc	92.0 bc	61.8 bcd	2.2 bcd	48.9 ab	91.8 bc	8.8 c	777 bcd	6.9 bc
854	10.3 ab	95.1 b	61.9 bc	2.4 bc	49.7 ab	100.4 b	8.2 cd	807 ab	6.0 ef
860	10.0 ab	104.9 a	60.5 f	2.8 a	46.7 bc	117.5 a	10.3 b	793 abc	5.0 g
869	9.7 bc	91.2 bc	63.4 a	2.1 bcd	51.0 a	92.3 bc	9.0 c	795 ab	6.9 bc
870	10.5 ab	94.6 b	60.9 ef	2.4 b	44.9 c	97.7 b	9.1 c	807 ab	6.4 cde
874	8.6 c	84.0 de	61.1 def	2.1 cde	47.7 abc	85.9 cd	8.3 cd	749 de	6.1 de
877	6.9 d	79.6 ef	63.2 a	1.8 e	49.9 ab	77.1 d	7.3 de	721 ef	7.5 ab
878	6.0 d	75.1 f	61.0 def	2.0 de	47.2 bc	85.5 cd	6.3 e	680 f	7.7 a
882	9.4 bc	87.1 cd	61.4 cde	2.3 bcd	47.6 abc	94.6 bc	7.0 e	752 cde	6.7 cd

† Within columns, means followed by the same letter are not significantly different according to LSD (0.05).





GISH staining of the translocation of chromosome 5DS-5BS in Soft Svevo (courtesy of M. Zhang & X. Cai).
90k SNP data indicate the translocation represents a replacement of ~20Mbp of 5BS with ~24 Mbp of 5DS (7).



Conclusion:

The traditional view of durum wheat with its inter-relationships among very hard kernel texture, milling performance, semolina production, and end-use quality no longer holds for soft kernel durum wheat. The substantial change in kernel texture greatly modified the processing, utilization and functionality of durum grain and flour. Expanded utilization of soft kernel durum may drive expanded production and contribute to global food security.

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