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# The fractional composition of wheat proteins and the possibility of its hereditability in $F_1$ generation

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Abstract

The fractional composition of proteins extracted from wheat flour samples of different baking quality was determined in order to find some relationships between the fraction contents, total extractability, and the $E_{280}$ /total N ratios of separate extracts and the baking quality of flour. There has been found an influence of the quality of fluor on the decrease of total extraction of protein and that of $E_{280}$ /total N ratio of NaOH extracts containing high mol. weight glutenin. As those flour properties should be of importance in technology and nutrition, the possibility of their direct hereditability in $F_1$ generation, using crossings between male sterile mother lines and fertility restoring father ones, was investigated. It has been shown, that the fractional composition of wheat proteins can be directly hereditable, the influence of mother line being much stronger than that of father line. Also, the influence of mother line on the hereditability of $E_{280}$ /total N ratio was found to be probable, although the results were found to be less regular.

## INTRODUCTION

The fractional composition of wheat proteins, as well as the compactness of molecules present in particular fractions, according to some authors (Bushuk and Wrigley 1971; Coates and Simmonds 1961; Hoseney and Finney 1971; Jankiewicz M. and Jankowski 1969; Pomeranz et al. 1970) should be closely connected with the technological value of flour. Therefore, in the following investigations, the intention was to confirm this dependence, using flour samples differing significantly in baking quality. As more than 70% of what in Poland is still used for baking, it was thought to be useful to investigate the possibility of direct hereditability in $F_1$ generation of the fractional composition of its proteins using male sterile lines with different baking quality from the collection of the Institute of Plant Genetics and Breeding. In fractions obtained the ratios $E_{280}$/total N, which

according to Jankiewicz (1969) and Pomeranz (1965) should be the evidence of molecule compactness, and of the baking quality, were also determined.

## MATERIAL AND METHODS

In the first series of investigations, six flour samples significantly different in baking quality, were used. They were obtained from following wheat varieties: 'Saratowskaja 29' and 'Bezenchugskaja 98' of very good quality, 'Bezostaja 1' of good quality, 'Manitoba' and 'Mironowskaja 808' of medium quality, and 'Varigo' of low quality. Methods of quality investigation and the evaluation principles were described earlier (Bernacka, Kączkowski, Liss 1971). In the second series of analyses, concerning the hereditability of protein fractional composition, four sets of samples were used; each of them was composed of the male sterile mother form, based on the cytoplasm *Triticum timopheevi* and containing the cytoplasm of *T. timopheevi* and carioplasm of *T. aestivum,* of father form *T. aestivum,* containing the cytoplasm and genes $R_f$ $R_f$ of the fertility restoring ability and of the crossing form. All mother and father forms were of own breeding of J. Jakubiec in the Institute of Plant Genetics and Breeding.

The following mother forms were used:

1. MS Splendeur, obtained by crossing of MS Nebrasca with French variety Splendeur, after five back crossings; it was morphologically similar to the fertile line;

2. MS (Norin 10 × Brevor) selected from the crossing MS Nebrasca × (Norin 10 × Brevor), after five back crossings. Norin 10 × Brevor constitutes the line found in the World collection;

3. MS San Marino, the line selected from the crossing of MS Nebrasca with the mutant of San Marino, after five backcrossings.

The following father forms were used:

1. Restorer 108 711 — the line selected from the crossing of Nebrasca restorer with the Institute's line 108 711, after two back crossings; it contains the genes restoring the fertility to *T. timopheevi.*

2. Restorer BO 56-92 — the line selcted from the crossing of Nebrasca restorer with the Yugoslavian one originating from the Plant Breeding Station Botinec, after two back crossings.

3. Restorer 103-31 × Produttore — the line selected from the crossing of Nebrasca restorer with the line selected from the crossing 103-31 × Produttore, after two back crossings.

4. Restorer Żelazna MP — the line selected from the crossing of Nebrasca restorer with the line obtained by crossing of Żelazna (Poland) × wheat couch grass hybrid (Soviet Union).

Flour of 70% milling was extracted according to Coates and Simmonds (1961), however, the preliminary defatting of flour with butanol was omitted in order to avoid the structural changes in protein. The extraction was carried out by shaking three times using 0.01 M pyrophosphate buffer pH 7.0; three times using 0.05 M acetic acid, and three times using 0.1 M sodium hydroxide. After each extraction the slurry was centrifuged at 7 000 rpm, the extracts of the same solvent were combined and in each solution the total volume, total Nitrogen, and the extinction at 280 nm were determined.

Total N in the initial flour samples; as well as in separate fractions was determined according to Reifer and Tarnowska (1950). The spectrophotometric determination was carried out using Zeiss VSU 2 spectrophotometer.

## RESULTS AND DISCUSSION

The contents of particular protein fractions in samples significantly different in baking quality, as well as corresponding ratios $E_{280}$/total N are presented in Table 1.

Table 1

Fractional composition of wheat proteins and the $E_{280}$/total N ratios

| Variety of wheat | Protein in % of total N in flour | | | | $E_{280}$/total N ratio | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| Mironowskaja | 18.1 | 50.1 | 30.1 | 98.3 | 0.250 | 0.065 | 0.182 |
| Bezenchugskaja | 13.0 | 53.4 | 25.8 | 92.2 | 0.163 | 0.072 | 0.147 |
| Saratowskaja | 11.7 | 46.5 | 35.0 | 93.2 | 0.170 | 0.056 | 0.119 |
| Manitoba | 20.8 | 54.3 | 23.2 | 98.3 | 0.220 | 0.062 | 0.348 |
| Varigo | 14.8 | 64.7 | 17.6 | 97.1 | 0.132 | 0.065 | 0.281 |
| Bezostaja | 20.2 | 57.0 | 27.9 | 104.9 | 0.182 | 0.056 | 0.308 |

Dispersing agent: 1 — pyrophosphate, 2 — acetic acid, 3 — NaOH, 4 — total.

The data indicate very good extractability in all samples reaching 92 to 100%. It is of interest, that samples of the best quality (Saratowskaja' and 'Bezenchugskaja') were extracted to the smaller extent (93 and 92%) and they contained a rather high percentage of the so-called "residual" protein. In those samples, however, very small amounts of pyrophosphate soluble proteins were observed; the contents of proteins in this fraction were found to be much more negetivety correlated with flour quality than any other protein fraction. The calculated values of the ratio $E_{280}$/total N differed strongly in particular fractions. On the

other hand, the differences depending on baking quality were observed only in the last fraction of "residual" proteins, where the values for samples of very good quality were found to be particularly low.

The fractional composition of wheat proteins was also investigated by other authors (Pomerantz and Finney 1970; Pomerantz 1965; Konarev 1973), as it should be of significance in the formation of the matrix in the dough. In our experiments only the pyrophosphate-fraction was negatively correlated with flour quality. On the other hand, the lower extractability of samples of good quality and the very low $E_{280}$/total N ratio for "residual" proteins of those samples indicate that the proteins show higher compactness of molecules than those obtained from samples of lower quality. As is suggested in our previous papers (Kączkowski et al. 1968; Bartoszewicz et al. 1972), the compactness of protein molecules, particularly those of sodium hydroxide fraction (high molecular glutenins) should influence the baking quality of flour.

Since the fractional composition of wheat proteins should be the factor affecting flour quality, as well as its nutritive value, experiments

Table 2

Fractional composition of wheat proteins in parental forms and $F_1$ generations

| Flour sample | Total protein N X 5.7 | Sedimentation number | Protein in % of total N in flour | | | | $E_{280}$/total N ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| MS-San Marino | 13.76 | 3.0 | 20.1 | 59.7 | 15.2 | 94.8 | 0.174 | 0.086 | 0.260 |
| Rest. Żelazna × × MP | 13.68 | 3.9 | 14.5 | 52.9 | 30.4 | 97.8 | 0.175 | 0.065 | 0.205 |
| Crossing $F_1$ | 13.90 | 2.3 | 18.5 | 65.9 | 14.9 | 99.3 | 0.163 | 0.081 | 0.245 |
| MS-Splendeur | 11.85 | 3.0 | 19.8 | 55.8 | 20.6 | 96.2 | 0.165 | 0.078 | 0.207 |
| Rest. 103-31 Produttore | 12.31 | 1.9 | 14.8 | 45.7 | 19.9 | 80.4 | 0.184 | 0.070 | 0.188 |
| Crossing $F_1$ | 12.37 | 2.5 | 19.2 | 56.4 | 19.6 | 95.2 | 0.170 | 0.074 | 0.219 |
| MS-Norin 10 × Brevor | 13.68 | 2.0 | 20.6 | 69.7 | 11.8 | 102.1 | 0.191 | 0.082 | 0.259 |
| Rest. BO 56-92 | 11.91 | 2.5 | 16.5 | 61.4 | 19.6 | 97.5 | 0.150 | 0.070 | 0.182 |
| Crossing $F_1$ | 13.17 | 2.6 | 18.7 | 65.5 | 16.4 | 100.6 | 0.168 | 0.078 | 0.219 |
| MS-Splendeur | 12.45 | 2.8 | 18.5 | 52.7 | 22.5 | 93.7 | 0.172 | 0.071 | 0.188 |
| Rest. 108 711 | 11.97 | 2.2 | 16.1 | 65.8 | 17.4 | 99.3 | 0.160 | 0.081 | 0.205 |
| Crossing $F_1$ | 14.14 | 2.8 | 18.9 | 60.0 | 14.7 | 93.6 | 0.167 | 0.083 | 0.230 |

Dispersing agents: 1 — pyrophosphate buffer pH 7.0, 2 — acetic acid, 3 — sodium hydroxide, 4 — total protein extracted.

have been carried out concerning the hereditary possibilities of this property together with the measurements of molecule compactness in particular fractions, expressed as the ratio $E_{280}$/total N. The results of those experiments are presented in Table 2. Table 3, contains averages of data presented in Table 2, calculated separately for mother, father and $F_1$ crossing forms.

As can be seen from the sedimentation numbers also given in Table 2, the differences in the quality of investigated samples, were not as significant as in the first series of experiments. Nevertheless, some general relationships found previously, can be observed also in this case. In almost all samples, the negative influence of extractability and positive one of the content of NaOH fraction on quality, expressed as the sedimentation number, could be shown. On the other hand, a relationship has been found between the pyrophosphate fraction content and flour quality. The differences in this property between two series of experiments can result from the fact that the quality determination in the second case was only indirect, and therefore less probable, than in the first case. The same explanation should be given to the fact, that not in all experiments the $E_{280}$/total N ratio for NaOH extracts was bound with flour quality.

Table 3

The average data calculated separately for MS, RS and $F_1$ forms from results given in Table 2

| | MS forms | RS forms | $F_1$ forms |
|---|---|---|---|
| Total protein in % dry matter | 12.94 | 12.46 | 13.39 |
| Sedimentation number | 2.7 | 2.6 | 2.55 |
| Pyrophosphate sol. protein in % | 19.75 | 15.47 | 18.82 |
| Acetic acid sol. protein in % | 59.47 | 56.45 | 61.95 |
| NaOH soluble protein in % | 17.52 | 11.82 | 16.40 |
| $E_{280}$/total N: pyrophosphate | 0.175 | 0.167 | 0.167 |
| acetic acid | 0.079 | 0.071 | 0.079 |
| NaOH | 0.228 | 0.195 | 0.228 |

Of interest are the data presented in Table 3, which represent the averages of protein contents and the $E_{280}$/total N ratio, calculated separately for MS, RS and $F_1$ forms. In almost all cases, the over whelming influence of mother forms on the properties of $F_1$ generation could be observed. The only exception was the influence of father forms in the case of $E_{280}$/total N ratio for pyrophosphate fraction. It is true that some of those values are of significance for baking quality, this property should be directly hereditable in breeding from mother forms. This should concern particularly the "residual" protein fraction, which

is thought to be of importance in the formation of flour's technological value.

This general suggestion is in agreement with the data of Konarev (1973), who investigated the fractional composition of proteins extracted from varieties and species of wheat of different genetical origin.

These findings seem to be of interest to breeders, who work on the selection of productive wheat lines of higher baking quality and higher nutritive value.

## CONCLUSIONS

1. The total extractability and the content of pyrophosphate fraction are negatively correlated with the baking quality of wheat flour.

2. The $E_{280}$/total N ratio in NaOH fraction is lower in samples of good quality; this suggests that the compactness of high mol. weight glutenin can be of importance for baking quality of flour.

3. Total extractability of proteins and their fractional composition can be directly hereditable in $F_1$ generation, the female lines being of much higher significance.

4. The influence of female lines on the $E_{280}$/total N ratio is less regular, though in most cases it could also be observed.

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## Skład frakcyjny białek pszenicy i próby wykazania jego odziedziczalności

Streszczenie

W próbach mąki pszennej o zróżnicowanej wartości technologicznej oznaczono skład frakcyjny białek w celu znalezienia współzależności pomiędzy zawartością poszczególnych frakcji, całkowitą ekstraktywnością i stosunkiem $E_{280}/N$ ogólnego poszczególnych wyciągów a wartością wypiekową mąki. Wykazano wpływ jakości mąki na spadek ogólnej ekstraktywności białka i obniżenie stosunku $E_{280}/N$ og. w wyciągu NaOH zawierającym wysokocząsteczkową gluteninę. Ponieważ te właściwości mąki mają istotne znaczenie dla technologii i wartości żywieniowej, przebadano możliwości bezpośredniego ich dziedziczenia w pokoleniu $F_1$ z zastosowaniem krzyżówek pomiędzy męskosterylnymi liniami matecznymi oraz liniami ojcowskimi mającymi zdolność przywracania płodności. Wykazano, że skład frakcyjny białek pszenicy może być dziedziczony bezpośrednio, przy o wiele silniejszym wływie formy matecznej, niż ojcowskiej. Zaobserwowano również wpływ linii matecznych na dziedziczenie współczynnika $E_{280}/N$ og., jakkolwiek wyniki nie wykazywały zbyt dużej regularności.