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New Method For Defining The Water Absorption Of Milled Rye Products

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Bibliography No. 2008/2 E

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2008-2e

1 Introduction

The use of rye flours is still of great importance for the bread varieties in Germany. While the bread varieties throughout the western and eastern neighbour countries are mainly based on wheat flour, within the middle, north and east Europe countries a great amount of rye is used. The reason for that is the fact, that in these areas traditionally also rye is grown, which is due to the climate or the soil quality does not make the cultivation of wheat very successful.
In comparison to processed wheat flour products there does not exist an established method for determining the water absorption of rye flour. The baker has to rely on his experience when producing rye doughs which leads quite often to the result that the rye doughs are too firm.

2 Bread Quality And Water Addition

In the process of bread production the quantity of water for the dough preparation is not only of great importance economical wise but also in respect of the quality of the baked goods, which depends mainly on the optimized water addition in respect of the crumb softness and shelf life. The quantity of water does play a big role in respect of the milled products and the handling of the doughs also in respect of separation and forming by machines. For the mixer operator still the empiric evaluation is relevant if doughs with high rye content are made. Based on his experiences he determines the water addition, which will create the least problems during dough preparation. The process of gaining the optimum water quantity could be repeated with each new flour delivery. However, after each new harvest the process of finding the optimum water addition for rye dough will have to be carried out definitely again. It can be taken that not the maximum water quantity will be used but rather that water quantity which is expected to create the least problems. This procedure, however, is economically not acceptable. This is also not useful in respect of obtaining a good shelf life by means of a fluffy and soft crumb. Fig. 1 shows bread, in which the shape as well as the small pores of the crumb shows the effect of an insufficient water addition, as well as a too small quantity of pre-dough.

The shown bread will have a crumbly crumb already after 1 day and a dry rupture could also be possible. That quality will not meet the expectations of the consumer who are looking for a rye bread with a moist, soft crumb which will also allow storing. Unfortunately enough this poor quality is still available on the market and this leads to decreasing sales of bread with high rye content.

Fig 1: a so called “Gersterbread” with too small pores caused by a too small dough yield, too high acidity level and too small pre-dough quantity.

3 The Demand For Rye Baked Products Is Decreasing

The decreasing milled quantities of rye stands for a reduced demand for rye baked products. The reasons are mainly the reduced quality of the rye breads which often have a dry crumb after only a short time, but also because they taste too sour. The following graphics show the decrease of milled rye on from the year 1990 until 2005. The steady decrease of around 1.2 million tons of approximately down to 900.000 ton corresponds to 300.000 t which is a quarter.

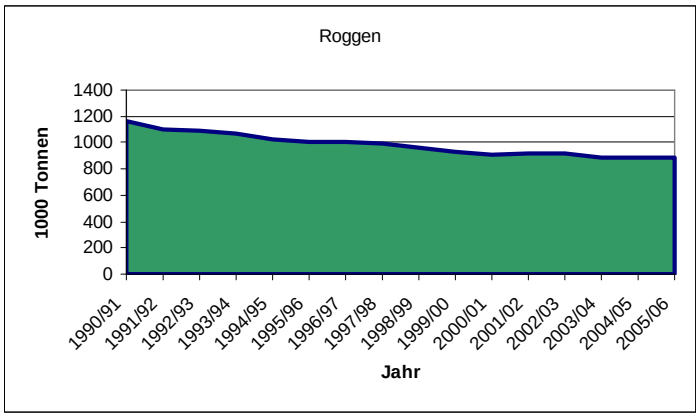

Fig 2: Decrease of the milled rye in Germany from 1990 till 2005 (Ref. Union of German Mills, 2007)

It is however, not likely that less bread was eaten in Germany because at the same time the amount of milled soft wheat increased from around 5 million tons up to 6 million tons. This constant rise cannot lead to the opinion that more confectionary products were consumed but rather that more of the moist wheat breads instead of the dry rye breads.

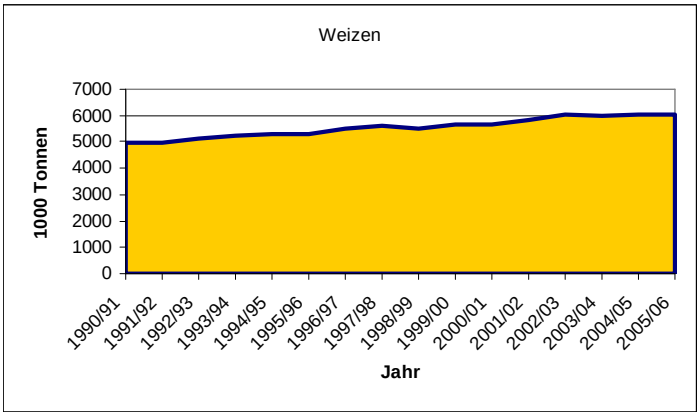

Fig 3: Increase of the milled soft wheat from 1990 till 2005 (Ref. Union of German Mills, 2007)

This comparison, however, also shows the tendency that in Germany the consumption of baked rye products is decreasing and the consumer increasingly buys wheat products. In a country which is known for the great varieties of breads and for the simultaneous use of rye and wheat products this change is remarkable and the reasons for it should be discussed.

3.1 Reasons For The Decrease Of Rye Bread Consumption

It is, of course, not fair to blame the bakers alone for the decrease in the demand. Moreover they should be informed about the changes the raw product rye has undergone. The Falling

Number and the Amylogram values clearly show that the enzyme activity decreased in comparison to the beginning of the 80ies. The Falling Number of some rye supplies is very close to those ones which have been measured with wheat. This is a result of rye breeding to avoid sprouting which is, of course, a good idea but leads to the fact that the rye is dry baking, i.e. it has a low enzyme activity. This effect is increased by the baker if they use sour dough or any other acid ingredients (as they were taught) to decrease the acid content of the dough to the value of pH 4.2 to pH 4.5 and this leads to the fact, that the anyway low starch degradation enzymes activity is weakened further. In combination with the acid another point shows up which should be paid attention to. The younger consumers are not used anymore to sour rye bread because of the available bread varieties. It is easy to say that there is already 1 generation which grew up without rye bread. More than 30 years ago, you could buy in every bakery so called “house breads” which were very tyfigal for that area. Today there are many non sour bread variations alternatively available. Thus only the older generation will remain as the consumers of sour rye breads. Elderly people will look for breads with a longer shelf life and a softer crumb. This, however, is not obtained with an insufficient dough yield and dry baking rye flours. Therefore information regarding the water absorption of rye products is of great importance for optimizing the rye products.

3.2 Necessary Reaction Of Producers And Mills

The bakers should reconsider the production of milled rye products generally. Firstly it will be necessary to reduce the part of the sour dough remarkably. This action has also a technological advantage because the acid is not used much anymore for the inactivation of enzymes, but it is still used for reasons of taste. For the production of rye breads from low enzyme flours, the non sour pre-doughs are of great importance for the quality, which also applies to wheat flour products. This can increase the part of soaked mill products by more than 50 %. Nowadays the baker needs much more information. The analysis data of rye flour which are supplied by the mills shows the following values:

- Moisture
- Ash content
- Falling Number
- Amylogram

The moisture values of around 13 % are partly quite low after the last harvest, the ask content is still balanced within the appropriate type. The Falling Number value are partly very high but show only little differences from the values obtained from wheat of normal years. The Amylogram, which is an exact method to demonstrate the combination of gelatinization properties and enzymatic activities, shows a non-uniform tendency. Besides high values which stand for dry baking properties, also results were obtained which show high Falling Number values which predict still good baking properties. Compared to wheat flour the baker does not get any information about the water absorption values of the supplied rye flour. This information could assist him very much for determining the water addition for each supply. Extending the information by this value provided by the mills, this could be an important contribution for the quality assurance within bakeries and for stabilizing the sales of milled rye products.

4 Presently Used Method For Determination Of the Water Absorption Of Milled Rye Products

Since 1987 there is a proposal from Brümmer (1987) for the determination of the water absorption of rye flours, using the Farinograph® mixer which was developed for wheat flours. Generally speaking this test was the right step and own tests showed that e.g. the firmness of rye doughs could be compared by using this method. The use of the Farinograph® mixer for determining the water absorption of milled rye products does not provide results with the same exactness, because the Farinograph® mixer was designed for visco-elastic doughs but not for plastic rye doughs. Many tests showed that when checking the water absorption with the Farinograph® mixer the tendency for bridging is very high and therefore deviations within the reproducibility are given.

Fig.4: Bridging in the Farinograph® wheat mixer while testing milled rye products.

The differences towards wheat are shown in the curve which is obtained with the Farinograph®-E. Fig. 5 clearly shows the elongated time which is necessary for soaking, furthermore the stability of the curve is only achieved after 10 minutes kneading time.

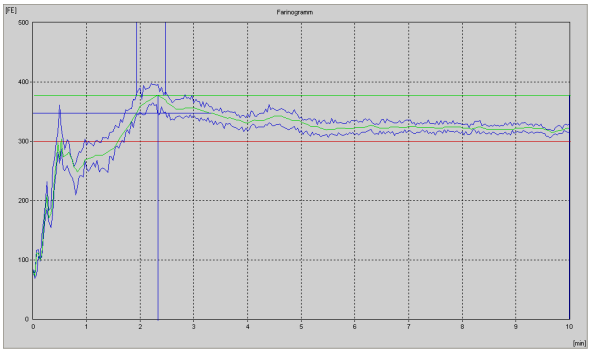

Fig.5: Farinogramme of a rye dough according to the Brümmer method, the longer soaking time compared to that of wheat flour and the beginning of the stability after 10 minutes is clearly shown.

The Brümmer method (1988) prescribes the following:

- 300 g rye flour referring to 14 % moisture
- expected dough consistency 300 FU
- consistency should be reached after 10 minutes.

During 2 ring tests this process has proved to be functional. A detailed regulation was introduced in the “Standard Methods of Grain, Flour and Bread” (Arbeitsgemeinschaft Getreideforschung e.V., 1994, page 155 – 158). In practice the water absorption of rye flour was not determined in this way as it is customary with wheat flour. This development should not reflect only to the test instruments, but also to the missing demand of the bakers for that value did not motivate to introduce this test method into the daily test routine.

Brümmer was able to point out several basic parameters during the determination of the water absorption of rye flours. Firstly a much longer soaking time will have to be considered so that immediately after the water addition for a period of 2 minutes deviations of the consistency are experienced. Secondly he recommended a kneading of minimum 10 minutes because this is the time which the rye flour needs to reach the consistency stability. Also our tests showed, that rye dough directly after pre mixing has a comparable high consistency for a short time, which however, is decreasing within the next minutes also very quickly again. It is obvious that the rye proteins, due to the mechanical stress, are giving off again the earlier bound moisture which leads to a softening of the dough in the mixer. The definition of the end consistency of 300 FU corresponds to the firmness of a rye dough in practice. The use of the Farinograph® mixer which is well suited for wheat doughs, was definitely a right step also considering missing alternatives. There, however, will always be the basic difference to wheat doughs, because rye doughs act plastic and therefore the consistency should be also determined with an appropriate measuring system.

5 Plastic Not Elastic

A measuring system for plastic materials was found with the Farinograph®-E as a drive unit and instead of the wheat mixer the planetary mixer P600 was attached. The planetary mixer originates from the measuring programme for testing plastics and it is used for the quality assurance for some years. Fig. 6 showa the measuring device including a thermostat, the Farinograph®-E as well as a corresponding PC.

Fig.6: measuring device for tests for developing a method for determining the water absorption of milled rye products with the planetary mixer P600.

The P600 is attached to the Farinograph®-E instead of the wheat mixer. It is double walled and therefore a tempering is possible. In the mixer bottom a thermocouple is built in and the evaluation and storage of the measuring results is carried out with the available software. In comparison to the used measuring instrument the water dosing and the cleaning (scraping of the dough remainders) can be optimized by the next development stage. Based on the available hard- and software the following method was created.

6 Clarification Of The Basics For The Development Of The Method

The aim of this project was to work out a method using the P600 for determining the water absorption of milled rye products, including answering those questions arising from the use of the hardware and those resulting from the specific properties of rye. In order to open up the secret of rye regarding the bounding of water for the bakers, certain decisions will have to be taken also in respect of the practice orientation.

10 different rye flour samples were used for working out answers for the following questions:

- which mixing tool is well suited,
- what flour quantity should be used,
- which speed can be used without damaging the elementary structure of rye,
- what is the planned end temperature,
- how long should the test time be,
- what consistency should be achieved and how can it be tested.

These questions were mainly answered by using statistically secured tests which are documented in Kim's report in 2007. The necessary definitions which are used for standardization are explained as follows.

6.1 Mixing Tools

The available tools were a stirrer as well as a kneading hook. Compared to the stirrer, which allows for a generally more intensive mixing, the kneading hook is better suited. The at the beginning very firm dough, stuck to the stirrer and could not be processed which disturbed the test extremely. The kneading hook is better suited for the mixing because it turns rotates around itself and also moves along side of the mixer walls. The counter wise moving scraper is pushing the adhesive dough mixture back into the mixing bowl towards the kneading hook and avoids that the material is sticking to the mixer wall. The present available model is not yet giving optimal performance because it is sometimes necessary to clean the mixer wall with a separate scraper. The kneading hook corresponds to the ones generally used in practice also because of that, it is the better choice. The following figures show the stirrer and the kneading hook.

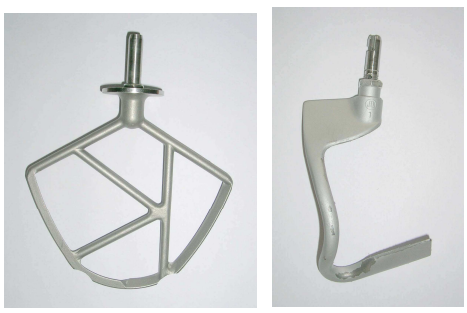

Fig.7: Stirrer and kneading hook (coated)

6.2 Flour Quantity

The volume of the P600 mixer requires a bigger quantity of flour than the Farinograph® mixer 300 for wheat doughs. The volume of the mixer bowl is 2500 cm³. Pre tests showed that a flour quantity of 600 g and a pre defined water addition of 450 ml (≈ 450 g) provided for a suitable filling of the mixer. This stands for 1050 g of dough which is obtained using this standard. The rye flour quantity had to be adjusted if the moisture content does not correspond to 14 %. The different flour quantities can be taken from a table showing the moisture deviations.

6.3 Water Addition

In correspondence with the flour quantity an amount of 450 ml water was defined as a basis. This quantity corresponds to a dough yield of 175 % which is customary in practice for pure rye flours. This water quantity should be reduced when tests are carried out using rye doughs with addition of sour dough, yeast, and salt because the degradation of pentosanes and proteins during the maturing of the sour dough will result in a decrease of the consistency. This can be between 7 and 13 % depending on the sour dough preparation.

6.4 Speed Of The Mixing Tool

Different speeds were tested during the various test rows also in respect to shorten the process. The chosen speed of 63 min^{-1} corresponds to the speed used for the wheat mixer of the Farinograph®. The reason for this definition results from the practice and the used mixing system for rye dough production. The swelling time of the rye doughs has to be considered as well, and the mechanical stress due to too high mixing speeds have to be avoided. The observed temperature increase of the dough during the measuring time was even higher due to higher speeds.

6.5 Water And Mixing Bowl Temperature

In practice rye doughs are produced at a temperature of about 28℃ and 30℃. The final temperature during the water absorption should be within this range. During those tests it was found out that the dough warming during the measuring time is around 5℃ and this has to be considered as well. For this reason the tempering of the water and the mixer bowl to 25℃ is proposed. This procedure leads to the fact that the dough temperature reaches the temperature of 30℃ at the end of the test.

6.6 Final Consistency

With a constant dough yield of 175 % the centre of the curve reaches a torque value of 6 Nm after the measuring time. This torque value corresponds to the Brabender® unit (BU) of 300 in the wheat mixer of the Farinograph®. This consistency value was also proposed by Brümmer (1987) because it corresponds to the dough characteristics of rye dough relating to the process ability.

6.7 Measuring Time

The supposed total measuring time amounts to 15 minutes. Into this value the proposals of Brümmer as well as the practical experiences regarding the development of rye dough were brought in. Caused by the changes in consistency during the test as well as by the degradation of the proteins and pentosanes after moistening and due to the mechanical influence, stable values are only reachable after 10 minutes.

Rye flours also need more time to absorb the water as it is defigted in the wheat mixer curve of the Farinograph® in correspondence with the Brümmer method. The total measuring time is split up in the following steps:

6.7.1 Flour Tempering

The time of 1 minute is proposed for tempering and mixing of the test material. This time is also used in the Farinograph® Method for testing wheat flours.

6.7.2 Water Dosing Time

450 ml water should be added continuously within 2 minutes. The water is inserted by means of a drip hopper through the mixer lid into the running mixer. This period of time cannot be shortened because the quantity of water is not absorbed faster by the rye flour.

6.7.3 Dough Development Time

Additionally to the dosing time a further minute is necessary to form a homogenous dough in the mixer. It was not possible to shorten this process, by dosing the water faster or increasing the speed in order to obtain a dough which was evenly mixed. If, as explained later, the scraping of the dough remainders of the mixer walls should not be necessary, then the dough development time has to be extended by another minute up to 2 minutes.

6.7.4 Scraping The Dough Remainders

With the present available planetary mixer version P600 the scraper is not yet integrated optimal, because some dough remainders are sticking to the mixer wall and need to be scraped down into the dough manually. Also the dough remainders sticking to the kneading hook need to be brought back into the dough. Of course, this will not be necessary in a production site because then the scraping device is optimized this far, that no further manual steps are necessary. The scraping procedure will take another minute. Right now the measurement has to be stopped and the motor has to be switched off. This causes that all values will turn to zero as shown on fig. 8. Even when this procedure is not necessary anymore, the time will have to be considered for the dough development and therefore the dough development time will have to be adjusted as mentioned above to 2 minutes.

6.7.5 Kneading Time

The actual kneading time of rye dough is defined to 10 minutes. The tests of Brümmer as well as own experiences showed that the rye dough consistency is changing during the mechanical treatment. As already mentioned earlier cause by the mechanical stress the dough consistency of rye doughs are constantly decreasing at the beginning. This is mainly caused by the degradation of the proteins which result in this phenomena. Definitely the

pentosanes are also playing a role in this process. It is assumed that this effect is caused by the reaction between proteins and pentosanes. This effect has not been investigated so far and should be clarified further. In order to obtain a relatively stable consistency a further period of 10 minutes mixing time is necessary.

6.8 Diagrams Showing The Water Absorption Of Rye Flours

The diagram (fig. 8) of the water absorption of rye doughs provides information about the method and the result.

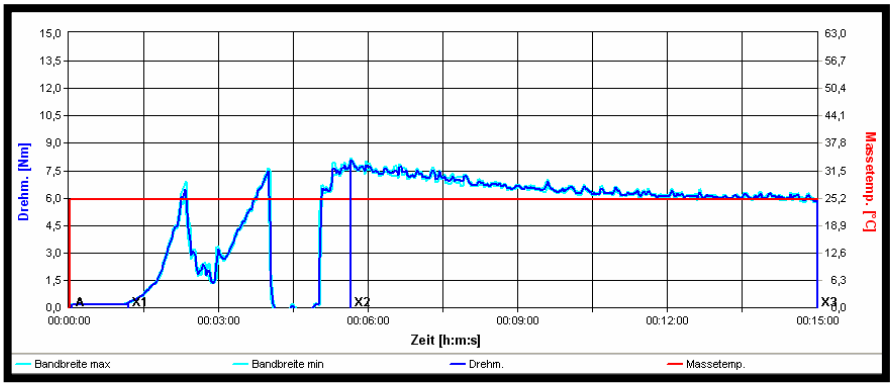

Fig. 8: Curve flow of the determination of the water absorption of rye flour

With the assistance of the curve the following points can be defined:

6.8.1 Consistency Maximum (CM)

The consistency maximum relates to the peak point in the curve in Nm.

6.8.2 Dough Development Time (DDT)

The dough development time is the time in minutes after the water addition up to the maximum in consistency.

6.8.3 Consistency decrease (CD)

Consistency decrease is the value in Nm which is measured on from the consistency maximum until the end of the measurement after 15 minutes.

6.8.4 Consistency End (CE)

The consistency end after 15 minutes, provides information about the water absorption of rye flours in Nm. For defining the water absorption of rye flour the end consistency is of great importance. It should be 6 Nm.

6.9 Calculation Of The Water Absorption

The indication of the dough firmness of 6 Nm as the end consistency, was proved to be the optimum value for rye doughs and rye baked products. As specified earlier this indication

also corresponds to the tests of Brümmer (1987) who, although it was meant for the wheat Farinograph® mixer, defined this value as the consistency end. If the consistency deviates from the value 6 Nm, then per 0.15 Nm 1 % more or less water has to be added to the dough. This stands for a correction of the defined dough yield from 175 % to 174 % or 176 %. In case of higher deviations a second test with the corrected water quantity will become necessary to secure the test results.

7 Baking Tests For Checking The Measuring Results

For the development and testing the method, various numbers of different rye flours and from different mills were used. Going by the following example the results of the method are explained.

Rye Flour	**A**	**B**	**C**	**D**
Flour moisture %	13.5	13.7	11.0	11.7
Ash content %	1.216	1.187	1.199	1.267
Falling Number (sec.)	188	213	237	236
Amylogram				
Gelatinization temperature max. (°C)	71.4	73.0	72.9	73.4
Maximum viscosity (AU)	497	519	617	465
Harvest year	2004	2004	2004	2005

Tab.1: Analysis data of tested rye flours

These flours showing different moistures and relatively equal Falling Numbers were tested with the above mentioned method and the results are displayed in the following table 2.

Rye Flour	**A**	**B**	**C**	**D**
Dough development time DDT [min]	4:42	4:40	4:32	4:26
Consistency maximum (CM) [Nm]	8.81	8.80	8.19	7.56
Consistency decrease (CD) [Nm]	2.75	2.77	2.20	1.49
Consistency end (CE) [Nm]	6.06	6.03	5.99	6.07
Water absorption [%]	73.6	73.0	77.3	72.9
Corrected water absorption [%]	74.0	73.2	77.4	73.4

Tab.2: Results of tests with the available rye flours in respect with the dough characteristics and the water absorption as an example of the method.

It is easily to recognize that the proposed dough yield of the flours range between 73.2 and 77.4 % which is a significant bandwidth. It is not possible to see an influence of the Falling Number, i.e. the enzyme activity to the water absorption. Remarkably is also the difference between the flours with lower moisture content. Although the Falling Numbers a comparable the water absorption of flour C is by 4 % higher than that of flour D. The economical advantage arising from this method justifies the additional effort of the measurement in any case. Bread were produced in accordance with the defined water absorption using the tested rye flours, thereof made sourdough, water, salt, and yeast. The following table No. 3 shows the results of the baking tests.

	Flour/Bread A	**Flour/Bread B**	**Flour/Bread C**	**Flour/Bread D**
Volume [ml)	1880	2040	2000	1950
Shape	Still good	Good	Good	Good
Browning	Normal	A bit strong	Still normal	Normal
Aeration	Still good	Good	Good	Good
Uniformity of the pores	Quite even	Quite even	Even	Even
Elasticity	Good	Good	Good	Good
pH-value/S°	4.3/10.0	4.2/10.5	4.3/10.0	4.2/10.5

Tab.3: Results of the baking test obtained with the 4 rye flours of table 1, using the water absorption determined with the P600.

The photos of the bread shape and the bread crumb are shown in fig. 9.

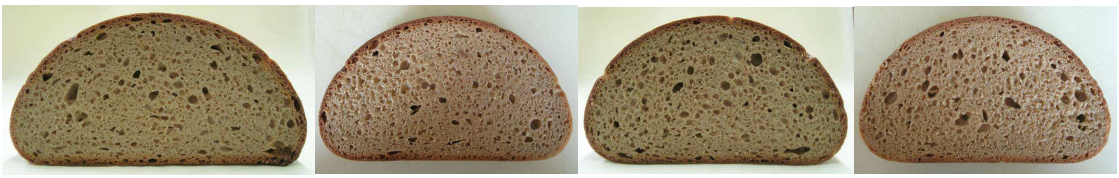

Fig. 9: photos of the breads produced with the obtained water absorption value of the above mentioned rye flours and the thus calculated water addition.

The photos show that the shape of the breads could be defined as good, although the dough yield differed, with the exception of product A.

8 Proposal For a Method For Obtaining The Water Absorption Of Rye Flours

Based on the experiences of many tests carried out in the past we suggest the following method for determination of the water absorption of rye flour types.

8.1 Title

Determination of the water absorption of milled rye products using the Brabender® mixer system P600 and the Brabender® Farinograph®-E as a drive and measuring unit.

8.2 Application Field

Determination of the water absorption of milled rye products.

8.3 Definition

In the P600 the quantity of distilled water is defined which is necessary to produce a dough of a defined quantity (600 g) of rye flour, with a moisture content of 14 %, and which has an end consistency of 6 Nm. The consistency defines the mixing resistance which applies to the kneading hook rotating at constant speed during the dough production.

8.4 Working Principle Of The Method

In the P600 a dough of 600 g rye flour is produced under standardized conditions. During premixing the resistance applying to the kneading hook is constantly measured and recorded. In order to obtain even dough characteristics it is necessary to determine the water absorption first. This is done by dosing 450 ml water to the rye flour based on 14 % moisture content, so that the end consistency of 6 Nm is reached after 15 minutes. This water absorption indicates the water quantity necessary for that rye flour.

In case the end consistency is not within the defined tolerance range of 6 +/- 0.15 Nm, another test is done with the same flour, but with a corrected water quantity. This dough is also mixed for 15 minutes. The mixing curve supplies information about the dough development, the decrease in consistency as well as the water absorption.

8.5 Reagents

Distilled water

8.6 Instruments

- Brabender® Planetary Mixer P600
- Brabender® Farinograph®-E
- Thermostat for tempering the mixer
- Volumetric cylinder 1000 ml
- Precision balance 0.001 g
- Laboratory balance 0.1 g
- Electronical thermometer 0.1℃
- Drip hopper 1000 ml
- Plastic scraper

8.7 Preparations

ICC-Standard No. 130

8.8 Determination Of The Moisture Content

The determination of the moisture content of the rye flour is measured in accordance with ICC-Standard No. 110/1.

8.9 Test Material

Considering a moisture content of 14 % the sample weight is 600 g for each test. In case of deviations of the moisture content the sample weight has to be adjusted accordingly. If found necessary the flour is tempered to 25℃.

8.10 Tempering

The thermostat has to be switched on at least 1 hour prior to the test begin, and the temperature should be set to 25℃. The temperature needs to be checked before the measurement starts.

8.11 Determination Of The Water Absorption

The following procedure applies to rye flours as well as for mixtures of rye- and wheat flours, with a rye content of more than 50 %. 600 g rye flour or the adequate quantities of flour mixture with a moisture content of 14 % are given into the mixer bowl. Then the mixer lid is locked. The drip hopper is filled with the quantity of 450 ml distilled water, temperature of which is 25℃ +/- 1℃. The test is started by press ing the start button at the Farinograph®-E and at the start button window at the monitor. The flour is tempered and premixed for 1 minute. The water quantity of 450 ml is dosed through the dosing inlet in the mixer lid, into the running mixer and within a period of 2 minutes. Then you mix for another 1 minute. Afterwards the Farinograph®-E is stopped. The mixer is opened and the dough remainders adhering to the mixer wall and the kneading hook are pushed back with the plastic scraper within 1 minute. The mixer is closed again, the Farinograph®-E is started again and the dough is mixed for another minute. The optimum consistency is reached when the end consistency reaches 6 Nm (tolerance +/- 0.15 Nm). The 0.15 Nm stands for a water absorption of 1 %. When the tolerance is exceeded the test will have to be repeated using the corrected water absorption. The measurement is finished by pressing the stop button of the Farinograph®-E. The mixer and the mixing tool have to be cleaned before another test is started.

9 Conclusion

Based on tests with different rye flours and other additives the water absorption of rye dough could be measured. The results were checked with baking tests. It could be shown that the water absorption obtained for milled rye products, produced rye doughs with a comparable consistency, and breads which in shape and crumb softness meet also highest demands. This method will assist the bakers to define the necessary water quantity for rye flours. The secret about the water absorption of different milled rye products could be opened and it contributes to improve the bread quality of rye.

This method considers the relatively slow swelling of rye dough, as well as the usual decrease in consistency caused by the input of mechanical energy. When it will be possible by defining the water absorption of milled rye products to produce high quality rye breads, then it could assist to stabilize the sales of milled rye products.

Literature

1. Arbeitsgemeinschaft Getreideforschung e.V./AGF (Hrsg.) Standardmethoden für Getreide, Mehl und Brot. 7. Aufl.- Detmold: Verlag Moritz Schäfer (1994)
2. Brümmer, J.-M.: Ermittlung der Wasseraufnahme von Roggenmehlen für den Sauerteig-Standard-Backversuch.- Mühle und Mischfutter 124 (1987) 23, S. 306-310
3. Brümmer, J.-M.: Erfahrungen mit der Roggenwasseraufnahme bei Roggentypenmehlen.- Getreide, Mehl und Brot 42 (1988) 9, S. 272-276
4. Kim, M.-Y.: Messung und Beeinflussung der Konsistenz von Teigen aus Roggenmehl.- Hannover, Leibniz-Universität, Dissertation 2007