NOTE

A Simple Wheat Flour Swelling Test[1]

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ABSTRACT

Flour swelling tests have been widely used to assess the intercultivar differences in starch properties. This note describes a modified flour swelling test which uses ≈30 mg of flour. It avoids the use of a high-temperature water bath, and does not require a set of uniform and leak-proof tubes. The modified procedure offers a simpler and more rapid alternative to those previously reported, and provides a similar level of discrimination and precision. It is particularly suitable as a micro-scale early generation test for wheat flour swelling properties.

The behavior of starch in water during heating has been related to textural properties of certain types of noodles, especially soft-textured Japanese noodles (Udon). Starch with high pasting viscosity in wheat flour is beneficial in the production of noodles with a smooth surface and soft texture (Nagao et al 1977, Moss 1980, Oda et al 1980, Rho et al 1988). Instruments frequently used for monitoring starch or flour pasting characteristics are the Brabender Viscograph and the RapidVisco Analyser. The analysis time and sample size required for these instruments is too restrictive for them to be used routinely in a wheat breeding program for early generation testing. As the swelling ability of starch granules is largely responsible for the degree of paste viscosity observed when a starch suspension is heated (Leach et al 1959, Endo et al 1988), it has been suggested to use the starch and flour (including whole meal flour) swelling power as a simple test to assess the intercultivar differences in starch properties (Crosbie 1989, Toyokawa et al 1989, McCormick et al 1991). Application of the swelling power test to starch or flour derived from samples of individual cultivars indicates a strong association between measurements of swelling power and noodle texture (Crosbie 1989, 1991; Toyokawa et al 1989; McCormick et al 1991; Crosbie et al 1992; Konic et al 1992, 1993, 1994; Ross et al 1997). High swelling degree is positively related to the softness of Japanese white salted noodles and negatively correlated to the firmness of yellow alkaline noodles. Morris and coworkers (Morris et al 1997a,b; Zeng et al 1997) have recently determined the physicochemical basis, and genotypic and environmental variation for flour swelling properties in wheat. The reduction in the amylose content of wheat starch corresponds well with the number of granule-bound starch synthase null loci, and that variation in amylose content can largely explain the variation in flour swelling properties among wheat genotypes. Flour protein content was found to have significant effect on the flour swelling test for potential noodle quality of wheat (Crosbie 1997, Kovacs et al 1997). Various methods, referred to as swelling power (weight of the gel relative to the weight of the sample) or swelling volume (volume of the gel) have been used to measure the flour or starch swelling properties. In all methods, the container, sample concentration, temperature, heating period, stirring method, and centrifugation conditions are specified. The flour swelling volume test developed by Crosbie and coworkers (Crosbie 1991, Crosbie et al 1992, Crosbie and Lambe 1993), although widely used, has a few disadvantages, such as requirement of a set of uniform, strong, and leak-proof tubes; the need for the tubes to be inverted regularly during gelatinization at high temperature (92.5°C); and the need for very time-consuming test tube cleaning.

This note describes a simple flour swelling test that is rapid, easy, and inexpensive, and can evaluate large numbers of wheat lines for starch properties. Swelling power was assessed on samples of flour using 1.5 mL of polypropylene microcentrifuge tubes. Flour (≈33 mg) was weighed into a preweighed microcentrifuge tube, to which 1 mL of distilled water was added. The tubes were quickly capped and contents immediately vortexed for 5 sec. The microcentrifuge tubes were then placed in a constant temperature (95 ± 1°C) thermomixer (Eppendorf model 5436, Brinkmann Instruments, Inc., Westbury, NY) at 1,400 rpm. The thermomixer with transfer rack can accommodate 24 tubes. After 30 min of heating and shaking, the tubes standing in the transfer rack were placed in a room temperature (≈23°C) water bath for 5 min, and then centrifuged at 15,000 × *g* for 10 min. The supernatant was carefully removed by suction, and the tube with sediment gel was weighed. Swelling power was calculated as the weight of sediment gel divided by the original weight of the sample (14% mb).

This modified flour swelling test was compared to the widely used flour swelling volume test (Crosbie et al 1992) by using 21 flour samples milled from Canadian and Australian wheat cultivars, with a range of starch quality. Flour swelling determinations were performed in three replicates using both methods. The swelling power determined by the modified method is highly correlated ($r^2 = 0.88$, $P < 0.01$) with the swelling volume obtained by the method of Crosbie et al (1992) (Fig. 1), reflecting the common dependence of these two measurements on the extent of water uptake by starch during gelatinization. The discrimination and precision of this modified method were evaluated by measuring three wheat flours with high, medium, and low swelling properties. Flour swelling was determined in 32 replicates of each sample using both methods. The results (Table I) showed that the modified flour swelling test was very precise with a 3–5% coefficient of variation, and provided a good differentiation among high-, medium-, and low-swelling samples. The precision of the two methods was comparable, although the amount of flour used in the modified method (≈33 mg) was much less than that of Crosbie method (450 mg). The precision of the modified method is probably related to the improved resolution of the interface between the gel and supernatant, which was achieved by applying a higher centrifugal force (15,000 × *g*) to the samples in microcentrifuge tubes. The centrifugal force applied to glass tubes was much lower, usually limited to ≈1,000 × g (Crosbie et al 1992).

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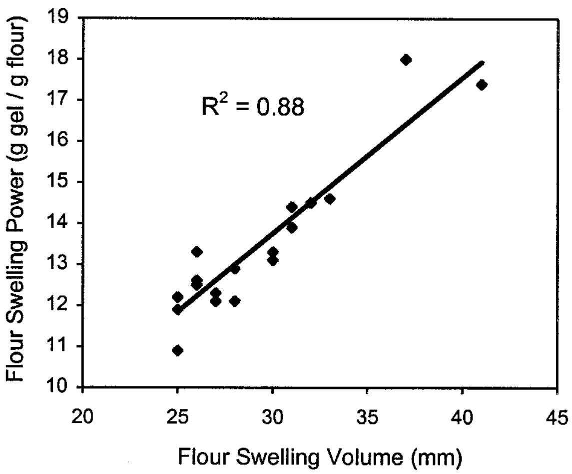

Fig. 1. Relationship between flour swelling volume (gel height in mm) determined by the method of Crosbie et al (1992) and swelling power (ratio of gel weight to flour sample weight) by the modified flour swelling test described here. Flour swelling properties of the 21 cultivars were determined in three replicates using both methods. Mean values obtained were used in the statistical analysis.

TABLE I
Distribution of Swelling Power/Volume of Three Flours with Diverse Swelling Properties[a]

	Mean ± Standard Deviation		Coefficient of Variance (%)	
Cultivar	Method A[b]	Method B[c]	Method A	Method B
Neepawa	11.5 ± 0.60	24.6 ± 1.1	5.2	4.3
Genesis	14.4 ± 0.61	32.8 ± 1.0	4.2	3.1
Eradu	18.3 ± 0.62	36.9 ± 1.2	3.4	3.1

[a] Method A is the modified flour swelling power test described here, and Method B is that of Crosbie et al (1992). All determinations were made on three flours in 32 replicates using both methods.
[b] Ratio of gel weight to flour sample weight.
[c] Gel height (mm).

The differentiation power of the modified method appeared to be slightly better than that of Crosbie et al (1992), as the relative differences in swelling among the three flours measured by the former method were larger than that determined by the latter method (Table I). Eradu, an Australian standard white wheat cultivar with a B genome mutation at the *wx* locus, has significantly higher swelling than that of Canadian hard red spring wheat Neepawa; ≈60% and ≈50% more swelling as determined by the modified method described here and the method of Crosbie et al (1992), respectively.

The procedure for the modified flour swelling test described here avoids the use of a high-temperature water bath and does not require a set of uniform and leak-proof tubes that have to be carefully cleaned after each use. This procedure offers a much simpler and more rapid alternative to those previously reported, and provides a similar level of discrimination and precision. It is, therefore, particularly suitable as a small-scale early generation test for flour swelling properties.

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