Gliadin Electrophoregrams and Measurements of Gluten Viscoelasticity in Durum Wheats

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Production of cultivars with high pasta-making quality is a major objective of durum wheat breeders.

Evaluating the ability of a cultivar to be processed into yellow amber pasta is no problem. Several laboratories have developed technological (color index measurements) and biochemical (carotenoid content, lipoxygenase activity, isoperoxidase composition) tests that meet breeders' requirements.

Fast small-scale methods for direct estimation of the cooking quality of durum wheats are also available. Some consist of processing grains into semolina and pasta disks or spaghetti, cooking them, and determining their characteristics with an aleurograph or a viscoelastograph apparatus. However, cooking quality evaluation at the breeding stage is a more critical problem.

In opposition to its color and particularly to its yellow component, a varietal characteristic, cooking quality of durum wheat is highly influenced by growing conditions. Table I shows the cooking quality scores (10 = excellent, 0 = very poor) of 24 durum wheat samples made up of three cultivars grown in eight different locations.

Breeders clearly cannot get entire satisfaction from these methods, which are hardly able to account for the respective influences of the genotype and the environment except by multiplying the number of field tests. Therefore, we think it fruitful to clearly distinguish between two types of tests: 1) breeding tests that must account for the varietal intrinsic quality of genotypes and 2) commercial tests (including microcooking tests) that must assess the commercial quality of wheat samples, ie, the result of interactions between the varietal intrinsic qualities and the growing conditions of the plant.

In this paper, we present our recent progress in developing breeding tests that are required to have the following characteristics: 1) independence of the results with regard to the agronomical record of the sample, 2) high correlation with the varietal ranking that would have resulted from conventional experiments, and 3) potential for analyzing a large series or a small amount of material.

In developing the breeding test for cooking quality of durum wheats, we have evaluated: 1) the varietal nature of the viscoelastic properties of the cooked gluten, 2) the relationship

Table I. Variability of Cooking Quality[a] of Three Durum Wheat Cultivars Grown in Eight Locations

	Varieties		
Location	Agathé	Lakota	V 39
A	10	8	8
B	10	8	6
C	10	8	4
D	8	4	4
E	8	4	0
F	6	4	0
G	6	4	0
H	4	0	0

[a] 10 = Excellent, 0 = very poor.

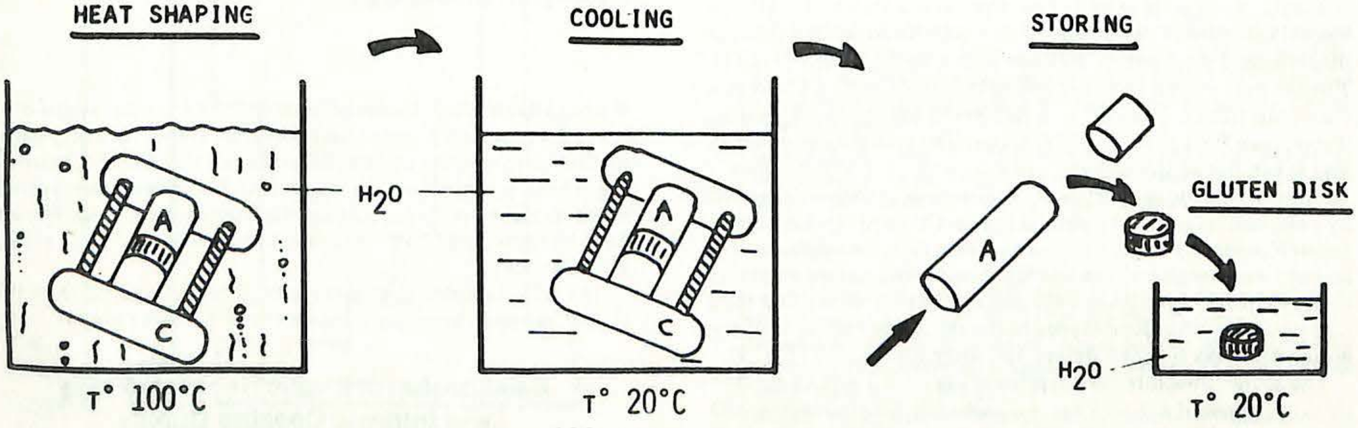

Fig. 1. Disk gluten shaping by heat treatment. A = piston, C = clamp.

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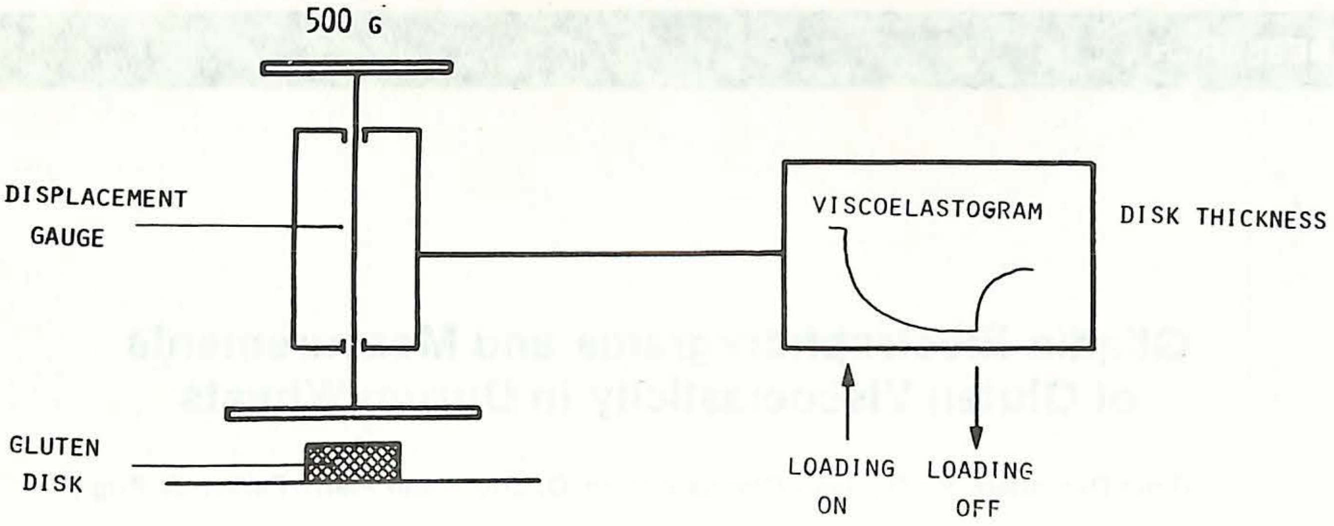

Fig. 2. Evaluation of gluten viscoelasticity with a viscoelastograph.

Table II. Intrinsic Cooking Quality and Gluten Viscoelasticity[a]

	Intrinsic Cooking Quality	
Variety	**High**	**Low**
Agathé	1.79	...
Bidi 17	170	...
Blondur	1.91	...
Brumaire	1.90	...
Diabolo	1.77	...
Edmore	1.71	...
Mondur	1.91	...
Montferrier	1.90	...
Trinakria	1.81	...
Valdur	1.82	...
Durtal	...	0.79
Lakota	...	1.28
Poinville	...	0.72
Randur	...	0.75
Rikita	...	0.47
Tomclair	...	0.59
Valsacco	...	0.59
Wells	...	0.71

[a] Absolute elastic recovery (e_2-e_1 in millimeters) of thermomolded gluten (average of analyses of samples of different origins).

between the viscoelastic properties of cooked gluten and the cooking quality of durum wheat varieties, and 3) the clear-cut relationship between gliadin electrophoretic patterns and viscoelastic properties of gluten.

Genetic Dependency of Viscoelastic Properties

First, a new method for the evaluation of gluten viscoelasticity was perfected. After extraction through manual dispersion, 1 g of gluten was put into a molding cell (Fig. 1). Pistons were placed on either side of the gluten ball and held by a clamping frame. The cell was immersed for 90 sec in boiling water, then for 120 sec in 20° C water. The resulting gluten disk was taken out of the cell and put into water for about 1 min.

The viscoelastic properties of the gluten were then determined by a viscoelastograph (Tripette Renaud-Chopin) (1). This apparatus (Fig. 2) follows the strain of a solid in terms of applied stress and of time. The gluten disk was taken out of the water and put on a sample plate; a constant load was applied for 40 sec and then removed. The time dependence of the thickness variation of the gluten disk was scanned before and after loading off (Fig. 3).

The gluten absolute elastic recovery ($e_2 - e_1$) was computed from the value of e_1 (thickness immediately before loading off) and e_2 (final thickness, 20 sec after loading off).

Elastic recovery was determined for a large number of samples of different varietal and agronomical origins (2).

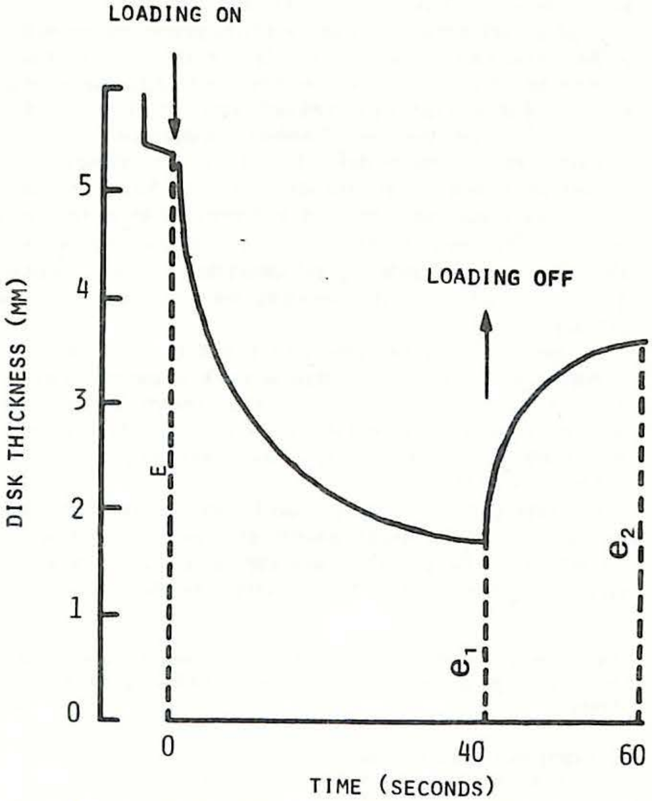

Fig. 3. Cooked gluten disk viscoelastogram. (Absolute elastic recovery: e_2-e_1. Firmness: e_1.)

Within all samples, absolute elastic recovery values ranged from 0.3 to 2.1 mm. In a given variety, absolute elastic recovery varies within narrow limits around an average value that decreases as the wheat protein content increases. The lower this average value is, the more important are the fluctuations. A variety can be characterized by this average value of its gluten viscoelasticity.

The 117 samples that were analyzed segregated into two classes around the mean values 0.6 and 1.8 mm (Fig. 4).

Relationship of Elastic Recovery Value and Intrinsic Cooking Quality

Well-known cultivars with either high or low cooking qualities were checked for their gluten viscoelastic properties

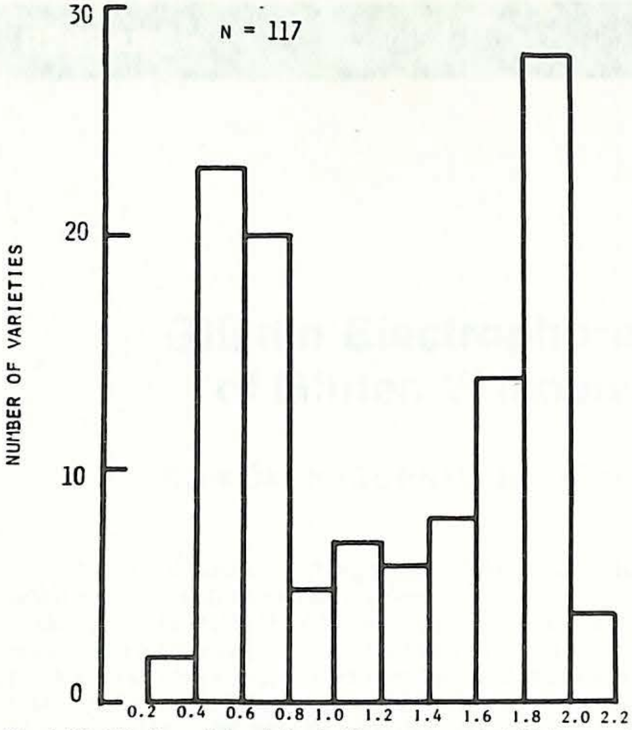

Fig. 4. Distribution of absolute elastic recovery of glutin in sample of durum wheat.

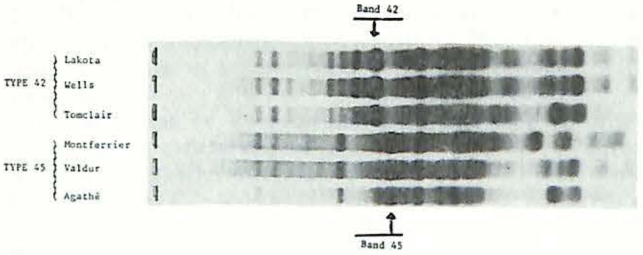

Fig. 5. Electrophoregrams of durum wheat varieties (polyacrylamide gel/aluminum lactate buffer, pH 3.1).

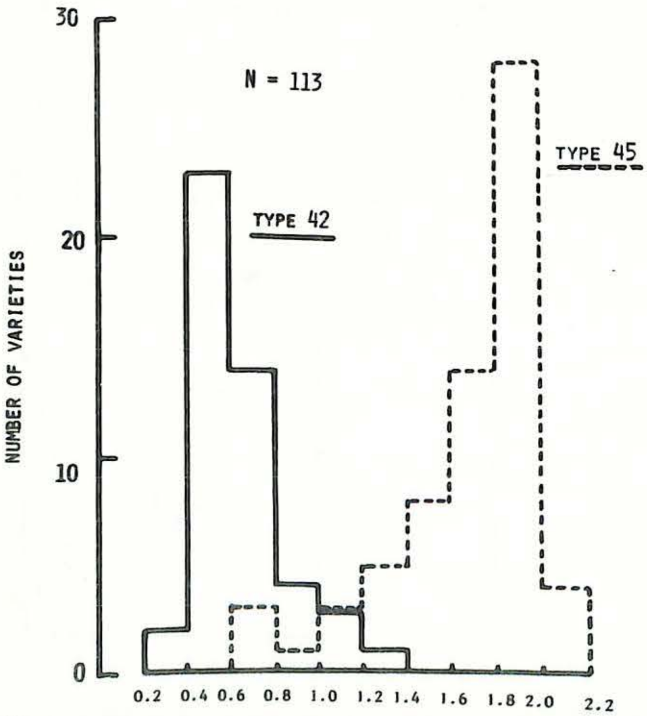

Fig. 6. Relationship of electrophoretic patterns and viscoelastic properties of durum wheat samples.

(Table II). Gluten in all cultivars known for good cooking quality had absolute elastic recovery values above 1.6. Glutens in low or medium cooking quality cultivars had absolute elastic recovery values below 1.0 (except for Lakota, which can be regarded as a medium quality cultivar).

Agreement Between Gliadin Electrophoretic Patterns and Absolute Recovery

One hundred seventeen durum wheat varieties of different genetic origins were examined (3). After extraction by 70% ethanol, gliadins were fractionated in polyacrylamide gel by the electrophoretic technique of Bushuk and Zillman (4). Component mobilities were established by reference to the standard *51* band, in agreement with the common wheat gliadin nomenclature (5).

Wheats were classified into two main groups according to the gamma gliadin region (Fig. 5). One was characterized by the presence of a strong band *45* and the absence of a band in the *38–42* region, the other by the absence of a band *45* and the presence of a strong band *42*. Sixty-six varieties belonged to the *45* type, 47 to the *42* type, and four to neither.

One of the most interesting results of this study was the excellent agreement between the electrophoretic patterns of the durum varieties and their viscoelastic properties (Fig. 6). In 59 of the 66 varieties (89%) of the *45* gliadin type, the elastic recovery of gluten was above 1.2 mm. In 46 of the 47 varieties (98%) of the *42* gliadin type, the elastic recovery was below 1.2 mm.

Conclusions

The results raise many questions about the nature of the linkage between the gliadin electrophoregrams and the viscoelastic properties of gluten. Is the linkage a genetic marker? Is it a functional relationship? At present, we can only speculate.

Our work has led us to several practical deductions, however. The results provide plant breeders with a new tool to screen new high cooking quality durum wheat varieties. To assist in this program, we would suggest using the following breeding diagram: 1) screen at the F3 or even the F2 generation, on half kernels, for the presence of the electrophoretic component *45*; 2) screen the F5 generation of lines that consistently belong to the *45* type for high elastic recovery of gluten (about 1.5 mm); 3) confirm end-use properties at the later breeding stages by checking the cooking quality through microtests and pilot plant tests and evaluating the effects of growing conditions. Simultaneous breeding for high protein content would be advisable.

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