RELATION BETWEEN MOLECULAR-WEIGHT DISTRIBUTION OF ENDOSPERM PROTEINS AND SPAGHETTI-MAKING QUALITY OF WHEATS[1]

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ABSTRACT

The relation between glutenin and spaghetti-making quality was investigated using 14 durum wheat varieties of different quality. Gel filtration fractionation of the AUC (acetic acid, urea, and cetyltrimethylammonium bromide)-soluble endosperm proteins revealed that those varieties with higher glutenin:gliadin ratios were generally of superior cooking quality to those with lower ratios. Correlations significant to 1% were obtained between glutenin peak area and farinograph mixing tolerance index (−0.661), gluten strength (0.845), and tenderness index (−0.681). The glutenin:gliadin ratio correlated linearly with the farinograph mixing tolerance index (−0.666). These results suggest that there are differences in protein composition among durum wheat varieties of different quality. These differences appear to be related to the spaghetti-making quality as it was possible to rank the 14 varieties on the basis of their gel filtration fractionation results in essentially the same order established by rheological and cooking tests.

Unlike common wheats (*Triticum aestivum*) which are used primarily for making bread, durum wheats (*T. durum*) have been traditionally used for the production of pasta products because they have an undefined balance of constituents which interact to produce products with the desired organoleptic qualities.

In Canada, the farinograph test (1) has recently been added to the technological tests used to evaluate new varieties of durum wheat for spaghetti-making quality. Varieties with a "strong" farinogram usually give spaghetti with superior cooking quality. Studies of bread wheats by Orth *et al.* (2) have shown that two important farinogram parameters, mixing tolerance index and dough development time, are strongly correlated to the amounts of acetic acid-soluble and -insoluble glutenin. On the basis of this information, a study was undertaken to obtain data on the possible interrelationships between solubility and/or molecular-weight distribution of durum wheat endosperm proteins and farinograph properties of semolina-water pastes and cooking quality of spaghetti. This article reports the gel filtration results.

MATERIALS AND METHODS

Wheat Samples

Table I gives the names, pedigree, and country of origin of the varieties used. With the exception of L 592 and the Tunisian variety, all of the samples were grown in Winnipeg in 1970 and 1971. L 592 and the Tunisian durum were obtained from Argentina and Tunisia, respectively. Table I includes one experimental line, DT 412, that was not used in the present study but was included in later studies (3). It is listed in Table I (also in Table II) to obviate the need to repeat the entire tables in the companion article (3).

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Quality Data

Quality data for the 15 wheats are given in Table II. The wheats are listed in decreasing order of overall spaghetti-making quality as assessed according to the Canadian system used in evaluating new varieties of durum wheat. In this system, the relative overall quality rank is determined by a number of objectively measured technological properties including semolina pigment, protein content, lipoxidase activity (4,5), farinograph properties (1), gluten strength (6), and the cooking properties of the spaghetti from each variety (7,8). Although the results from all the tests are considered in the overall assessment, considerable importance is placed on the gluten strength in this system of quality assessment.

Milling

For easier extraction of endosperm proteins, the wheat samples were milled into flour rather than into semolina. This was accomplished on a Brabender Quadrumat Junior mill using overnight tempering to 16.5% moisture.

Extraction with AUC Solvent

Flour (1.0 g) was extracted with a Potter-Elvjhem homogenizer for 5 min with 17 ml of AUC solvent (0.1*M* acetic acid, 3*M* urea, and 0.01*M* cetyltrimethylammonium bromide) at room temperature (9,10). The homogenized mixture was centrifuged twice at 20,000 × *g* for 30 min to remove most of the starch and at 100,000 × *g* for 1 hr to clarify the supernatant.

Gel Filtration

The procedure for preparing and using chromatographic columns for fractionating AUC extracts of flour was described by Bushuk and Wrigley (9). Gel filtration was performed on a 2.5 × 36-cm bed of Sephadex G-150. Sample volume was 3 ml (corresponding to about 20 mg of protein). The volume was adjusted so that the same amount of protein was injected for each trial. The column effluent was collected at a rate of five 3-ml fractions per hour. Proteins of

TABLE I
Durum Wheat Varieties Studied and Their Pedigrees

Variety or Line	Pedigree[a]	Country of Origin
L 592[a]	Unknown	Argentina
Candealfen	Unknown	Argentina
Pobulacion Tangarog	Unknown	Argentina
Tunisian	Unknown	Tunisia
DT 316	Lakota[2] × Pelissier	Canada
DT 406	RL 3601 × (RL 3442 × Lakota)	Canada
Pelissier	Unknown	Algeria
DT 332	RL 2607 × DT 182	Canada
DT 412	DT 188 × DT 224 × DT 182	Canada
Hercules	(RL 3097 × RL 3304) × (Stewart × Ld. 393)	Canada
Golden Ball	Unknown	South Africa
Wascana	Lakota[2] × Pelissier	Canada
Leeds	Br. 180 × Wells	U.S.
Mindum	Unknown	U.S.
Stewart 63	St. 464 × Stewart[8]	Canada

[a]Full description of parent varieties can be obtained from D. Leisle, Agriculture Canada Research Station, Winnipeg, Canada.

TABLE II
Quality Data for Durum Wheats

Variety	Semolina			Rheological Farinograph			Cooking		
	Protein[a] (14% mb) %	Pigment ppm	Lipoxidase activity μl O_2/min/g	DDT[b] min	TI[c] BU[d]	Gluten strength[e] min	Compressibility %	Recovery %	Tenderness index mm/sec $\times 10^3$
L 592	13.4	...	...	5.00	100	300[f]	80	36	34
Candealfen	12.0	3.69	...	4.50	70	300[f]	67	45	44
Pobulacion Tangarog	11.0	3.49	...	11.00	80	50	71	38	41
Tunisian	10.6	...	...	13.00	0	300[f]	78	3	47
DT 316	13.6	6.16	15	4.00	75	300[f]	65	36	40
DT 406	13.9	6.26	20	4.50	80	300[f]	68	31	39
Pelissier	12.9	3.93	25	5.25	75	300[f]	69	38	37
DT 332	13.7	7.10	14	4.50	100	300[f]	70	41	40
DT 412	12.6	6.31	...	5.00	100	150	78	31	42
Hercules	13.5	5.82	15	3.50	120	52	72	29	41
Golden Ball	10.8	4.75	30	3.50	90	25	75	25	46
Wascana	13.6	7.55	14	3.25	130	18	72	28	42
Leeds	13.6	7.56	...	3.25	170	2	75	25	50
Mindum	13.2	4.38	14	2.50	150	19	75	24	50
Stewart 63	13.3	4.32	15	3.00	160	4	77	22	51

[a]Protein (N $\times$ 5.7).
[b]DDT = dough development time.
[c]TI = tolerance index.
[d]BU = Brabender Units.
[e]Gluten strength = time required for gluten ball to stretch 10 cm in H_2O at 25°C.
[f]Projected time (no movement in 10 min).

known molecular weight were used to calibrate the column for molecular-weight distribution. Elution curves were plotted using absorbancy of collected fractions measured at 280 nm with a Zeiss Model PMQ2 spectrophotometer. The curve was divided into four regions as recommended by Meredith and Wren (10). Quantitative distribution of material among the four groups was determined from the areas under the corresponding portions of the elution curves.

RESULTS AND DISCUSSION

The elution curves for the three durum wheat varieties, L 592, DT 316, and Wascana, representative of varieties with excellent, good, and mediocre spaghetti-making quality, respectively, are shown in Fig. 1. The varieties are

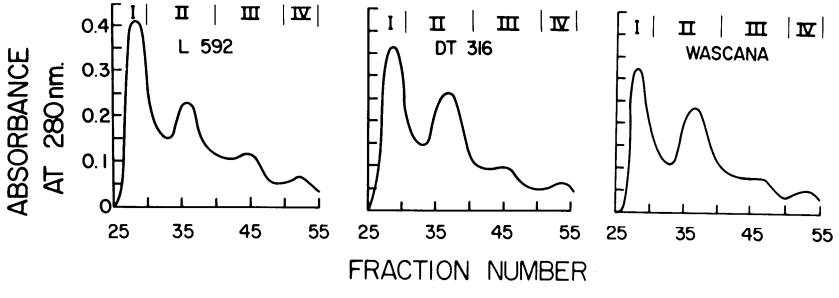

Fig. 1. Gel filtration elution profiles of AUC extracts of three durum wheat flours. I = glutenin, mol wt $\geq$ 100,000, II = gliadin, mol wt range 25,000 to 100,000, III = albumin, mol wt range 10,000 to 25,000, IV = nonprotein nitrogen, mol wt $\leq$ 10,000.

TABLE III
Glutenin and Gliadin Peak Areas and Their Ratios for Varieties Listed in Decreasing Order of Quality

Variety	Glutenin Peak Area[a]	Gliadin Peak Area[a]	Glutenin: Gliadin Ratio
L 592	113,535	87,232	1.30
Candealfen	92,157	73,359	1.25
Pobulacion Tangarog	70,092	67,396	1.04
Tunisian	98,560	63,765	1.54
DT 316	101,925	139,230	0.733
DT 406	98,980	100,825	0.980
Pelissier	81,030	98,362	0.825
DT 332	84,072	113,628	0.730
Hercules	74,556	120,060	0.622
Golden Ball	75,012	110,700	0.677
Wascana	76,608	99,630	0.767
Leeds	68,670	78,925	0.870
Mindum	58,880	87,098	0.676
Stewart 63	56,242	85,796	0.657

[a]Arbitrary units determined with an electronic integrating X-Y plotter.

TABLE IV

A Correlation Matrix Showing Simple Correlation Coefficients between Gel Filtration and Rheological and Cooking Tests

		Glutenin Peak Area 1	Gliadin Peak Area 2	Glutenin: Gliadin Ratio 3	Dough Development Time 4	Tolerance Index 5	Gluten Strength 6	Compress-ibility 7	Recovery 8	Tenderness Index 9
Glutenin peak area	1	1.00								
Gliadin peak area	2		1.00							
Glutenin:gliadin ratio	3	0.630*	−0.661**	1.00						
Dough development time	4			0.715	1.00					
Tolerance index	5	−0.661**		−0.666**	−0.744**	1.00				
Gluten strength	6	0.845**				−0.707**	1.00			
Compressibility	7							1.00		
Recovery	8							−0.627*	1.00	
Tenderness Index	9	−0.681**					−0.617*		−0.592*	1.00

* = 2.5% level; ** = 1% level.

arranged in order of decreasing overall spaghetti-making quality from left to right.

Although the profiles for the 14 varieties were qualitatively similar, there were definite quantitative differences among some varieties. These differences will be discussed with reference to glutenin and gliadin peak areas and the ratio of these areas. The derived data for this discussion are listed in Table III.

Samples with higher glutenin:gliadin ratios were generally superior in quality to those with lower ratios. There are a number of minor exceptions to this generalization. The variety Leeds had a glutenin:gliadin absorbance ratio of 0.870, which suggests that this variety should be of relatively high quality. However, subjective ranking on the basis of rheological and cooking tests showed that this variety is of relatively low overall spaghetti-making quality. One possible explanation for this discrepancy is that the glutenin:gliadin ratio does not include the effect of protein content on spaghetti-making quality. It is well known that certain criteria of spaghetti-making quality of durum wheat (*e.g.*, dough development time, mixing tolerance index, and tenderness index) depend on both protein content (11,12) and quality of the protein (6,13). To isolate the quality factor, it would be necessary to have an index of spaghetti-making quality expressed per unit of protein.

Glutenin and gliadin peak areas and glutenin:gliadin absorbance ratios were correlated with specific quality parameters to further examine their relationships with technological tests used to measure durum wheat quality. Table IV gives a matrix of simple correlation coefficients between a number of quality parameters, glutenin and gliadin elution peak areas, and glutenin:gliadin ratios. Only those correlation coefficients that are greater than 0.590* (significant to 5% or better) are given.

Highly significant correlations were obtained between glutenin peak area and mixing tolerance index (−0.661**), gluten strength (0.845**), and tenderness index (−0.681*). The glutenin:gliadin ratio correlated with the dough development time (0.715) and the tolerance index (−0.666**).

The results obtained from the gel filtration experiments lead to the conclusion that differences exist in protein molecular-weight distribution among durum wheat varieties of different quality. Furthermore, these differences appear to be related to spaghetti-making quality as it is assessed by rheological and cooking tests since it was possible to rank the 14 varieties on the basis of the glutenin:gliadin ratio obtained from the gel filtration fractionation results in essentially the same order established by rheological and cooking tests. With a few exceptions, this order of ranking was the same as that based on overall spaghetti-making quality as assessed by a number of technological tests. Accordingly, it may be possible to predict the spaghetti-making quality of durum wheat from gel filtration profiles of AUC extracts of the endosperm proteins.

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