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QUALITY CONTROL OF RAW MATERIALS IN THE MILL AND BAKERY

KONTROLA JAKOŚCI SUROWCÓW W MŁYNIE I PIEKARNI

***Summary**: From the point of view of the quality of the finished product, which is bread or other products, the quality of the raw material is strategically important. In the case of the milling industry and bakery, this raw material is grain, usually wheat or less often, rye. The technological value of the grain is a function of many different factors such as a variety, the size and profile of fertilization, agrotechnical and climate conditions during the growing season or the conditions of harvesting and storage. Knowledge about the quality of grain, including its humidity or chemical composition is crucial to assess its suitability for bakery or confectionery purposes. Chemical composition of wheat grain, and above all the quantity and quality of wet gluten often determine the usefulness of such grain and its price at the purchase point. The grain quality assessment methods include the assessment of such features as moisture content, glassiness and bulk density in the healing state. In the case of flour, its baking value is crucial, as in the case of grain, the quantity and quality of gluten, as well as the falling number or sedimentation indicator, as well as the results of water absorption measurement using farinograph. Farinograph, as well as the extensograph, are used to analyze the rheological properties of the dough made from the tested flour. The rheological features of the dough determine the quality of final products. In addition, a fermentograph and alveograph are used to assess the baking value of flour. In the present paper, the review and the characteristics of commonly used methods and devices to assess the quality of grain and baking flour were carried out.*

***Keywords**: grain, flour, baking value, farinograph, extensograph, fermentograph, alveograph*

***Streszczenie**: Z punktu widzenia jakości wyrobu gotowego jakim jest chleb lub inne wypieki strategicznie ważna jest jakość surowca. W przypadku branży młynarskiej i piekarskiej surowcem tym jest ziarno, najczęściej pszenicy lub rzadziej żyta. Wartość technologiczna ziarna jest funkcją wielu różnych czynników jak odmiana, wielkość i profil nawożenia, warunki agrotechniczne i klimatyczne w czasie okresu wegetacji czy też warunki zbioru i przechowywania. Wiedza na temat jakości ziarna, w tym jego wilgotności czy składu chemicznego jest kluczowa do oceny jego przydatności na cele piekarskie czy cukiernicze. Skład chemiczny ziarna pszenicy, a przede wszystkim ilość i jakość glutenu mokrego niejednokrotnie decydują o przydatności takiego ziarna oraz jego cenie w punkcie skupu. Metody oceny jakości ziarna obejmują ocenę takich cech jak wilgotność, szklistość oraz gęstość w stanie usypowym. W przypadku mąki jej wartość wypiekowa kluczowe są, podobnie jak w przypadku ziarna ilość i jakość glutenu, a także liczba opadania czy wskaźnika sedymentacji, jak również wyniki pomiaru wodochłonności przy użyciu farinografu. Farinograf podobnie, jak i ekstensograf stosowane są do analizy właściwości reologicznych ciasta wytworzonego z badanej mąki. Cechy reologiczne ciasta decydują determinują jakość wyrobów gotowych. Oprócz tego do oceny wartości wypiekowej mąki jest wykorzystywany fermentograf oraz wiskograf. W pracy dokonano przeglądu oraz charakterystyki powszechnie wykorzystywanych metod i urządzeń służących ocenie jakości ziarna i wartości wypiekowej mąki.*

***Słowa kluczowe**: ziarno, mąka, wartość wypiekowa, farinograf, ekstensograf, fermentograf, alweograf*

Introduction

Cereal products are an important component of everyday human diet as they are the main source of energy and of simple and complex carbohydrates. According to the guidelines of Pyramid of Healthy Nutrition and Physical Activity, developed at the Institute of Food and Nutrition for adult persons, cereal products should be the component of majority of meals. It is important to utilize most frequently the products resulting from the so-called whole grain milling. The cereal products coming from such milling are more abundant in nutrients; they contain more vitamins, especially from B group, certain mineral compounds and dietary fibre. The last one plays also a prebiotic function in human body [1]. It is just the high content of fibre in the mentioned products and by this, its high level in the diet which is especially important in preventing the non-infectious diet-dependent civilization diseases [2]. The assortment of dietary fibre-rich products includes, *inter alia*, whole meal bread (dark bread, graham), whole meal brown pasta and, also, grits (incl. buckwheat and barley) and flakes (*inter alia* from oats). The second important problem is the accessibility of cereal products for the persons suffering from celiac disease or gluten intolerance. The results of the conducted studies indicate that the frequency of consumption of gluten-free cereal products among the persons with the celiac disease is high. The mentioned above products have a key importance in composing their diet [3]. During the recent years, we have observed a considerable decline in consumption of bread and cereal products in Polish households. According to the newest data of the Chief Statistical Office (GUS) in 2021, the average monthly consumption per person was equal to 5.17 kg. On the other hand, in the years 2015 and 2011, it was 6.09 and 6.70 kg, respectively [4].

The direction of development of cereal sector may be determined by many factors, including prices of raw materials and manufacturing costs, nutrition trends, level of export of the grain and cereals products. In the light of the mentioned

problems, it should however be the search for new food products based on cereal grain and pseudo-cereals and their products which would satisfy the needs of the consumers, with the special care of their quality and safety. In the present paper, the review of the methods for control of the quality of the grain, intended for milling and of the methods employed in the quality control of the raw materials used in milling and bakery production.

Control of the quality of the grain destined for consumption purposes

The commercial quality of the wheat grain is dependent on many factors, inter alia, on variety, weather condition during the period of plants' vegetation and grain harvesting as well as on the region of cultivation. The commodity assessment of the wheat grain in respect of the content of protein, gluten, density of the grain in bulk (loose) state and the falling number indicates the differentiation of the wheat grain depending the season of the grain's harvesting and climate-cultivation region [5, 6]. Rye is less differentiated in its varieties in respect of the technological quality of the grain [7]; climate conditions during the cultivation have a big importance for the quality of the grain [8]. The wheat grain-collecting points determine the quality parameters, their minimum level and also precise the methods of the tests according to the direction of the destination. The quality discriminants may be classified into the following groups: 1: specifying general properties of the grain (flavour, appearance, gloss, degree of maturity), 2: specifying the storage suitability (contamination presence, humidity or presence of pests), 3: connected with the health safety of the grain and 4: characterizing technological value [9].

The quality of wheat grain is determined by many parameters which inform about its milling and baking quality. The milling value of the grain is evaluated, *inter alia*, on the grounds of such qualities as density in loose (bulk) state, glassiness, protein content, gluten content and, also, the content of ash in the grain and in the flour, obtained from the discussed grain [10]. In the opinion of Dziki and Laskowski [11] hardness is the most important property of wheat grain. The mentioned parameter has an enormous impact on milling, and, in particular, on conditioning (technological treatment), disintegration and sieving (screening) and by this, on the properties of the obtained flour [10]. The methods for measurement of the cereal grain hardness have been improved for many years; we may classify them as technological ones and endurance tests [12].

The humidity of cereal grain is one of the most important parameters deciding on its suitability for long-term storage. It is also significant from the viewpoint of the preparation of the grain to milling due to energy consumption during the disintegration process as well as effect on the quantity and quality of the milling products. The measurement of the grain humidity, depending on the needs and accessibility of technical support, may be performed by different methods. On the market there are available mobile hygrometers for measuring of the grain humidity; they are, most frequently, compact and precise devices allowing determination of humidity of the whole grains. NIR analyzers are equipped with sensors with the matrix of LED diodes, emitting radiation in near infrared (NIR). The humidity of material is measured on the grounds of radiation intensity [13]. Contrary to classic filter analyzers and those scanning with a mobile monochromator, the modern instruments employ stationary monochromator and light-sensitive element composed of 256 linearly situated InGas detectors (Diode Array) with the sensitivities, corresponding to energies obtained in the range of NIR 950-1650 nm. The applied technology and utility solutions enabled elimination of the basic inconvenience of classic NIR technology i.e. form of analyzed substance as it may analyze the samples in such form as they have, without preliminary milling or homogenization [14]. The humidity of the grain may be also determined by laboratory methods by the measurement of the mass loss during drying of the samples and with the application of moisture balances.

The commodity evaluation of the grain includes, *inter alia*, determination of the grain density in loose state; the mentioned test is carried out using manual or automatic, mechanical, electric or electronic measuring devices for determination of the mass of hectoliter. The density of cereal in loose state is also called the specific weight or volume weight. The discussed parameter is a ratio of cereal mass of the full container and its volume, under the closely specified conditions; it is expressed in kg per hectoliter (kg/hl) [15]. The popular densitometers for the grain include, inter alia, the equipment intended for the determination of the grain density in the loose state of cereals, using 1-litre measuring container [16].

The weight of 1000 grains is a parameter which determines the quality of the grain and the level of filling with reserve substances what affects its suitability for food industry [17]. The market automatic devices with programmer, being called counters of the grains are destined for counting of the grain as well as counting out the required number of the grain. Hence, they find a special application in cereal laboratories, cereal cultivation points and scientific -research units [18].

The glassiness of the wheat grain is the important parameter of its suitability for the consumption purposes [16]. The glassy grains are characterized by a compact structure of endosperm and higher content of protein compounds, including gluten proteins [19]. The determination of the grain glassiness may be carried out by the methods of visual evaluation, using pharinotome. The mentioned device is used for cutting of the grain and evaluating its cross-section appearance; grey and glossy cross-section is typical of the glassy grains. The application of diaphanoscope consists in overexposure of the grain; glassy grains transmit more light and during the test, they are brighter [20].

The parameters deciding about the technological value of the grain, according to the destination, includes as follows: protein content, the quantity of the washed out wet gluten, indicator of Zeleny's sedimentation, and falling number [21]. The mentioned tests may be performed with the use of equipment or device which allow a quick classification of the grain lot, e.g.

in respect of the suitability for production of specific flours or production of milling mixtures. The content of total protein may be determined using NIR analyzer [14]. The determination of the level of wet gluten is carried out by the method of washing out with the application of mechanical equipment, e.g. Perten Glutomatic System [22]. ICC (No. 155) standards and PN-EN ISO 21415-2:2015-12 are employed [23, 24]. Zeleny's sedimentation index is a measure of the quality of gluten proteins [20]. The falling number is commonly used quality parameter for determination of the activity of amylolytic enzymes in wheat and rye grains [25]. The mentioned determination is carried out using the equipment for determination of the falling number by Hagberg-Perten method, e.g. instruments for determination of the falling number by Sadkiewicz Instruments (Bydgoszcz, Poland) or Falling Number by Perkin Elmer Inc. (Waltham, USA). The determination of the falling number is performed according to the requirements of the following standards: ICC/107/1 [26], AACc 56-81.03 [27], ISO/DIS 3093 [28] and Polish standard PN-EN ISO 3093:2010 [29].

The grain which comes to the mill is directed, after the previous preparation, to milling. As it is followed from the conducted studies [30, 31], the unitary energy of the grain disintegration is dependent on glassiness, density at the loose state and ash content in the grain. Gradually with the increase in glassiness and loose density, the unitary energy of disintegration is increased. Index of disintegration effectiveness is increased together with the increase in glassiness, loose state density and weight of thousand grains and is decreased together with the increase in the ash content in the grain. Glassiness is a feature affecting the stronger impact on energy consumption at disintegration as compared to density at the loose state and ash content and gluten content. As it was revealed in the studies of the wheat grains [32], the energy consumption of the disintegration of the discussed species of grain is more strongly connected with the glassiness of the grain than with the gluten content.

The studies on the baking value of flour

The content of ash in the flour is the basis of the flour classification, to the particular types [33, 34]. The determination of the ash content in the flour is carried out by the method of the sample's combustion in the muffle furnace [35, 36]. The mentioned method is time-consuming and highly energy-consuming. To satisfy the needs of bakers and millers, Polish scientists have developed the method for determination of the flour whiteness, using the whiteness meter [37]. The whiteness meter is destined for measurements of light reflection coefficient of the flour samples and other food products. The established value of the mentioned reflection indicator enables qualification of the sample in accordance with the requirements set in the standards. The whiteness of the flour is determined by the brightness of the colour, i.e. the degree of its brightening or darkening; its componential elements include brightness and degree of yellow colour [37, 38].

Baking value of the flour is most frequently specified as the set of features, characterizing its behaviour in the process of dough preparation and during baking. The baking value of the flour is also connected with the considerable differences in its chemical composition and physicochemical properties of the particular components, and, especially of gluten. The methods employed in evaluation of the baking value are classified into two groups: indirect and direct. The indirect methods include chemical and physical methods [20 39]. The tests carried out by the chemical methods cover determination of protein content and other components of the flour. The tests of the quantity and quality of gluten and of sedimentation index have a great importance [23, 24].

The methods of the flour quality based upon the chemical analyses and determination of the quantity and physical properties of gluten obtained from the dough do not give the complete information about the baking value of the examined flour. The chemical tests are supplemented with the examination of physical properties of the dough produced from the mentioned flour. In the research and industrial laboratories, there were introduced many devices, serving for the examination of the physical properties of the dough; they were employed in testing of the behaviour and physical properties of the dough during the process of its mixing (agitation), fermentation etc., in the conditions similar to those in the industrial manufacturing process [20, 30].

Methods of evaluation of the rheological properties of the dough

The methods for the evaluation of the rheological properties of the dough gain more and more application in the qualifying assessment as well as in relation to the requirements set before the producers of wheat flour. The chemical tests of the flour are supplemented with tests of the physical properties of the dough made of it. Specialized laboratory equipment is used to test the behavior and physical properties of the dough, while maintaining test conditions similar to industrial conditions [20, 39].

Most often, the analysis of the physical properties of the dough during its production is performed with the use of a farinograph [20]. **Farinographic analysis** is based on the measurement of the resistance posed by the dough during mixing and analysis. The flour water absorption and dough parameters (dough stability, dough development time, softening) are determined Farinograph may be employed in the tests of the flour coming from laboratory milling and of the commercial flours obtained from the wheat grain [40]. The newest constructional solutions of farinograph with strain gauge electronic dynamometer allow a very accurate evaluation of the characteristics of the resistance revealed by the dough during its kneading process. Additionally, there is available the automatic station, feeding water to the kneader (mixer) of the farinograph, with the own temperature-controlled container for water and volumetric system of its dosing [41] what additionally improves the accuracy of the measurements.

Supplementing the data obtained in the farinographic analysis on the quality of flour is the **extensographic analysis**. The resistance of the dough during its tearing is determined using an extensograph. In addition, it also gives the opportunity to study the effect of fermentation process conditions (time and temperature) on dough stretching [20]. It is a tool for control of the produced flour, allowing ensuring the constant quality of the product in accordance to the individual requirements of the customer. The results of the analysis enable the evaluation of the effect of additives, e.g. oxidizing elements such as ascorbic acid, or enzymes, on the flour also in a function of relaxation time. It facilitates the control and ensures the optimal rheological properties of the flour [42, 43]. It may be very useful in optimization of manufacture of the dough obtained with the application of health-promoting additives in production process of the enriched bread.

Alveograph is another device that is used to test the dough. It is used in the study of viscoplastic properties of dough made of wheat flour. The **alveographic analysis** is performed using the international reference method, determining the alveographic values (resistance, stretching ability, elasticity and baking strength) [44, 45]. Apart from the mentioned above methods, the method of alveographic assessment belongs to the most frequently employed methods for evaluation of the rheological properties of the dough, produced from the wheat flour. It consists in the examination of the resistance of the dough sample during its even blowing up. The parameters of the dough as determined using alveograph are the basis of the quality classification systems of the wheat grain and wheat flour in such countries as, *inter alia*, France, Spain, Italy and Argentine. The alveographic assessment gains more and more wide application also in other countries, e.g. in Poland. Based upon the differentiation of alveographic parameters in the studies of wheat flours, the results of the analysis are helpful in evaluation of the direction of utilization of a given flour, e.g. for production of bread, rolls or pastry products [45].

The ability of producing and retaining gases during the fermentation of the dough and baked product is the important issue from the viewpoint of assessing the quality of the flour [40]. Examination and registration of flour and yeast fermentation properties are performed using a laser fermentograph. **Fermentographic analysis** makes it possible to determine the ability of flour to retain CO_2 produced during dough fermentation, as well as to determine the gas-producing capacity of flour [46, 47]. It may be also employed in optimization of the manufacture of the dough with the additives, e.g. abundant in biologically active compounds.

The baking capacity of the flour is dependent on the properties of gelatinization of starch and activity of enzymes (α- amylase) [20, 48, 49]. Amylolytic activity of the wheat and rye flour is the component of their baking value and is determined by the same methods as in the case of the grain meal [26–28]. **Amylograph** is a specialized instrument for measurement and recording of characteristics and properties of starch gelatinization in the flours, depending on time and temperature [50], including the initial and final temperature of gelatinization, maximum viscosity of the glue, produced from the flour suspension.

The rye dough does not generate gluten net what results also from the presence of a high quantity of pentosans in the rye grain. They have the capacity of creating very viscous solutions. High enzymatic activity if the rye grain is connected with its high sensitivity to sprouting during harvesting and storage. Due to this reason, the moderately low level of α- amylase activity is the main requirement in relation to the quality of the rye grain. Also, due to the same reason, baking value of the rye flour is characterized, first of all, on the grounds of the falling number and amylographic parameters of the flour suspension. The discussed methods are focused on the evaluation of the starch properties, its ability to swell and gelatinize and on the susceptibility to effect of amylolytic enzymes and assessment of the activity of amylases, present in the flour [51, 52].

Tested baking is a direct method for evaluation of baking value of flour. Baking may be classified according to the site of performance and, consequently, also the scale into: laboratory (performed in laboratory conditions) and industrial (carried out in a bakery) [20]. The industrial test baking is the last stage of the studies, allowing the complex assessment of baking value of the flour and deciding on its optimum direction of utilization [53].

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