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LABORATORY SCALE EVALUATION OF STARCH EXTRACTABILITY OF WHEAT VARIETIES*

Abstract

Since several years the structure of the European starch industry undergoes exceptional changes. Potato starch production stagnates as a result of agro-political decisions of the EU commission resulting in strict quota regulations. With corn starch growth rates are rather marginal. In case of wheat starch production huge capacities have been installed just recently or are in state of construction. As a result, one of the main targets is to improve the competitive situation of wheat starch and to provide appropriate source material. Concerning isolation techniques, recent developments in process technology allowed at the same time a withdrawal from wheat and wheat flour quality standards based predominantly on protein and mineral content. These standards were valid in the minimum for bread wheat. They could maintain their strong position over a relative long period as long as the Martin process was the prevailing technology.

However, modern processes based on centrifugal separation principles and pre-treated wheat flour and water mixtures opened a turn towards an economically more beneficial wheat and wheat flour quality. In fact, it became well known meanwhile that industry is able to process wheat flours having a significantly different property profile. If wheat quality characteristics of the German system of wheat classes are applied, these lots will probably be ascribed to feed wheat.

The described situation that could not be ignored any more initiated investigations on wheat quality characteristics relevant for modern technology in industrial wheat starch extraction. Basis for first studies was the well-known extraction procedure using the Glutomatic 2000 system for recovering starch A and B fractions and gluten from a conventional flour dough. Besides also the so-called „mixer test", a rather time and labour consuming testing system has been applied. Coming from industry its background is practical and achieved experimental results can be applied well in plant construction. At the same time a lately tested rapid method adapted to conditions of modern wheat starch production is used for evaluation of the formation of a workable wheat flour/water mixture. With regard to changes induced in the initial phase of the batter formation by mixing flour and water this method has been indicated as „gluten agglomeration test". Two groups of test samples have been used in this investigation. The first set of wheat samples comprised breeding material produced in a normal agricultural regime while the second set was part of a N_2-fertilisation and phyto-sanitation trial. The trial resulted in wheat samples and flours with well-defined protein concentrations that varied according to fertilisation level. Relationships between results of general

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bread wheat quality assessment and the described methods have been tested by rank correlation analysis. The lately established gluten agglomeration test allowed the desired differentiation and provided information about rate and extent of gluten agglomeration that differed extremely depending on cultivar and fertilisation regime. Characteristics of the gluten agglomeration test did not show very significant and close connections with grain and flour criteria. However, they all were related to protein quality. The results achieved in the mixer-test allowed evaluation and differentiation for the whole set of samples. It confirmed that only samples with adequate high protein level can be processed satisfactorily.

Introduction

Economic situation of wheat starch production

In Germany and, in particular, Western Europe the role of wheat as substrate in relation to maize and potato is becoming more important. Extraordinary large production capacities for wheat starch are in construction, above all in France. While a somewhat older statistic [1] shows a total starch production of $7.0 \cdot 10^6$ t for the European Union consisting of 15 member states and a 25% portion for wheat starch in 1996, a just recently published study [2] is giving a total starch production of approx. $7.3 \cdot 10^6$ t for 1997 in Europe. The corresponding share of wheat starch is now said to be $2.55 \cdot 10^6$ t which represents 35% of the total production.

Several factors promoted the development towards an increased use of wheat in starch production. In the European Union wheat prices were almost steadily reduced since 1983/84. At that time costs per ton were 220 ECU as compared to 120 ECU in 1994/95. Looking on net costs of wheat or maize as a raw material for starch the costs relevant for wheat were significantly smaller until 1997 [2]. Besides, many wheat starch plants are situated in or near by main areas of wheat production. However, from an economical point of view maize should be the more attracting substrate. An estimation of net starch production costs evaluated on the basis of figures raised in Germany in the period 1986–1992 indicated 740 DM/t for maize starch versus 840 DM/t for wheat starch and 1020 DM/t for potato starch [3]. Nevertheless, wheat seems to be brought in focus as a substrate that can equalise the position of maize. Besides, potatoes will not be increasingly used as substrates since EU quotations limited potato starch production to in total approx. $0.7 \cdot 10^6$ t (including an extra quota for investments made in new federal provinces shortly after reunion).

Recent developments in starch extraction procedures

The principles of modern starch production from wheat have been described just recently by Meuser [4]. Wheat flour remained the unique material, although numerous attempts have been made to replace the ground product by whole grains [5]. The still ongoing economic interest in wheat gluten as an important side-stream product was at most responsible for retaining in wheat flour as starting material. The wet extraction of

a concentrated flour-water system (1 part flour to 0.6 part water) similar in consistency to a bakers bread dough dominated industrial processing until centrifugal separation could be introduced as the more promising principle in separating starch and gluten and at the same time in reducing water consumption to less than 5:1. In contrast to the new hydrocyclone (4-5:1) or decanter (4:1) based processes the Martin process consumed still the 15 fold amount of process water and the batter process the 5-7 fold based on flour weight [6]. This development was a decisive milestone in modernising wheat wet milling processes irrespective of the applied centrifugal technique [4, 6-8]. The well-known density differences between A starch, as the main fraction, and gluten plus B starch, fibres and pentosans allowed an arrangement of these fractions in more or less separated layers in the gravity field [6, 9]. In the following, hydrocyclones or decanters were the central units in separating diluted flour/water mixtures after pre-treatment of their concentrates. The pre-treatment was at most prerequisite for splitting off hydrated wheat protein bodies from starch granules and the subsequent gluten formation. Both principles dominate technology of wheat starch production since that time (10).

Adaptation of wheat varieties to starch production

As result of the described changes in principal process techniques the source material should have been adapted to new processing conditions. In particular, the former requirements in protein quality relied on quality characteristics relevant for baking flour and the preparation of a stiff dough and finally the production of a more or less rubbery, chewing gum like gluten. With new process technologies Barr [10] still mentioned the necessity of wheat having a higher protein content and better processing characteristic without being specific in detail. Details in specification of wheat and wheat flour suitable to wheat starch production have been presented by Witt [7] for the first time and in more recent time by Lindhauer and Zwingelberg [11]. They described wheat quality at much lower protein levels of 12 to 12.5% d.b. (nitrogen conversion factor 5.7) giving a flour protein content of approx. 11 to 11.5% d.b.. Using the nitrogen conversion factor accepted in wheat starch industry (6.25) flours should reach a protein level of 12 to 12.5% d.b. Besides, starch and protein content are inversely correlated, i.e. reduced grain protein concentrations induced by low input-oriented N_2 fertilisation produce an increase in starch content. Further wheat characteristics promising higher starch yields were given as low endosperm hardness and small shares of mechanically damaged starch granules. At last these authors concluded that from an agronomical point of view wheat cultivars should have a soft to medium endosperm structure, low protein and pentosan concentrations and good starch quality (high falling number and amylograph data). Concerning milling wheat cultivars should show good millability that means production of a high flour yield having a mineral content 0.6%

d.b. (in Germany: type 550). A flour standard quality produced from low-protein wheat of soft structure could be enriched by adding high-protein wheat if a protein rich flour is required by the starch factory [11, 12].

New developments in laboratory-scale procedures

Development in testing procedures both of laboratory and small technical scale have been published just recently in summarised form [13]. The ultimate state in laboratory-scale methods was a mixer method used and provided by the relevant machinery industry [14]. There, the fractionation of wheat flour into its components is based on a batter formation by high speed mixing treatments of a concentrated flour/water mixture (ratio: approx. 1:0,9). For stimulation of gluten agglomeration and separation water is added until a ratio of 1:1,8 is reached. Wet gluten is recovered after washing out starch, pentosans, and fibres in a manual procedure. After removing fibres by wet sieving the resulting starch slurry is concentrated by centrifugation and separated carefully by hand into fractions of A and B starch [13].

Material and methods

Grain samples

Two different sets of winter wheat grain samples have been used in this study. The first set comprised 6 samples of winter wheat grain (cv. Kanzler, Ritmo, Contur, Crousty, and Soissons) produced conventionally in northern Germany by breeders. Their history remained in detail unknown. The total weight of each sample was 6 kg.

The second set provided by Prof. Hellriegel Institute e.V. Bernburg, Bernburg, Germany, consisted of 8 grain samples each having a weight of 6 kg. They were produced in a fertilisation trial using 1 German and 1 EU variety (Contra and Soissons) and 1 breed (LP 235194). In order to induce a differing protein composition besides the control variant (no nitrogen fertilisation), the plants have got nitrogen at two and three stages of development, resp. The 50+50 kg/ha variant received its doses at tillering and bolting and the 70+70+50 kg/ha variant at tillering, bolting, and breading. Besides, both fertilised variants have been treated with fungicide.

Prior to analytical characterisation and grinding the samples have been cleaned by aspiration. Then 500 g subsamples have been taken for grain characterisation by dividing. The residual samples have been moistened and stored over night for equilibration. These samples were finally milled in a Bühler mill, type MLU-202. Flour streams passing 180 µm flat sieves and 250 µm rotation cylindrical sieves were combined and taken for analytical characterisation.

Grain characterisation

Grain samples were ground in a Falling number mill and the resulting breaks were stored until analysis in tight polyethylene boxes. The crude protein content was determined by using ICC Standard Method 105/1 (factor 5.7). The sedimentation value was determined by ICC Standard Method 116/118. For evaluation of the gluten content ICC Standard Method 137 was used [15].

Flour characterisation

Flour moisture content as well as protein (factor 5.7) were determined by using ICC standard techniques (ICC Standard Method 110 and 105/1)). For determination of the sedimentation value the method described in ICC Standard Method 116 has been applied [15]. For determination of the starch content the DIN EN ISO 10520 procedure [16] was used. The relevant Farinogram and Extensogram characteristics were derived from respective diagrams as described in standard methods (ICC Standard Method 115 and 116, resp.) [15]. The nitrogen conversion factor for protein evaluation in gluten was 6.25.

Agglomeration test

Referring to a procedure described by Hanneforth, Zwingelberg, and Gebhard [17] for rapid evaluation of protein quality with regard to agglomeration in batters for wafer production a concentrated flour/water suspension is produced in a standard mixer blender using conditions of batter formation according to starch separation processes. After formation of a homogenous suspension the energy consumption during mixing is registered by an ammeter and evaluated by means of specific software.

In detail 120 grams of wheat flour, type 550, are mixed in a blender (type Rotor-Blender GT 1000, neoLab, Heidelberg, Germany) with 120 grams of water heated to +35°C. Two treatments each lasting 20 s are done for batter formation using level 3.5 of the mixer scale. Then, current consumption is measured during the following mixing period of 240 s using level 4.5. For registration a analog/digital multimeter (type Metrahit 15 S, Gossen-Metrawatt GmbH, Nürnberg, Germany) connected with a memory interface (type Metrahit SI 232, Gossen-Metrawatt GmbH, Nürnberg, Germany) allowing direct transmission of data to a PC is used. Data transformation into diagrams is done under Metrawin 10 as software (Gossen-Metrawatt GmbH, Nürnberg, Germany). Available data concerning time until current consumption onset (agglomeration time) and maximum current consumption are derived from diagrams.

Mixer method

The wet separation of flour components yielding fractions of A starch, B starch, wet gluten, fibres, and solubles within process water is investigated by applying the mixer method [13]. In order to allow determination and comparison of dry substance and protein dispersed in water used for the gluten and fibres washing process water volume is limited each to in total 6500 ml.

In detail, 87 grams of tap water heated up to +35°C are mixed with 100 grams of wheat flour substance in a suitable blender (type MX 32, Braun AG, Kronberg, Germany) for 2 x 20 s using level 3 of the mixer scale. Material thrown to the mixer bowl wall is combined with the main part prior to a second treatment. Then, further 100 grams of tap water (+35°C) are added and the blender is switched on four times 1 s each.

The resulting suspension is then transferred quantitatively to a sieve of 200 µm mesh. Residues that remained in the beaker are removed with a small amount of tap water. In order to wash out starch from gluten water is added drop wise (approx. 4.5 L plus approx. 1.5 L for fibre washing). The suspension passing the sieve is recovered in 5 L beakers. In order to combine agglomerated small gluten particles the mixture remaining on the sieve is treated first carefully with a rubber wiper blade. Later on the formed gluten ball can be washed starch-free manually. At least, surplus water is removed from the gluten ball by manual pressing until gluten tends to stick to the hand. The moist gluten is weighed and finally dried in small portions with a gluten dryer (type Glutork 2020, Perten Instruments AB, Huddinge, Sweden). For separating fibre from starch the suspension is transferred to a vibration sieve (type L 2426, Rhewum GmbH, Remscheid, Germany) having 56 µm mesh. As soon as fibres could be washed starch-free they are poured quantitatively in a petri dish for pre-drying in a drying chamber using 40 to 50°C air temperature. The pre-dried fibres are then dried moisture-free by applying 130°C for 90 min. After cooling to room temperature in a desiccator the amount of fibres and insoluble pentosans is determined by weighing.

The starch layer settled from the suspension and containing A and B starch as well is resuspended and poured into centrifuge beakers in adequate portions and centrifuged for 10 min at rotation speed of 4000 min^{-1} (centrifuge type Varifuge S, Haereus Holding GmbH, Osterode). Specifically more dense A starch settles first and will be covered by less dense protein-rich B starch. The top layer of process water containing soluble protein is decanted and collected in a beaker. Finally all starch sediments are put together, re-suspended and again centrifuged. The resulting sediment is then stored in a refrigerator over night to allow stabilisation. The following day A and B starch layer can be successfully separated by hand with a spatula. In general, both layers can be distinguished clearly by its colours. The weight of total process water (washing liquid) is determined and registered and the solution carefully suspended again. A

quantity of 5 ml is immediately filled in a weighing glass for determination of dry matter content. Its drying is done at 130°C during 90 minutes. Besides, the drying procedure in detail is done as described with fibre material.

Finally, A starch and B starch are dried in an agitated drying chamber at an air temperature of 40°C. For moisture equilibration of dried starch samples remain at room climate for at least 2 h. The recovered samples of gluten and starch are broken to small pieces and then finely ground in a laboratory mill equipped with a ring sieve with 0.5 mm perforation (type ZM 100, Retsch GmbH & Co.KG, Haan, Germany).

Statistical analysis

For the analysis of relationships of investigated characteristics the non-parametric rank correlation coefficient due to Spearman has been used since the basis of samples (n = 6) was rather small and not normally distributed [18].

Results and discussion

Composition of wheat flours

The composition of flour samples (type 550) milled from conventionally produced grain samples of the wheat cultivars Kanzler, Ritmo, Contur, Crousty, and Soissons is given in Table 1. Because of protein levels in grains, generally unexpected low for that production area, the flour protein content comprised only a range of 10.0 to 11.6% in dry basis. According to expectations, the flour starch content followed inversely corresponding flour protein contents. The range was given by 80.6 to 82.4% in dry basis.

Table 1

Composition of 6 fours (type 550) from soft winter wheat - breeder samples

Variety	Quality grade*	Moisture content, %	Protein content, % d.b.	Starch content, % d.b.
Kanzler	B	14.2	11.6	80.6
Ritmo	B	14.5	10.6	81.7
Contur**	-	14.4	10.5	82.4
Soissons***	-	14.4	11.6	80.9
Crousty I**	-	14.4	10.8	81.6
Crousty II**	-	13.8	10.0	81.6

* *German testing system for cultivars*

** *German breeds (soft endosperm structure) (comparable to quality grade A to B)*

*** *French cultivar (comparable to quality grade A to B)*

The flour composition of samples produced in N_2 fertilisation trial on the basis of the wheat cultivars Contra, Soissons and the breed LP 235194 was compiled in Table 2. The protein content represented clearly the used levels of N_2 application. Without N_2 the protein content was extremely small (5.7 to 5.8%). A divided fertilisation of two portions of 50 kg per ha each resulted in a level of 7.6 to 8.0% and a fertilisation regime of two 70 kg portions together with a final 50 kg portion which was described as optimal for the production area produced a range of 9.9 to 10.6% d.b. similar to the conventionally produced set of wheat samples. The flour starch content followed clearly, but in inverse direction the effects of fertilisation producing the highest content without N_2 application (84.2 to 85.2% d.b.). Flours from cultivar Soissons had always the highest starch content in respective fertilisation levels

Table 2

Composition of flours (type 550) from soft winter wheat - samples from fertilisation trials

Sample	Moisture content, %	Protein content, % d.b.	Starch content, % d.b.
Contra			
without N-fert.	14.0	5.7	85.2
50+50	13.0	8.0	83.6
70+70+50	13.3	10.2	81.7
LP 235194			
without N-fert.	13.2	5.8	84.2
50+50	12.9	7.6	82.5
70+70+50	13.2	9.9	80.8
Soissons			
50+50	13.6	7.9	85.0
70+70+50	13.9	10.6	83.8

Results of correlation analysis

Based on results of usual wheat quality evaluation and on the other hand on estimates of the agglomeration test (gluten agglomeration time and maximum current consumption) divers relationships have been tested by means of correlation coefficients. Although a rather low probability level (P = 90%) has been accepted only a few connections, with i.e. sedimentation value, moist gluten weight, and different characteristics derived from Farinogram and Extensogram diagrams, could be found being significant (Table 3).

With respect to the assessment of wheat breaks a relevant correlation existed only between maximum current consumption and moist gluten content, but, this connection was rather wide (100 r^2 approx. 50) and not enough consistent. This situation was

similar for the investigations done with flour, too. With regard to gluten agglomeration time only an inversely oriented connection to the sedimentation value could be established. Looking again on the maximum current consumption there existed direct connections to water absorption capacity and dough stability determined in the Farinograph and to extensibility evaluated in the Extensograph. To dough softening, another Farinograph characteristic, an inverse connection could be determined in agreement with expectations. But, because of the rather small proportions associated to the tested characteristics (100 r^2 almost 50) the achieved results, however, have not been accepted as sufficient at all and have therefore not been used in further considerations.

Table 3

Results of a correlation analysis of gluten agglomeration test and wheat quality assessment characteristics

Source	Gluten Agglomeration Test Characteristic	Wheat Quality Assessment Characteristic	Rank Correlation Coefficient
Flour	Agglomeration time	Sedimentation value	-0.786
Breaks	Maximum current consumption	Moist gluten weight (Glutomatic)	0.7714
Flour	Maximum current consumption	Water absorption capacity (Farinogram)	0.829
Flour	Maximum current consumption	Dough stability (Farinogram)	0.7714
Flour	Maximum current consumption	Dough softening (Farinogram)	-0.7714
Flour	Maximum current consumption	Extensibility (Extensogram)	0.7714

Test statistic (P = 90%; n = 6): 0.771

Agglomeration test

The ability of the agglomeration test to discriminate between flours of the above mentioned cultivars is shown well in diagrams of Figure 1. The flour samples could be separated into three groups. In case of cv. Ritmo a certain degree of agglomeration occurred even during batter formation. Further mixing needed high current consumption instantly. For the flour samples of cv. Kanzler, Contur and Crousty II, with 35 to 65 s agglomeration took place significantly later. With 120–130 s, the flours of the third group (cv. Soissons and Crousty I) required much more time for agglomeration. Maximum current consumption was in between 3 and 4 A for all samples showing no specific trend.

A quite different situation was given with flour samples from N_2 fertilisation trials. In case of adequate N_2 supplementation the 70+70+50 variants allowed obviously the formation of a sufficient amount of high molecular gluten proteins. As a result ag-

glomeration, observed by maximum current consumption, took place in the same manner as previously shown with conventionally produced wheat (Figures 2 to 4).

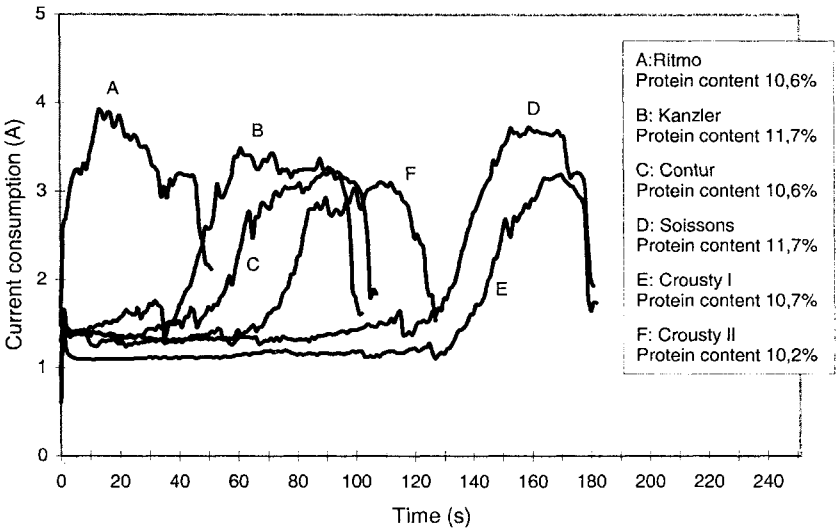

Fig. 1. Gluten agglomeration test applied to conventionally produced wheat varieties - cv. Ritmo, Kanzler, Contur, Soissons and Crousty (I + II)

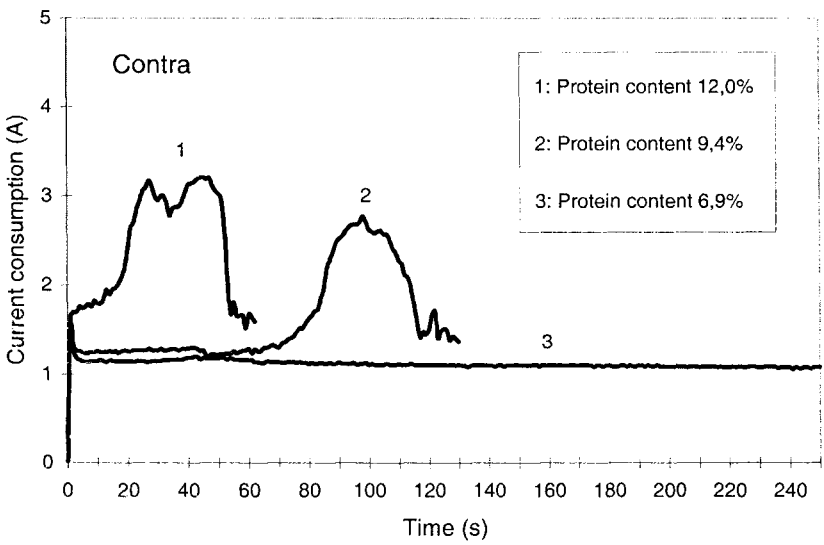

Fig. 2. Gluten agglomeration test applied to wheat samples of cv. contra produced in a N_2 fertilisation test.

Nevertheless, differences due to the tested cultivars were obvious in agglomeration time, in particular. Effects of reduced fertilisation levels became visible, too, in two respects. The 50+50 variant seemed to prevent the formation of a sufficient amount of high molecular gluten proteins which resulted in delayed and retarded gluten agglomeration as measured by agglomeration time and maximum current consumption. This effect was much more pronounced in the variant without fertilisation, where in case of cultivar Contra agglomeration could not be measured, at all (Figure 2).

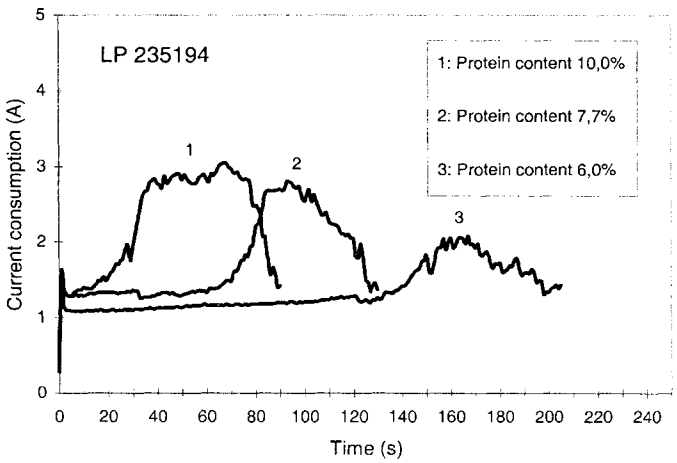

Fig. 3. Gluten agglomeration test applied to wheat samples of breed lp 235194 produced in a N_2 fertilisation test.

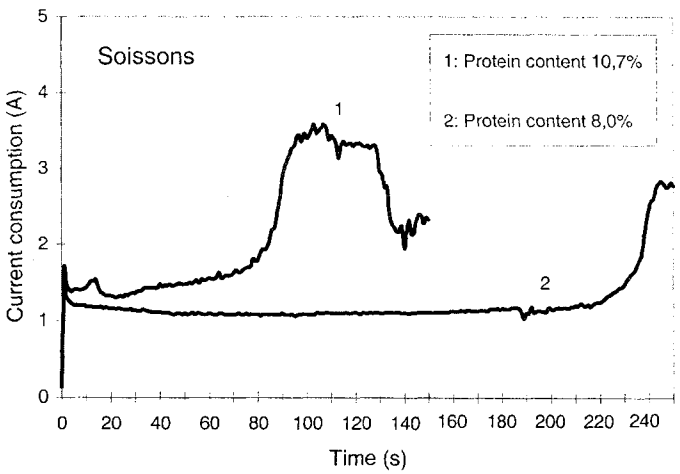

Fig. 4. Gluten agglomeration test applied to wheat samples of cv. soissons produced in a N_2 fertilisation test.

Mixer test

Looking on results of the mixer test of the first set of flours (Table 4) moist gluten weight as well as dry gluten yield followed well the flour protein content. For yields of A starch and B starch fractions, however, remarkable differences could be seen. With one exception represented by cv. Ritmo total starch yield was in good accordance with flour starch content, i.e. total starch yield exceeded the flour starch content by 0.1 to 1.6%. This could be explained as a result of impurities recovered with B starch. For Ritmo, in contrast, a reduction of 0.9% was observed together with serious losses of A starch. The difference could be found as an increase of B starch yield. These results in combination with the absence of measurable agglomeration time were reason to assume a methodological deficiency.

With respect to B starch yield the data allowed the formation of two groups. In the first group consisting of cv. Kanzler, Contur, and Crousty II B starch yield comprised a range of 7.5 to 9.6% which corresponded well with the lower range described for commercially produced wheat flour samples of a previous investigation [8]. But, also B starch yield represented by the second group of Ritmo, Soissons, and Crousty I was covered by once reported results. The range of this group was 11.3 to 14.2%.

Another differentiation of samples could be seen with fibre yield, too. The first group comprised Kanzler, Ritmo, Contur, and Crousty II (range: 1.09-1.19%) and the second group Soissons and Crousty I (range: 1.57–1.76). Besides, these observations concerning the discrimination between the analysed samples could be found partially by comparing yield values of B starch and fibres with agglomeration time. Soissons and Crousty I needed more than two times the mixing time than cv. Kanzler, Contur, and Crousty II as given by the significant difference of 35 to 65 s versus 120 to 130 s.

For the yield of solubles recovered as dry matter of the process water the over all range was 4.0 to 6.7%. A pronounced difference between the investigated samples could not be found.

Finally, the divergence in agglomeration behaviour of two growth samples of variety Crousty, in particular Crousty I and Crousty II, effected clearly extractability and purity of A starch, B starch, and fibres in giving better results at shorter agglomeration time.

The very distinct differences observed in agglomeration tests for effects of fertilisation with growth samples of breed LP 235194 and the varieties Contra and Soissons (Figure 2 to 4) could be found in equivalent order in results of the mixer test, too (Table 5). With cv. Contra agglomeration could not be observed within time of regular measurements and for LP 235194 current consumption was very small. The observed situation indicated that in a deficient situation of N_2 fertilisation plants of tested samples could not store enough protein and obviously could not form the quantity of gluten proteins required for sufficient agglomeration. Looking on results of the mixer test

these samples could not be separated well into components. In particular, dry gluten yield was extremely small while B starch yield and fibre yield were not acceptable in their amount. With level 50+50 effects of fertilisation were in no manner acceptable with regard to extractability of starch and gluten, however negative effects on B starch yield and fibres were less pronounced. Very problematic were the small yields of gluten. Soissons reacted extremely on the applied level of reduced nitrogen fertilisation

Table 4

Results of the mixer test of 6 flours from conventionally produced wheat - breeder samples

Cultivar	Ritmo	Kanzler	Contur	Crousty II	Soissions	Crousty I
Agglomeration time (s)	0	35	45	65	120	130
Flour protein content (% d.b.)	10.6	11.6	10.5	10.0	11.6	10.8
Flour starch content (% c.d.)	81.7	80.6	82.4	81.6	80.9	81.6
Moist gluten (g)	25.9	29.5	25.8	24.2	29.4	26.3
Dry gluten yield (% d.b.)	9.7	11.0	10.0	9.4	10.9	10.1
Total starch yield (% d.b.)	80.8	84.8	83.0	83.2	81.0	82.4
A Starch (% d.b.)	**66,6**	73.8	75.0	73.6	69.7	70.8
B Starch (% d.b.)	**14.2**	7.5	8.0	9.6	**11.3**	**11.6**
Fibre (% d.b.)	1.1	1.1	1.2	1.2	**1.8**	**1.6**
Solubles (% d.b.)	6.3	4.0	5.9	6.1	6.7	5.5

Table 5

Results of the mixer test of flours (Type 550) from soft winter wheat - samples from n-fertilisation trials

N_2-Fertilisation	without		50+50			70+70+50		
	Contra	LP*	Soissons	Contra	LP*	Soissons	Contra	LP*
Agglomeration time (s)	n.b.**	130	235	85	70	65	20	25
Flour protein content (% d.b.)	5.7	5.8	7.9	8.0	7.6	10.2	10.2	9.9
Flour starch content (% d.b.)	82.5	84.2	85.0	83.6	82.5	83.8	81.7	80.8
Moist gluten (g)	**1.3**	**5.0**	**6.6**	**13.3**	**14.2**	25.7	23.0	21.8
Dry gluten yield (% d.b.)	**0.6**	**1.9**	**2.9**	**6.1**	**6.1**	9.7	9.6	9.0
Total starch yield (% d.b.)	88.7	86.1	86.7	84.9	84.6	83.3	83.0	83.2
A Starch (% d.b.)	74.1	75.9	75.1	76.1	76.0	73.5	74.4	74.0
B Starch (% d.b.)	**14.6**	**10.2**	**11.6**	8.8	8.6	9.8	8.6	9.2
Fibre yield (% d.b.)	**3.3**	**3.1**	**4.1**	**1.7**	**1.6**	1.1	1.1	1.2
Solubles (% d.b.)	6.6	9.2	6.7	7.3	7.8	8.9	6.0	6.5

* LP 235 194

** not determined

that might be compared with measures of extensive plant production. The 70+70+50 fertilisation level provided a sufficient nitrogen supplementation. Agglomeration time and maximum current consumption were comparable to the range achieved in variety testing. Corresponding data for moist gluten weight and dry gluten yield reached a somewhat lower, but acceptable level. The amount of A starch and B starch were in the desired range and even the particular fibre yield was in good agreement with data presented for conventionally produced wheat samples of good processing suitability (Table 4).

Conclusion

A comparison of generally used methods for the assessment of protein quality in wheat with results of a batter mixing test system adapted to conditions of gluten agglomeration (= gluten agglomeration test) by means of correlation analysis did not prove any acceptable close relationship between the selected characteristics.

Although further investigations could use only the available set of samples the gluten agglomeration test showed even in a form that needs some improvement a fair potential for beneficial application in the differentiation of wheat flour suitable for starch production. A comparison of agglomeration time of six flour samples of conventionally produced wheat with results of a laboratory test for separation of wheat flour components (yield of moist and dry gluten, A starch, B starch, fibres, and dry matter of solubles) allowed the observation, that slowly occurring gluten agglomeration (120 to 130 s) will result in increased B starch and fibre portions. A more rapid agglomeration (35 to 65 s) reduced the amount of separated B starch significantly and produced yields of approx. 8%. At the same time A starch yield was increased to a generally accepted level. An extreme short agglomeration time signalised flour properties producing methodological difficulties that require further investigations. The described effects of more or less quick and intense gluten agglomeration could be found clearly with flour samples of a nitrogen fertilisation trial, too. An interesting finding was, that in combination with flour protein contents of 6 to 8% high molecular gluten had not been produced in sufficient quantities. As a result serious problems arose in the mixer test, in particular with the separation and purity of B starch and fibres. Wheat flours offering the finally described phenomena will probably not allow acceptable processing in industrial starch production.

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EKSTRAHOWALNOŚĆ SKROBI Z RÓŻNYCH SKROBI PSZENNYCH NA PODSTAWIE BADAŃ W SKALI LABORATORYJNEJ

Streszczenie

Od szeregu lat w wyjątkowy sposób zmienia się struktura europejskiego przemysłu skrobiowego. W wyniku polityki agrarnej Unii Europejskiej ograniczającej ilości produkowanej skrobi produkcja skrobi ziemniaczanej została zahamowana. Wzrost produkcji skrobi kukurydzianej jest nieznaczny. W przeciwieństwie do tego szybko wzrasta produkcja skrobi pszennej w związku z czym buduje się nowe krochmalnie i ulepsza technologie wyosobniania tej skrobi i otrzymywania lepszej jakości surowca. W zakresie technologii wydzielania osiągnięto postęp pozwalający wyodrębniać skrobię o wysokiej jakości. Dotychczas, jakość skrobi pszennej określano na podstawie zawartości białka i składników mineralnych.

Nowoczesne procesy stosujące wirowanie oraz stosujące wstępnie przygotowaną mąkę pszenną oraz zawiesiny wodne pozwoliły produkować pszenicę i mąkę z niej w bardziej ekonomiczny sposób i w szerszym asortymencie wysokiej jakości wyrobów.

Podjęto próby określenia jakości pszenicy do przerobu nowymi technologiami określając ekstrahowalność skrobi i glutenu z ciasta.