STUDY OF THE LOW-MOLECULAR WEIGHT WHEAT PROTEINS*

By

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1. Some introductory remarks

The proteins of the gluten complex can be divided into two groups: low-molecular weight proteins (gliadins) — characterized by a single polypeptide chain and intramolecular disulphide bonds — and high molecular weight proteins (glutenins). The latter have a more complex structure. Several single polypeptide chains are conjugated with intermolecular disulphide bonds [1, 2].

In the past twenty years great progress was made in the investigation of wheat proteins.This progress is well illustrated in Tables 1 and 2 demonstrating the development of our knowledge concerning the number of wheat endosperm protein fractions and N-terminal groups of gliadin [6—15].

Nevertheless, elucidation of the finer structure of wheat proteins, better knowledge of the correlation between chemical structure and rheological properties of gluten, and understanding of the biochemical processes of cereal processing at a molecular level need further investigations. In our paper we want to give a short review about the results of our investigations of the gliadin components of the gluten complex.

Table 1

The number of wheat endosperm protein fractions separated by different techniques

Method	Number of fractions	Year
Osborne	4	1907
Paper electrophoresis	6—8	1950
Gel chromatography	6—8	1963
Gel electrophoresis (1 dim.)	20—25	1963
Isoelectric focusing and gel electrophoresis	40—45	1970
Calculation on the basis of N-terminal Groups	40—50	1968

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Table 2

N-terminal groups of gliadins

Authors	N-Terminal groups	Number of N-terminal groups
Körös [6]	His	1
Dévényi, Szörényi [7]	Phe	1
Mills [8]	Asp, Ser, Val	3
Ramachandran, McConnell [9]	Glu, Asp, Ser, Val, Ala, His	6
Melteva, Polotnova [10]	Asp, Thr	2
Reznichenko et al. [11]	Asp, Thr	2
Rohrlich, Schlüssler [12]	Glu, Gly, Ala, Val, Leu, His	6
Reznichenko [3]	Glu, Phe, Thr, Leu, Lys	5
Lásztity, Nedelkovits [14]	His, Ala, Thr, Val, Cys	5
Varga [15]	Asp, Glu, Ser, Thr, Gly, Ala, Val, Phe, Leu, His	10

2. Aims and methods

The main objectives of our investigations were as follows:

— preparation of the gliadin and fractionation, using gel chromatography and gel electrophoresis,
— enzymatic (papain) and chemical (BrCN) splitting of the subfractions,
— determination of amino-acid composition and N-terminal groups of the subfractions and products of splitting,
— on the basis of the new results, development and improvement of a hypothetical model of the gluten structure.

The fractions and subfractions inevstigated and the methods used are summarized in Figure 1. The detailed description of the methods was published earlier [3, 4, 15].

3. Results and discussion

In this paper we only discuss the results of the investigation of the fraction G 2 (see Fig. 1). This fraction is a mixture of ω, α, β and γ-gliadins (according to the nomenclature of JONES et al.). Using a QAE Sephadex ion exchange column, the fraction G 2 was separated, yielding four subfractions (G 21, G 22, G 23 and G 24). All subfractions were split. using papain and the products of splitting were analyzed (quantity, molecular weight, further fractionation

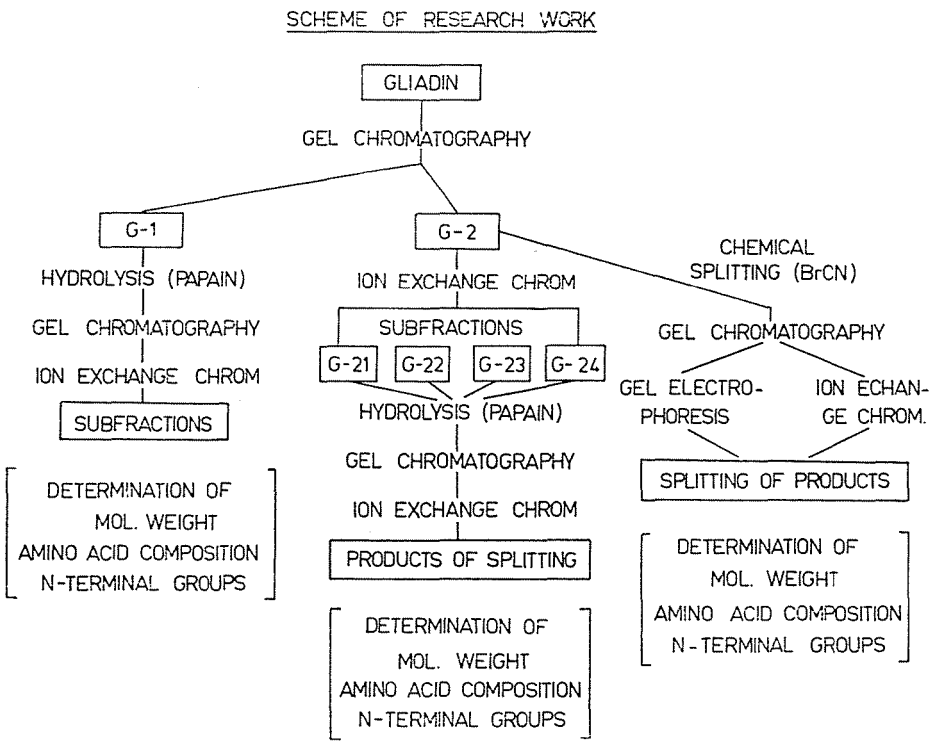

Fig. 1

by ion exchange columns, amino-acid composition, N-terminal groups). Some characteristic results of the investigation are summarized in Tables 3, 4 and 5. Based on the results in Table 3 it may be stated that the major product of splitting has a higher (15—20 thousand) molecular weight.

The data summarized in Table 4 show an increase of the quantity of the hydrophobic amino acids in the low-molecular weight products of splitting and a relatively higher amount of glutamin and glutamic acid in the high-molecular weight products of splitting.

In Table 5 some results of the investigation of splitting by Br—CN are summarized. The distribution of the products of splitting with regard to molecular weight and amino-acid composition has the same character as by hydrolysis, using papain. The high-molecular weight products of splitting are relatively more homogeneous. This fact is reflected by the results of N-terminal group determination. Only valine and leucine terminal groups were observed.

On the basis of the results it can be stated that the characteristic gliadin fractions have at least two different sections in the polypeptid chains: one section with high polyglutamic acid, glutamin and prolin content and a second one having high amounts of hydrophobic amino acids. This finding permits a

modification of the molecular model of low-molecular weight gluten proteins given earlier by the authors (cf. Figs 2 and 3). On the basis of the molecular model we assume that the aggregates of gliadin polipeptide chains have a more hydrophobic character, owing to the interaction of glutamin acid-glutamin section (cf. Fig. 4).

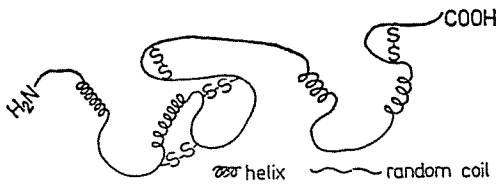

Fig. 2

Table 3

Some characteristics of the hydrolysis products of gliadin subfractions

Subfraction G-2.1.					
Products of splitting	G-2.1.1.	G-2.1.2.	G-2.1.3.	G.2.1.4.	G-2.1.5.
Quantity	50%	15%	12%	8%	15%
Mol. weight	20 000	~3 000	<3 000	<3 000	<3 000
Ion exch. fr.	—	4	4	4	3
Subfraction G-2.2.					
Products of splitting	G-2.2.1.	G-2.2.2.	G-2.2.3.	G-2.2.4.	G-2.2.5.
Quantity	47%	14%	19%	9%	11%
Mol. weight	20 000	~3 000	<3 000	<3 000	<3 000
Ion exch. fr.	—	4	4	3	4
Subfraction G-2.3.					
Products of splitting	G-2.3.1.	G.2.3.2.	G-2.3.3.		
Quantity	53%	13%	34%		
Mol. weight	20 000	~3 000	<3 000		
Ion exch. fr.	—	5	5		
Subfraction G-2.4.					
Products of splitting	G-2.4.1.	G-2.4.2.	G-2.4.3.		
Quantity	48%	10%	42%		
Mol. weight	15 000	~3 000	<3 000		
Ion exch. fr.	—	4	5		

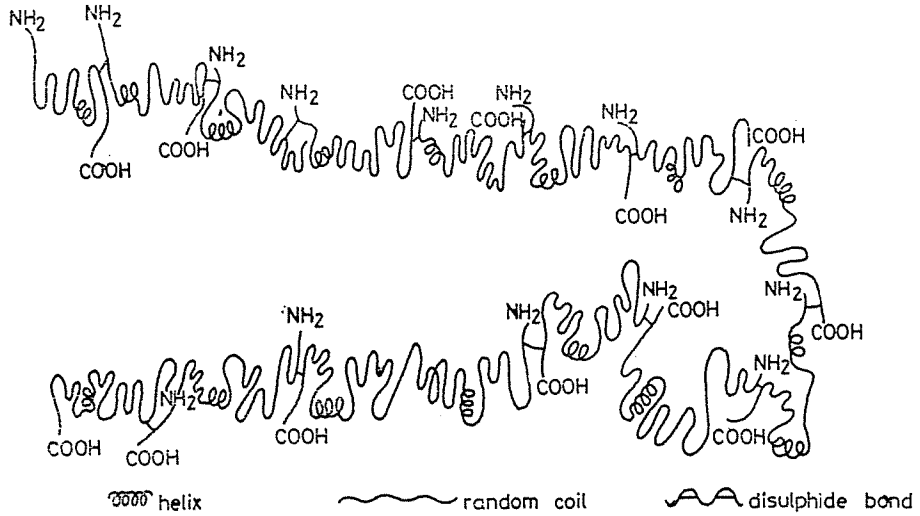

Fig. 3

Table 4

Some characteristics of the amino acid composition of the hydrolysis products of gliadin subfractions

Subfractions G21, G22, G23, G24

Products of splitting	Gln (Glu) %	Glu (Gln)+Pro %	Hydrophbic A.A. %	Hydrophob. Glu (Gln)
G211	45.0	60.0	36.5	0.81
G212	14.0	19.5	46.0	2.30
G213	18.0	26.0	38.0	2.10
G214	23.0	29.0	34.0	1.48
G215	27.5	34.5	31.0	1.13
G221	42.0	53.5	30.5	0.73
G222	27.0	33.0	44.0	1.63
G223	28.0	36.0	44.0	1.57
G224	28.0	36.5	41.0	1.46
G225	28.5	37.0	44.0	1.54
G231	47.0	64.0	31.5	0.67
G232	24.5	33.0	48.0	1.96
G233	28.8	38.0	43.5	1.51
G241	42.0	55.0	31.0	0.74
G242	18.5	29.0	48.2	2.60
G243	17.0	27.5	46.0	2.70

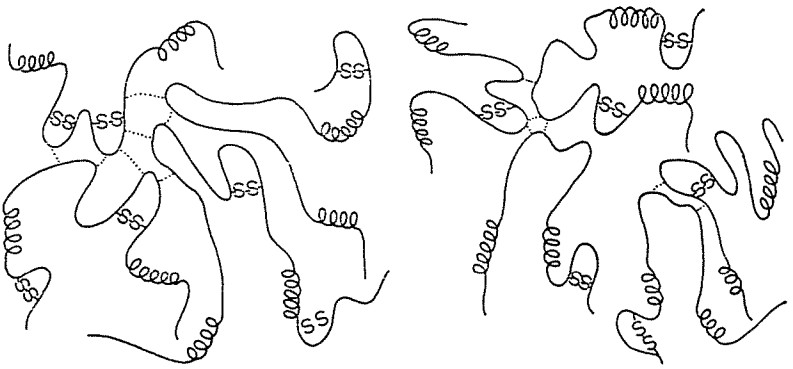

Fig. 4. Proposed hypothetical structure of the gliadin aggregates ...: H-bonds ∼: random coil γγγγ: α helix

Finally, in Figure 5 we show a hypothetical structure of the gluten complex, and we hope that our further investigation will contribute to the elucidation of some problems of wheat proteins and cereal technology.

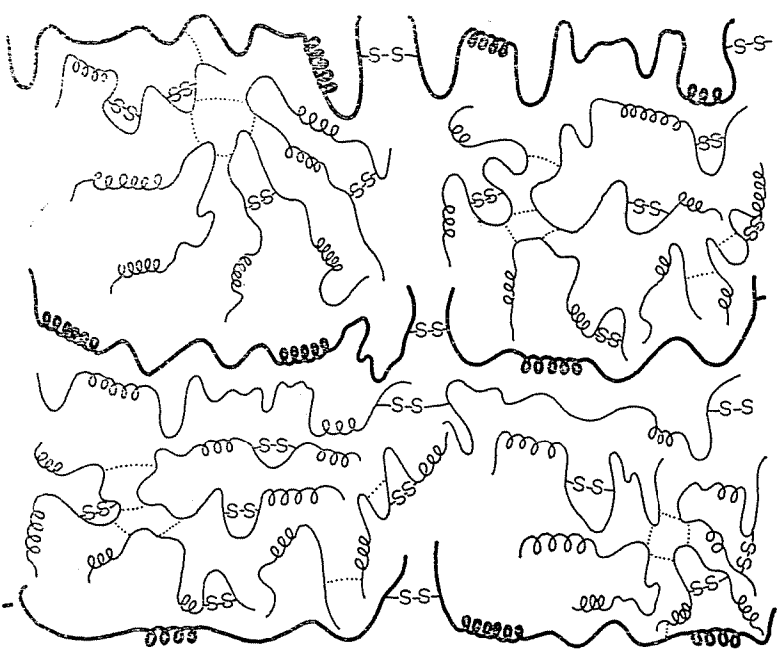

Fig. 5. Hypothetical structure of the gluten complex

Table 5

Some characteristic properties of the products of splitting (BrCN) of gliadin

Quantity and molecular weight		
Product of splitting	Quantity	Mol. weight
G2B1	54%	25 000
G2B2	26%	10 000
G2B3	20%	~5 000

Amino acid composition				
Product of splitting	Glu (Gln)	Glu (Gln)+Pro	Hydrophobic	Hydrophob. / Glu (Gln)
G2B1	44.5	61.5	37.5	0.84
G2B2	29.5	37.0	41.0	1.39
G2B3	29.0	35.5	30.5	1.05

Summary

The low-molecular weight component (gliadin) of the gluten complex was investigated with the aid of gel chromatography, enzymatic (papain) and chemical (BrCN) splitting of subfractions. The molecular weight, amino-acid composition and N-terminal groups of the products were determined.

From the results it could be stated that the characteristic gliadin fractions have minimum two different sections in the polypeptide chains: one section having high contents of polyglutamic acid, glutamin and proline and a second one having high amounts of hydrophobic amino acids. Based on the results, a new molecular model of low-molecular weight gluten proteins was proposed.

References

1. LÁSZTITY, T.: Periodica Polyt. Chem. Eng. **16,** 331, 1972.
2. LÁSZTITY, R.: Die Nahrung **19,** 749, 1975.
3. VARGA, J.: Recent results in the investigation of low-molecular weight proteins (gliadins) of gluten complex. Dissertation. Technical University Budapest, 1975.
4. VARGA, J.—LÁSZTITY, R.: Élelmiszertudomány **2,** 185. 1968.
5. VARGA, J.—LÁSZTITY, R.: Élelmiszertudomány **4,** 116. 1971.
6. KÖRÖS, Z.: Magyar Kémiai Folyóirat **56,** 131, 1950.
7. DÉVÉNYI, T.—SZÖRÉNYI, E.: Acta Physiol. Acad. Sci. Hung. **9,** 301, 1954.
8. MILLS, Y.: Biochem. Biophys. Acta **18,** 593, 1955.
9. RAMACHANDRAN, L. J.—MCCONNELL, W. B.: Canadian J. Chem. **33,** 1463, 1955.
10. MELTEVA, N.—POLOTNOVA, L.: Shorn. Nautshn. Rab. Leningradskogo Inst. Sovo. Torg. **12,** 124. 1957.
11. REZNICHENKO, M.—MELTEVA, N.—POLOTNOVA, L.: Biokhimija **23,** 649. 1958.
12. ROHRLICH, M.—SCHLÜSSLER, H. J.: ZLUF **108,** 405, 1958.
13. REZNICHENKO, M.: VNIIZ Nautchn. Konf. po voprosam biokmii zerna. Moscow 1960.
14. LÁSZTITY, R.—NEDELKOVITS, J.: Magyar Kémiai Folyóirat **71,** 197. 1966.
15. VARGA, J.: Investigation of the N-terminal groups of wheat proteins. Dissertation. Budapest, 1957.

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