15 Rye Flour

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15.1 Introduction

Rye – the Latin name is *Secale cereale* – is still generally regarded as the typical German bread cereal. Nevertheless, there is a continuous decline in rye consumption. In the case of this bread cereal, too, it is chiefly winter rye that is used for baking. Although over 90% of the world's rye is grown in Europe, the cereal is by no means a uniform product. The main growing areas and breeding centres are in eastern, central and northern Europe, although rye is also grown and bred in North America, Australia and other regions.

Generally speaking, the objectives of breeding crop plants are to achieve and maintain yield as an "agricultural value" and, where necessary, to ensure good properties for a specific use as a "technological value". Taken together, the two values ultimately determine the market value of a variety. This also applies to rye as a bread cereal.

15.2 Yield as a Mark of Progress in Breeding

The breeding of rye took a tremendous step forward with the introduction of hybrid[20] varieties around 1970. The importance of this progress lay in the much greater yield of the hybrids as compared with pure breeds and the fact that this yield was largely independent of soil quality. Although the reliability of the yield depends on climatic conditions and is therefore subject to certain annual fluctuations, the possibilities of increasing the yield with hybrid varieties remain constant. A further advantage in years with poor weather and in unfavourable locations is the hybrids' good resistance to sprouting.

Fig. 92 shows the development of varieties over the past three decades and the significance of the hybrids for the Falling Number as a criterion for evaluation.

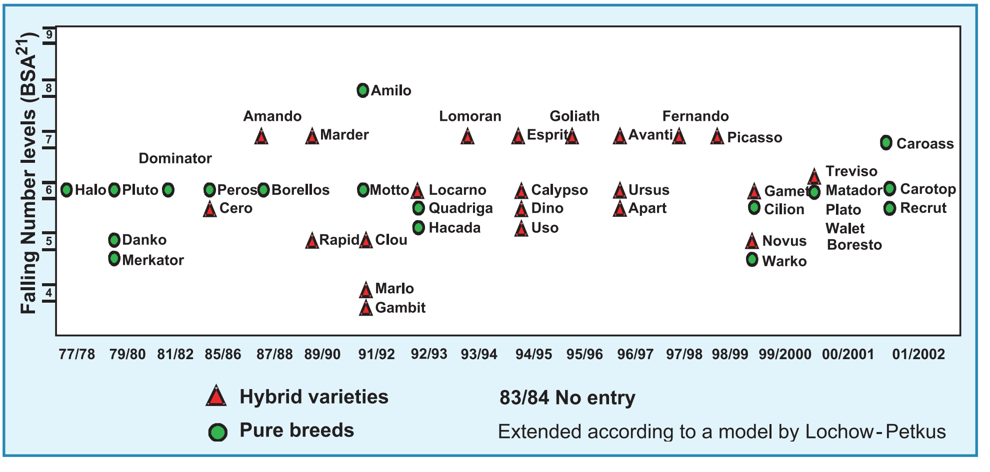

Fig. 92: Falling Number levels for the rye varieties approved in Germany since 1977

[20] *Hybrid: offspring from two genetically dissimilar parents. Two organisms are crossed with different desirable characteristics with the premise that the offspring will possess more of the desirable characteristics.*

Yield is an important factor in all forms of crop husbandry.

189 Rye is an interesting cereal from the point of view of ecologically controlled and organic farming because it shows its advantages in respect of yield and yield stability even with extremely little use of agricultural inputs, including pesticides. For this reason rye and also dinkel are sometimes regarded as the "health cereals".

Further advantages of rye are that its protein has greater biological value for man than that of wheat, that it is less susceptible to mould – including *Fusarium* – than many wheat varieties and that it is less inclined to form fusariotoxin.

However, the subject of ergot should be considered in connection with rye. Possible differences in susceptibility to *Claviceps purpurae* infections between the hybrid and pure breeds are still being discussed.

Tab. 69 shows the rye varieties most widely grown in Germany at present on the grounds of regional decisions and yield. Hybrid varieties account for over 75% of the rye grown.

15.3 Objectives of Breeding in Respect of Technical Suitability for Processing as Bread Rye

The BSA[21] considers the following criteria important for rating the suitability of rye for bread-baking:

- Thousand kernel weight (TKW);
- Crude protein content (CPC);
- Peak Amylogram values for viscosity and temperature;
- Results of the Falling Number test.

When assessing new wheat varieties the BSA carries out baking trials: this is not the case with rye. In contrast to the procedure for baking wheat, the four criteria stated above were considered an adequate basis for describing the suitability of new bread rye varieties for baking when the present rating systems were

Tab. 69: Percentages of the main rye varieties grown in Germany (2004 harvest)

Pure breeds	%	Hybrid varieties	%
Nikita	11	Avanti	23
Amilo, Recrut	3	Fernando	12
Danko, Hakada	1	Picasso	25
		Esprit	35
		Treviso	1

introduced. This was justified as long as a sufficiently elastic crumb was the only quality attribute to be achieved in rye bread, an attribute that was usually guaranteed by adequate enzyme levels in the greater part of the rye harvest.

Rye grain Falling Numbers of about 100 to 120 s or higher – corresponding to peak Amylogram temperatures of about 63 °C – were considered necessary to ensure this aspect of processing quality.

15.4 Rye Quality

In the European Community, rye is defined according to the support criteria as having a Falling Number of at least 120 s.

In Germany the expression bread rye is still used and defined as having Amylogram maximum temperatures of at least 63 °C. Peak Amylogram viscosity is not used for evaluation, but the Falling Number is considered additionally.

The rheological index figures for rye as a raw material are determined using a milled whole-meal product ground on a defined cross-beater mill, the Falling Number mill. For the rye flours normally used in Germany, with a mineral content of about 1% (d.b.), the Falling Numbers for bread rye are about 120 to 130 s and the Amylogram gelatinization temperatures are 64 to 65 °C.

Increasing Falling Numbers and Amylogram values for rye have established themselves

[21] *Bundessortenamt, German Federal Institute for varieties*

almost unnoticed, partly because of selection by breeders and partly as a result of more favourable weather and more accurate forecasts of the ideal time for harvesting. But the following are further reasons for the change in the rheological values of bread rye:

- increase in the total pentosan content;
- reduced proportion of soluble pentosans;
- reduced or delayed effect of the amylase naturally contained in the grains, or of its enzymes;
- shift in the range of varieties towards more high-yield hybrids;
- changes in cropping areas and thus the growing sites for rye;
- specific use of agricultural inputs, especially to increase the yield;
- great improvements in harvesting techniques;
- greatly improved post-harvest treatment;
- slight changes in the milling process and flour yields;
- certain changes in the tolerances for minerals in classified rye flour types.

Nevertheless, rye remains a sprout-endangered cereal, and in contrast to wheat the site on which rye is grown has a greater influence on the regional harvest result than the variety. (Brümmer, 1999a)
A comparison of the years 1960 and 2004 (Tab. 70) shows the typical changes in the various index figures over the past four decades. Interestingly, the bread volumes have fallen in spite of the higher values of the indirect methods. (Brümmer 1999b,c).

Tab. 70: Average changes in the analytical values for rye flours of the types 997/1150

Variable measured		1960	2004
Falling Number	s	110	240
Amylogram, peak temperature	°C	62	73
Amylogram, peak viscosity	AU	200	750
Maltose	%	3.0	3.8
Dough yield	g/100 g	165	175
Baked volume	mL/100 g	330	280

15.5 Rye Varieties

Since 1992 the BSA has issued descriptions of the properties of rye as well as wheat varieties and updated them where necessary.

The quality attributes of the varieties are described by comparison with one or more reference varieties. For some time Halo has been the reference variety. The results of other rye varieties are then shown as a percentage of this reference variety (= 100%) and divided into categories from 1 to 9. Category 1 means unfavourable results for an attribute.

The BSA's descriptive list of varieties currently contains 28 varieties of winter rye and three varieties of summer rye. The ratio of pure breeds to hybrid varieties has shifted continuously in favour of the higher-yield hybrids since the latter were first approved. The current list contains 12 pure breeds and 16 hybrids (next page, Fig. 93).

The suitability of rye, and products ground from rye, for making baked goods raised with sour dough or baker's yeast depends to a large extent on their composition. Limited enzymolysis is an advantage in processing (Drews 1971a, b). In this respect, rye varieties with a low protein content and high pentosan levels are said to be advantageous, as are those with low enzyme activity, particularly α-amylase.

15.6 Testing Methods for Describing the Quality of Rye

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For a long time the α-amylase activity of rye was thought to be the only factor limiting suitability for bread making. Sprouted grain is known to result in bread with a very moist crumb. Weipert (1998a, b) therefore sought to establish a correlation between α-amylase and Falling Numbers and Amylogram values. Only in the case of very low or relatively high amylolytic activities good correlations of Falling Numbers and Amylogram values have been detected.

For a long time, systematic tests to ascertain the fundamental technical characteristics of rye centred on the Amylogram and Falling Number as standard methods. Since 1994, consideration has also been given to the total pentosan content, the percentage of soluble pentosans, the flour yield (in a standard milling test) and suitability for bread-making (in a standard baking test using sour dough in a flour of the type 997). In 2002 this procedure was updated and now includes tests on grains and flour for Falling Numbers, the Amylogram, the new Rye Viscosity Test after Brümmer (2002) and the standard milling and baking test.

15.6.1 Milling Properties

The milling properties of rye varieties are determined in a standard milling test on a Bühler laboratory mill. The flour yield is assessed in relation to the mineral content of the most important rye flour types (mineral content around 1.0% d.b.). Because of the different structure of rye cells, mechanical damage to the starch grains during milling is relatively low compared to that of wheat. In the sensory analysis, i.e. when rubbed between the fingers, rye flours are generally found to be finer and smoother than wheat flours. Larger proportions of fine grains lead one to expect more rapid water absorption (swelling) and increased sensitivity, for example to enzymatic activity. These structural differences are influenced by the nature of the starch, the proportion of larger and smaller starch granules, the enveloping function of the hemiculluloses and other factors.

15.6.2 Baking Tests

The suitability of rye varieties for baking in Germany is generally tested with the German flour types 997 and 1150. But standard baking tests with wholemeal rye flour can be carried out with "Falling Number meal". For bread made of mixed wheat and rye flour, Neumann and Brümmer (2000) have suggested "basic baking tests".

Besides the practical baking test with sour dough there is also a baking test with yeast, without any acidification, and a further test is carried out with a standardized addition of lactic acid depending on the mineral content of the rye flour to be baked.

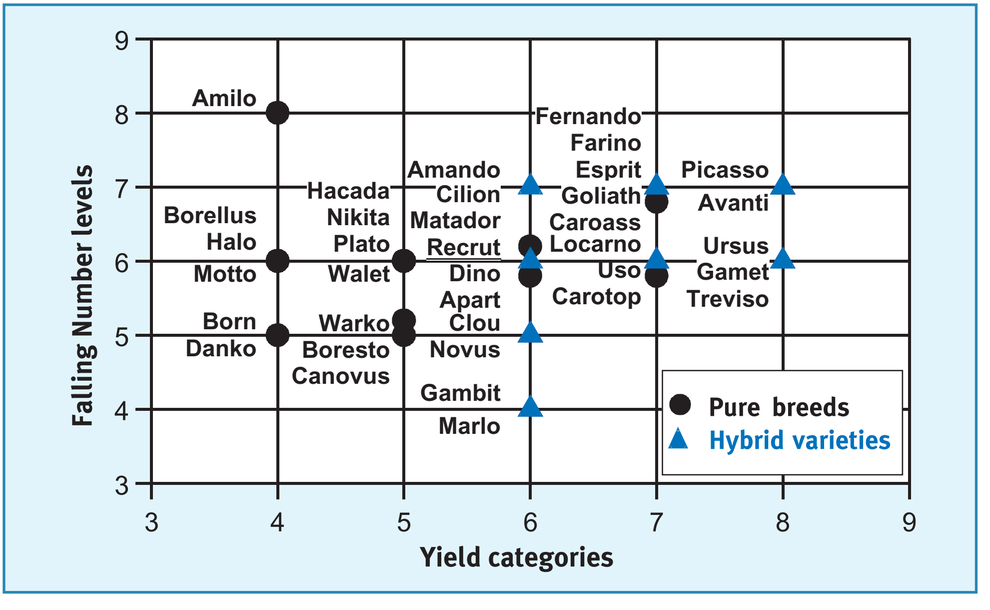

Fig. 93: List of German rye varieties, 2002

The most important attributes in the baking test with sour dough are dough yield and dough properties, volume yield, pore structure, elasticity of the crumb, purity of taste, and the flavour potential resulting from the sour dough. The results of the tests are used to calculate a Quality Number. For the mills, especially, this offers excellent possibilities of describing the quality of their flours.

Dough Yield and Dough Properties

Dough yield[22] is an important economic factor. At the same time it has a considerable influence on the processing properties of the dough and the quality of the rye bread. Indirect processes (sour dough) and direct acidification (with dough acidifiers) require different amounts of ingredient water. In the direct process the amount required is about 4 to 6 parts greater, depending on water-binding capacity and the nature and quantity of the dough acidifier. The water added must be sufficient to enable easy (usually mechanical) processing of the dough. At the same time there must not be too much release of water during baking, as this might weaken the crumb. A possible overdose of water is manifested in very soft, moist crumb and often a horizontal separation of the crumb from the crust, whereas vertical cracks in the crumb of loaves indicate that too little water has been added. They may be caused by dough that is too firm, by inadequate gelatinization of the starch or by excessive water loss during baking. To determine dough yield in the sour dough baking test, Brümmer (1988) has published a Farinograph method that can also be used to determine the amount of water to be added in the standard yeast and lactic acid baking tests. Nevertheless, a constant water addition of 73% is still generally used in these two special standard baking tests, although it is less in keeping with the raw materials.

To some extent dough behaviour can be predicted by the swelling curve (Drews, 1971a, b). The curve shows that the degree of softening and thus the dough yield and dough properties do not correlate with the Falling Number, the Amylogram and volume yield (Fig. 94 and Fig. 95).

[22] *Dough yield = sum of water and flour; i.e. a dough of 185 results from 100 kg of flour and 85 kg (litre) of water.*

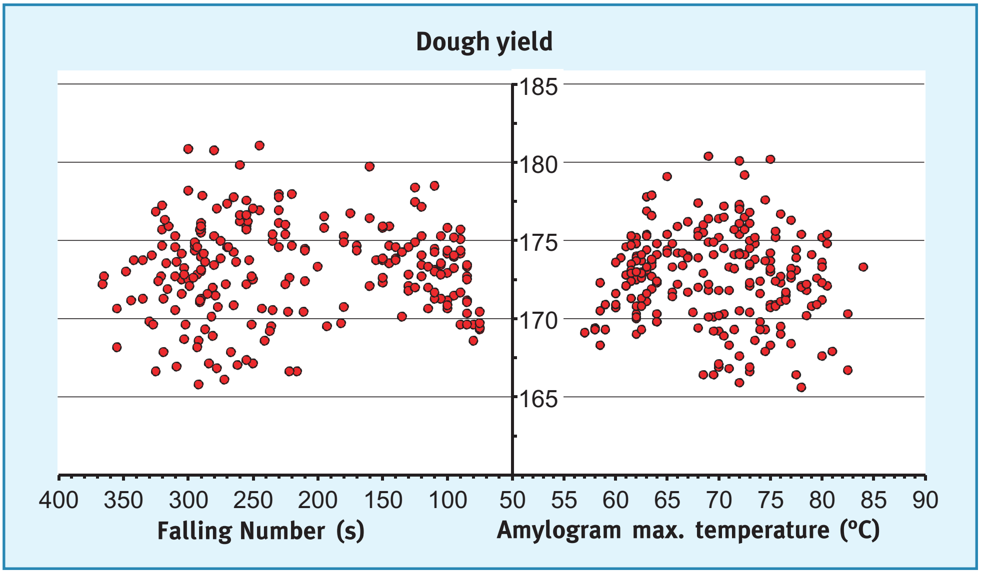

Fig. 94: Comparison between the values for indirect methods and dough yield in the baking test with rye flour and sour dough (German harvests of 1999 - 2002)

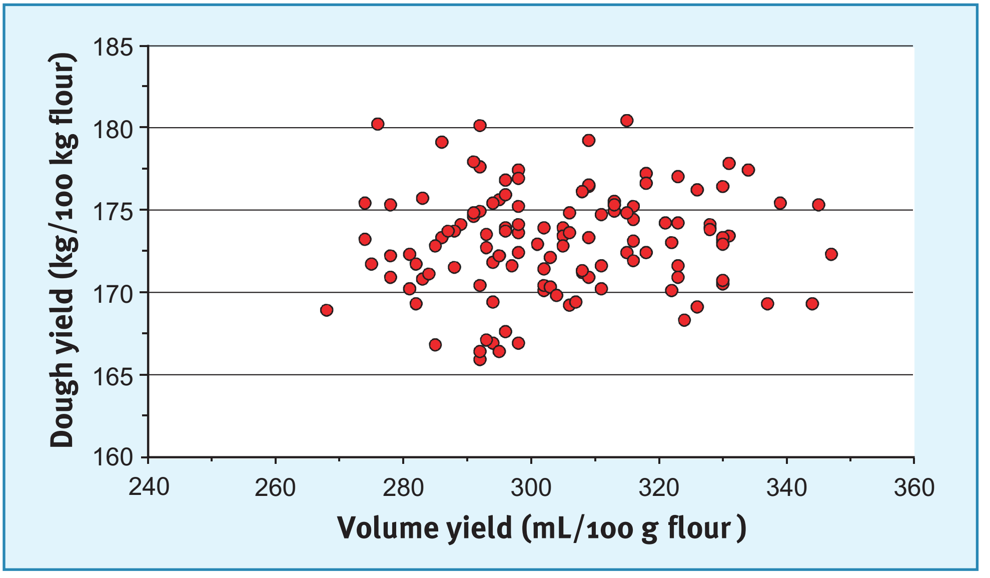

Fig. 95: Comparison between volume yield and dough yield in sour dough baking tests with rye flour (German harvests of 1999 - 2002)

Volume Yield

The volume development of rye bread is fairly limited. The average value is about 300 mL/100 g of rye flour with fluctuations of about ± 10% depending on quality. So with rye the differences in bread volume between varieties are considerably smaller than with wheat, where they are about ± 150 mL/100 g – in other words about 25% – in wheat flours of the type 550. Because of the slight differences, volume was long considered fairly unimportant for the baking value of rye. It does, however, have a decisive effect on the properties of the crumb and on shelf-life.

Elasticity of the Crumb

An important attribute for rating the quality of rye bread is the elasticity of the crumb. A technological objective is to produce a crumb that is moist and pleasantly cohesive and binding and at the same time elastic. In milled rye products, poor crumb elasticity usually only occurs in the case of rye whose constituents have an increased tendency to break down ("sprouting"). But poor crumb elasticity may also be a result of processing, e.g. excessive dough yields, too little acidification, very high volume due to extra ingredients, inadequate baking etc. Raw materials that do not break down readily (with high Falling Numbers or Amylogram values), over-firm dough processing or conditions that aggravate both these weaknesses (e.g. too little swelling of the constituents of the rye during processing of the dough, too little pre-dough, i.e. sour) result in a firm crumb, reduced inflation and thus poorer keepability of the baked goods. Such disadvantages have often occurred in the past ten years.

Quality Number

The calculation of a Quality Number takes account of efforts to achieve resistance to sprouting, which were dominant for a long time, and also dough properties.

On the basis of baking tests with sour dough, the dough yield, the volume yield and in particular crumb elasticity were included. This basis for evaluation was then extended to cover further criteria, such as dough properties, and a new description and classification of quality. The new characterization system was already used in the Walsrode Test.

15.7 Walsrode Test

In 2000 a test was carried out in cooperation with Förderverein Pflanzenbau e.V. in Walsrode. Some of the trial fields of rye were threshed at the usual – presumably optimum – harvesting time, whereas the rest were threshed about four weeks later. The quality parameters changed as follows between the first and second harvesting dates (Tab. 71):

Tab. 71: Quality values for rye harvested at different times under otherwise identical growing conditions

Determinant		1st harvesting date	2nd harvesting date
Falling Number	s	240	175
Amylogram, peak temp.	°C	70	66
Sour dough baking test,			
Quality Number		4.60	4.90

It was no surprise to the initiators of this test that the rye and the flours (Type 997) produced by the standard milling method from the second harvest had superior baking properties. Because of their lower (but more suitable) rheological values, these products were in a better range for baking. However, the highest Quality Number, 5.00, was not reached since the volume achieved even with the samples from the second harvesting date was still limited. Points were deducted because the resulting crumb lacked optimum moisture and soft, elastic properties, and therefore optimum shelf-life.

15.8 Optimizing Bread Rye Quality for the Market

On the basis of the work of Drews (1971a, b) on the introduction of a certain buffer for swelling curves, the Rye Viscosity Test (RVT) was developed. The test makes it possible to obtain some important additional information in about 30 to 45 min, a time that can usually be spared when rye is taken in, for example by a mill. Because of the small sample quantities it requires, the RVT can also be carried out by breeders as a selection criterion. The RVT is currently undergoing practical trials, and over 100 samples have already shown a certain correlation with baked volume. At the same time it has yielded further proof that some lots with higher Falling Numbers may have good inflation potential. In the past, only the Amando variety was known to have this property. When compared with other varieties it always produced the largest bread volume, independently of the site on which it was grown and its Falling Numbers and Amylogram values (Fig. 96).

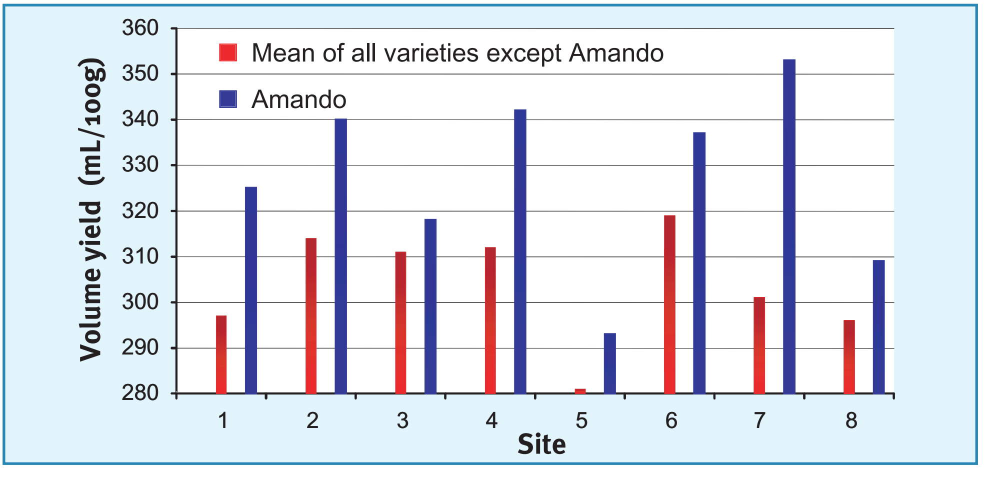

Fig. 96: Volume yields (rye/sour dough baking tests) of flours from the rye variety Amando compared with flour from other varieties (mineral content approx. 1% of dry weight; 1998 harvest)

Because of the baking results obtained over the past decades, the author considered it necessary to modify the current practice of assessing rye solely according to the criteria of the BSA's descriptive list of varieties, with steadily increasing results for 1000-grain weight, crude protein, Falling Numbers and Amylogram values. More and more, rye lots are being recommended whose high rheological Falling Number and Amylogram values are outside the optimum range for good rye bread quality. One way of achieving a more accurate prediction of bread quality is to carry out a standard baking test and determine dough yield, the degree of leavening, the volume of the bread and the elasticity of the crumb as quality criteria.

15.9 Current Rye Research and Processing Properties

Compared with other cereals, rye has only brief secondary dormancy. So under unfavourable weather conditions germination may start again, even in the blade, soon after the morphological ripening of the grains. If germination is visible it is known as visible sprouting. To the extent that they can be detected analytically, the preliminary stages of germination are described as latent sprouting.

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Such germination leads to increased enzyme activity, which in turn results in the breakdown of components of the cell walls and also stored substances. As sprout-damaged rye is considered unsuitable for bread-baking, this presented a challenge to breeders. In the past, α-amylase activity was generally measured as a selection criterion; now the assessment is almost always made on the basis of the Falling Number.

In rye research and analysis the pentosan complex used to be given greater attention than the structure of the starch. But the following starch ratios are considered relatively constant. At the time of ripening, the cereal starch consists of about 25% amylose and 75% amylopectin. The starch grains can be divided into two types: larger, lentil-shaped bodies with a diameter of about 40 mm – "A-types" – and smaller, more spherical "B-types" with an average diameter of about 10 mm. Besides these there is a fluctuating but nevertheless appreciable percentage of medium-sized starch grains. The exact ratio of A to B types of starch grains in rye is not known. Whereas about 90% of the starch grains in wheat are of the B type, the percentage of these smaller grains is thought to be somewhat smaller in rye. This may have significance for resistance to sprouting, since the smaller B starch grains and also the medium-sized types are more readily attacked by amylases because of their larger specific surface area. But in spite of their larger number, the percentage of smaller starch grains in the overall mass is fairly small in terms of volume and weight. Dreisörner (2002) also found a considerable proportion of medium-sized starch grains that increases with breeding.

The starch is broken down by hydrolases, mainly through the combined activity of the α- and ß-amylases in the cereal grains. When the grain is stored in the field, especially, α-amylases from moulds and bacteria on the ears and grains may have this effect. In particular the dextrins formed by α-amylase may then be exposed to further attack by ß-amylase or amyloglucosidase.

The α-amylase newly formed during germination seems to be an important factor influencing processing quality. Its concentration increases during ripening and reaches the highest values if latent or visible sprouting occurs.
A further breakdown is possible during gelatinization of the rye starch in the baking process, in the presence of sufficient water, high temperatures and a pH that is not too low.

There is an increase in temperature even when the grain is dried, but little moisture is present. Such tempering has also been found to reduce the tendency to gelatinize. This means that the water content of the grains is extremely important for the activity of the enzymes. Their effect seems to be greatest at a grain moisture of 30 - 40% and is largely prevented at values below 20%.

Determination of α-amylase is a complicated matter. It is measured with a large excess of water and often with the addition of a foreign substrate, e.g. coloured starch. So determination of enzyme activity is even farther removed from the conditions of bread-making than the Falling Number or Amylogram method. However, the effect of the enzymes during processing is more important than the enzyme activity that exists in absolute terms.

The grains contain a total of about 7 - 10% pentosans. Like proteins, they are one of the swelling substances of the rye, but unlike protein they are not considered to be energy reserves. The insoluble pentosans are a component of the cell walls. The ratio of the soluble pentosans (part of the content of the cell) to the insoluble pentosans (constituents of the cell walls) has yet to be determined. Larger percentages of insoluble pentosans are indicated by increasing Falling Numbers of the flour, whereas larger percentages of soluble pentosans seem to affect the peak values of the Amylogram but not the Falling Numbers. The pentosans are readily attacked even at dough temperatures, so it makes sense from the technical point of view to determine them.

The behaviour of the swelling substances of the rye during processing (e.g. viscosity of the dough) is therefore determined by the pentosan and protein content and its susceptibility to attack.

Certainly an adequate reduction of viscosity 184
has to be ensured in order to achieve the required attributes of the bread. This complex will doubtless become an important feature of technical rye research in the near future, especially as some rye varieties seem to react more sensitively than others to an overdose of water or cause greater softening of the dough in spite of high Falling Numbers, as swelling curves and the new Rye Viscosity Test (Brümmer, 2002) show (Fig. 97).
Successful breeding in respect of yield and the reliability of the yield is making rye more attractive again as a crop. Both of these factors and also resistance to sprouting still depend chiefly on the weather, harvesting techniques and post-harvest treatment and less on the properties of a particular rye variety. In

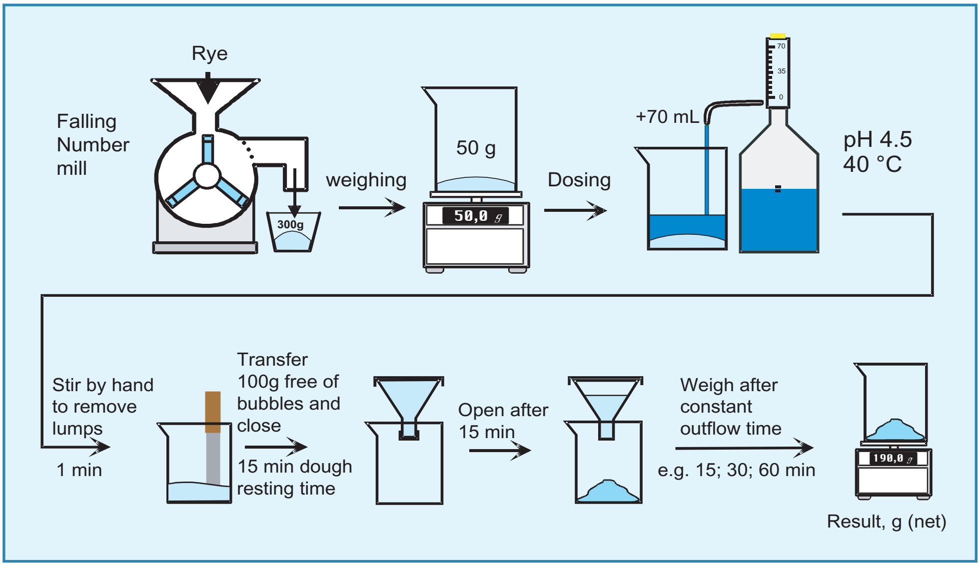

Fig. 97: Flow diagram of the Rye Viscosity Test

Germany, the characteristics of different rye varieties were only apparent under very uniform weather conditions.

But in spite of fluctuations, years of quality testing of milled rye products have revealed certain trends (Fig. 98).

The past few years, including the harvest of 2001, have almost made us forget that rye is still susceptible to sprouting. Although the rye of 1993 and 2002 broke down rather more readily, the commercial flours were drier when baked than ideal bread flours. This raises the question as to how much "sprouting" is necessary for baking bread and other, smaller products containing rye.

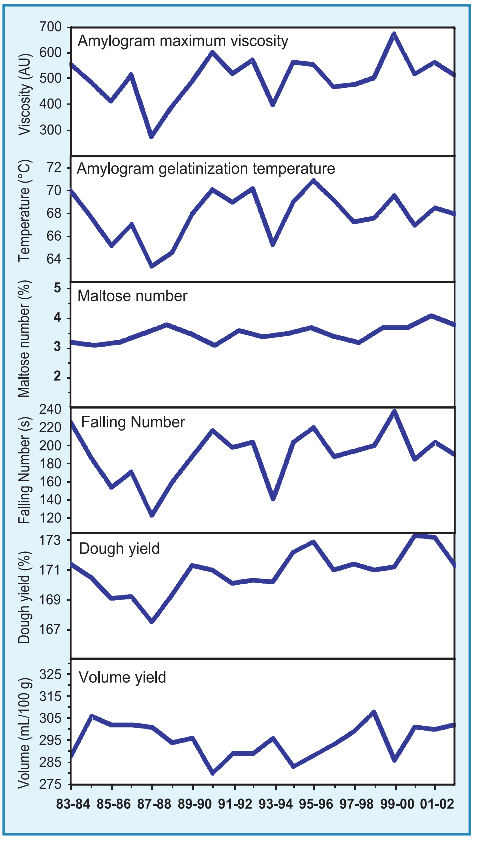

Fig. 98: Comparison of the analytical data for the German rye harvests of the years 1983 - 2002 (rye flour types 997/1150)

To answer this question, bakers have mainly considered the Amylogram and the baking test, complemented by the Falling Number, maltose content and swelling curve. The Falling Number is a quick determination method, but it is subject to greater fluctuations in respect of suitability for processing than the peak Amylogram temperature, for example.

Fig. 99 is an attempt to correlate the results of indirect methods with good bread quality. The "quality window" in the centre of the diagram shows the analytical ranges especially recommended for making bread and other small products containing rye. Outside this frame the uses of other ryes that break down more readily or less easily during baking are shown. Ryes that break down very readily should only be used for coarse meal. Milled products that reach into the dry baking range for flours of the types 997/1150 may be regarded as particularly suitable for fine whole meal or wholemeal flour.
Of course lots of this kind can also be used for making special baked products such as crispbread or to improve lots of rye whose substrate is too susceptible to attack or which show too much enzyme activity (mixed rye).

At present, millers are still very hesitant to grind rye with low Falling Numbers and Amylogram values in the usual way – probably a result of bakers' fears. But some bulk buyers have now recognized the opportunities offered by such rye properties for enhancing the quality of their bread

15.10 Changes in Milled Rye Products

15.10.1 Milling Technology

The tendency found in rye for the proportions of the substances contained in the grains to change in relation to each other naturally affects the milling properties, although this is less evident with wholemeal products. Higher crude protein levels are often thought to coincide with a lower flour yield.

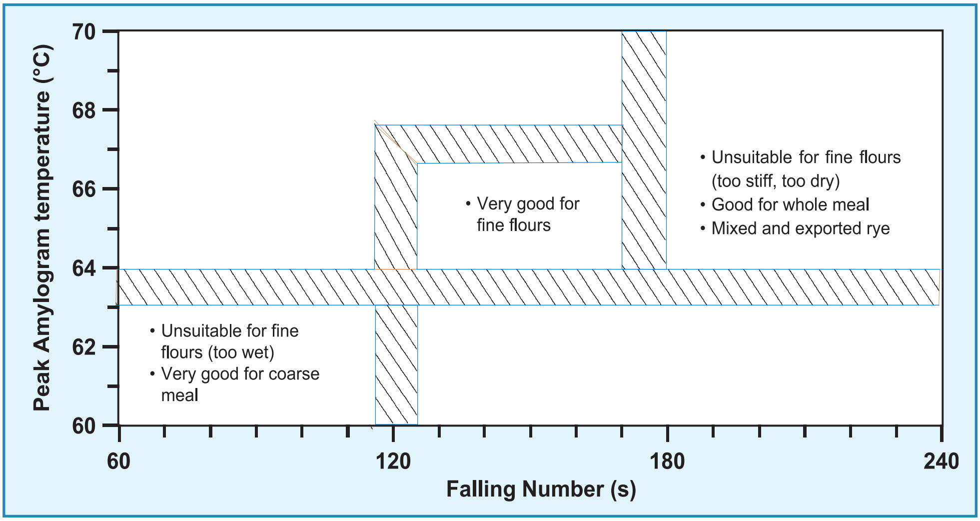

Fig. 99: Processing quality and results of indirect methods for rye: rye Amylogram – peak temperatures and Falling Numbers and expected suitability of the milled products for baking

Larger proportions of swelling substances change not only the ratio of swelling substances to starch but also the separability of the endosperm from the outer layers. This may result in milled products with a higher mineral content at the same degree of extraction. However, the overall mineral content has changed little in recent years.

15.10.2 Baking Technology

From the point of view of baking technology the following changes in rye as a raw material have occurred in recent years:

- higher Falling Numbers of the flour;
- higher temperatures at the gelatinization peak of the Amylogram;
- higher maltose values;
- increased dough yields;
- less uniform dough properties;
- less specific inflation, and thus
- reduced volume yields.

In the bread this led to changes in the elasticity and pressure resistance of the crumb from well leavened and soft to less well leavened and rather stiff.
The crumb also lost some of its moisture and good keeping properties.

The slightly higher dough yields and the addition of water-binding substances (e.g. hydrocolloids or wheat gluten) made it possible to compensate for this up to a point, but the properties of the crumb nevertheless shifted in the direction of tough and rubbery rather than moist and soft.

A change in viscosity is also noticeable in the pre-doughs and sponge doughs. Whereas dough yields of 150 often used to be recommended for sour dough, rye pre-doughs with dough yields of 160 are now considered too firm.
If sour doughs were still made according to the earlier recommendations, most mixing machines would be unable to achieve a homogeneous mixture.
The figure has therefore been raised to a dough yield of about 180 or more. Nowadays, dough yields are chosen on the basis of operating procedures such as lifting of the dough out of the mixer by hand or pumping of the sour. However, the water content has relatively little influence on the reactions in the sour dough.
The main factors are the temperature of the dough and the properties of the raw materials. Flavour development is also reduced, probably

because of changes in the properties of the substrate or reduced enzyme action, especially in the case of ryes with high Falling Numbers.

Changes similar to those in flours are also found in whole meal products. Even when large proportions of wholemeal rye flour are used, too much water is often added to the doughs in spite of their high water-binding capacity; this results in a very moist crumb or poor crumb elasticity. This is also the case if over-large amounts of water-binding additives are used, such as hydrocolloids or wheat gluten. Here too, more attention should be given to the properties of the dough and the swelling or mixing curves of the raw materials.

The necessity for greater swelling of the pre-doughs is also apparent when rye meal is processed.

In the case of coarse meal, especially, the percentages have had to be increased, for example in the brew.

If the process is unsuitable, for example if the dough is kept warm too long, undesirable fermentation may take place as a result of spontaneous reactions and greatly impair the taste of the bread.

15.11 Possibilities of Influencing Milled Rye Products

187 In the past, baking technology was directed solely towards combating sprouting. We have to take this into account when reading older literature and the recommendations such works give. In many cases out-of-date recommendations have been accepted without further thought for processing today's milled products.

In recent years, millers and bakers have gladly accepted improved raw materials and integrated them into their quality systems with correspondingly adjusted data. For example, the standard values for Falling Numbers and/or the Amylogram most often used for characterizing the value of the product for processing have constantly been raised. Because of this, lots with balanced enzymatic effect were often rejected, or the mills had to treat the flour in order to achieve the values stipulated in the contract. It was found that treatment of the flour with enzymes can change the Falling Number and Amylogram data, but it does not necessarily have a positive effect on baking properties. Rye with "natural" Falling Numbers between 120 and 150 s usually produces the best results, provided that the dough does not soften too much.

Even now, many bakeries still use multi-stage sour-dough processes, whatever the reason may be. Such processes used to be a reliable way of achieving good bread quality with highly enzyme-active milled products that break down readily. In these and some other sour dough processes, work is carried out in single steps with large quantities of starter (30% or more). The very acid conditions when a new sour dough starts to ferment reduce enzymatic conversion.

Milled rye products need sour dough to this day, not necessarily to achieve an even, elastic crumb but chiefly to form flavour components or their precursors, i.e. to enhance the taste of the bread. It is still not possible to separate acidification from flavour synthesis in the sour dough. Since the sour is so important as a source of flavour, the pre-doughs used should be correspondingly reactive. In order not to overdo acidification, it is advisable to work with sour doughs made overnight with a moderate proportion of starter and with a relatively low starting temperature and a high dough yield.

We therefore recommend one-stage sour-dough processing with:

- 5 to 10% starter (based on the amount of flour or meal in the sour dough);
- a dough yield of about 180 - 200% (or higher if it is to be pumped);
- an initial temperature not exceeding 25 °C in the sour dough;
- fermentation times of 14 - 18 h.

Although this sour dough should be used within one day of being prepared, it can be kept for up to 48 h without refrigeration if its temperature does not exceed 28 °C. If this presents a problem in the hot summer months, it is advisable to start at a somewhat lower temperature or to use the sour dough within 8 to 12 h of its maturing or to refrigerate it after this time.
Bread doughs should be processed as soft as the dough properties allow, and the temperature should be round about 28 °C. The quantity of yeast should be no more than 0.5 to 1.0% in rye bread and about 1.5 to 2.0% in mixed wheat and rye bread to achieve good leavening without too rapid fermentation. The amount of yeast needed naturally depends on the resistance of the yeast to acid, which means that the above figures are only a guide.

When rye flours that break down readily are baked, it is not necessary to make changes to the dough processing steps (including shaping) and fermentation. If only a small amount of yeast is added the dough resting time is slightly longer, but the final fermentation time can usually stay as it is. To achieve a soft, moist crumb it has proved an advantage to choose a hotter and slighter shorter baking regime or to make hearth bread or pan loaves. Acidification measures, dough yield and the baking regime remain the most important criteria for achieving a properly elastic crumb that is not too moist and does not roll into a ball – i.e. pleasant-tasting, moist bread with a good shelf-life.

15.12 Summary

The aim of this contribution is to show how important the properties of milled products are even during preparation of the dough. It includes references to characterization of the rye, not only on the basis of its behaviour during the hot phase of baking but also in the cold phase, i.e. during the dough processes. The Rye Viscosity Test may be recommended as a simple method of describing the dough properties of rye for baking purposes more reliably, with emphasis on bread and other small baked products leavened with yeast and/or sour dough.

15.13 References

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