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ANALYSIS OF CHANGES IN PHYSICAL PROPERTIES OF HULLED WHEAT GRAIN CAUSED BY MOISTENING

Marian Panasiewicz

Department of Food Engineering and Machinery, Agricultural University of Lublin, Lublin

Key words: hulled wheat grain, moistening, hygroscopic and structural-mechanical features

The paper presents the range of changes in moisture content and compressive force necessary to crushing hulled wheat grain, soaked in water solutions of selected food additives. Absorption capacity and changes in the mechanical strength of the grain were determined, as affected by the time and temperature of soaking in three food additive solutions. The objective of studies was to evaluate the possibilities of modifying selected organoleptic features of wheat grain and possible use of the raw material prepared in such a way in other food products. Investigation results and their analysis have shown a close relationship between moistening conditions and the extent of changes in selected physical properties (moisture content, compressive strength) of the wheat grains. It was found that the grain moistened in natural juice of red beet absorbed water less intensively (in comparison to other solutions) the levels of final moisture.

INTRODUCTION

Taking into consideration increasing assortment of various food products, including the cereal products, as well as ever-growing consumers' requirements and expectation of continuous extension of this assortment, it may be supposed that food production in the nearest future will be based on application of numerous new food additives [Andrzejewska, 1999, Rutkowski, 2003; Blaim, 1967; Kałuziak, 1999; Obuchowski *et al.,* 1997]. Thus, it should be expected that one of the main restrictions will consists in the health safety. That results from searching by the consumers healthy, less processed products, of high nutritive value and advantageously affecting condition and functions of the human organism [Kiokas & Gordon, 2003; Świetlikowska, 1995; Obuchowski, 1998; Panasiewicz, 2001]. Of course, it does not exclude creation of the taste and flavour values, which always play an important role in "supply – demand" relations. Thus, an opinion is being confirmed that the consumer is "buying by eyes" – the appearance and colour of product, or even its package, may be attractive at first, followed by the other organoleptic features, such as consistence, flavour, palatability *etc*. [Czerniawski & Michniewicz, 1998; Geates *et al.,* 2004]. Searching for wider possibilities of using the dye in cereal flour-milling branch, at simultaneous application of various wheat grain preparations and processing methods, gave the impulse initiating the studies in this field.

The studies were aimed at getting knowledge on the course of wetting process and recognition of selected physical properties of hulled wheat grain, moistened and saturated in water solutions of natural additives in the form of food dye. A determinant of experimental studies was the extent of changes in moisture content and compressive forces which occur at soaking raw materials under variable conditions of time and temperature. Detailed range of studies included the following experimental phases: raw material selection, cleaning and grading (separation of the average fraction); moistening-saturation of the raw material in water solutions of food dye under particular time and temperature conditions; measuring the moisture content w_k and force F_n necessary to crush a single grain after each of saturation treatments; and setting-up and evaluation of the obtained research results.

MATERIALS AND METHODS

Methods and procedures. Hulled grain of the soft wheat, Zyta cultivar, was used as the experimental material for studies. Before moistening in water solutions the grain was cleaned, next the average fraction was separated, as the most representative and most frequently used in production of cereal products counted among the so-called "breakfast articles". Initial grain moisture content was 11%. Grain samples of 50 g weight were immersed in 5% water solutions of food dye: the orange yellow (E110 + E124), cochineal red (E124) and fresh red beet juice with 1% salt addition. Grain samples completely soaked in particular food additive solutions were closed in air-tight plastic vessels. The samples prepared in such a way were kept immersed under differentiated temperature conditions (thermal chamber, refrigerator) for various time intervals: *i.e*. soaking temperature: t_{n1} = 4°C; t_{n2} = 20°C; t_{n3} = 50°C (±1°C; time of moistening (saturation): τ_{n1} = 1 h, τ_{n2} = 3 h, τ_{n3} = 5 h, τ_{n4} = 24 h).

Author's address for correspondence: Marian Panasiewicz, Department of Food Engineering and Machinery Agricultural University of Lublin, Doświadczalna 44, 20-236 Lublin, Poland; tel.: (48 81) 461 00 61 ext. 132, fax: (48 81) 441 09 49; e-mail: marian.panasiewicz@ar.lublin.pl

Moisture content w_k and force F_n were measured according to obligatory Polish Standards [PN-91/A-74010] and testing procedures of strength properties on the Instron 4203 apparatus [TA.XT2i – Stable Micro Stystems]

In the case of grain moisture content the mean values were determined from 3 repetitions, whereas the mean values of compressive force – from measurements of $n = 20$ grains.

In accordance with the object and range of studies a series of experiments was conducted, directed towards searching for new preparation and processing methods of grain and seeds, with the possibilities of their further, more versatile use as additives to other food products. Thus, the presented research results cover the extent of changes in the moisture content of grain and the force needed to its crushing after various duration of soaking in food additive solutions.

RESULTS AND DISCUSSION

The analysis of the obtained results dealing with the dynamics of changes in grain moisture content showed that the kind of applied dye matter in which the grain was immersed and soaked, considerably affected water sorption capacity of grain and – consequently – change of the force necessary to grain crushing. That is of importance for the technological process of flaking cereal grains (aspect of energy consumption). Regardless of the applied differentiated temperature and moistening duration parameters, the strongest effect on tested grain showed the synthetic food dye (Figure 2 and 3), to less extent the red beet juice solution (Figure 1).

The highest dynamics of water absorption, confirmed by highest rises of moisture content, were noted in the case of cochineal red colour solution (Figure 3). That concerns all the parameters connected with moistening conditions. In such case for all the moistening temperature levels, along with the extension of wetting duration, the moisture content of grain was observed to increase very intensively (in comparison to other solutions); this process proceeded most intensively during the first three hours of soaking grain in the solutions. Similar, though less intensively proceeding process took place at using the second synthetic orange yellow colour (Figure 2).

During next hours the dynamics of water absorption from food additive solutions was steady, however, all the time the courses of all curves (from three temperature levels) showed a rising tendency. The slowest was the water absorption process in a solution of natural red beet juice. Within the temperature ranges assumed to conduct the moistening-saturation process of grain, the most intensively and to the widest extent was absorbed the water from solutions at the temperature equal to $t_{n3} = 50^oC$, while the least intensively at the temperature $t_{n1} = 4.2^oC$. The high differences in final moisture contents confirmed that the temperature of grain soaking in food additive solutions, both natural and synthetic, significantly affected (likely to soaking in pure water) the final quantity of water absorbed by grains. Thus, the sorption of water by hulled wheat grain from heterogenous solutions depends, to large extent, on the temperature con-

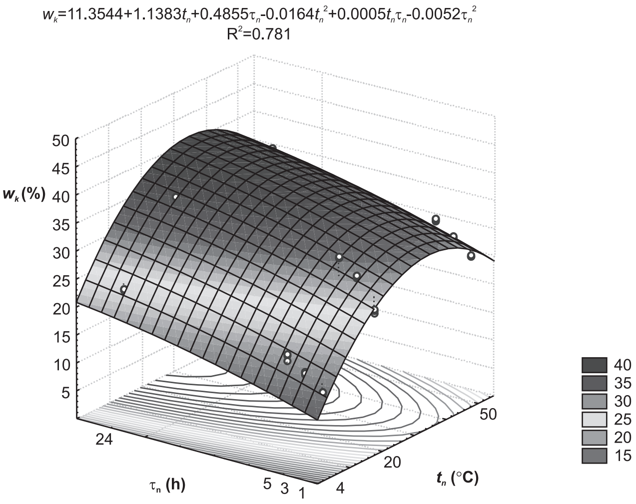

FIGURE 2. Range of changes in moisture content w_k of the wheat grain soaked in a solution of orange yellow dye at differentiated time and temperature parameters: τ_n – soaking duration, t_n – moistening temperature.

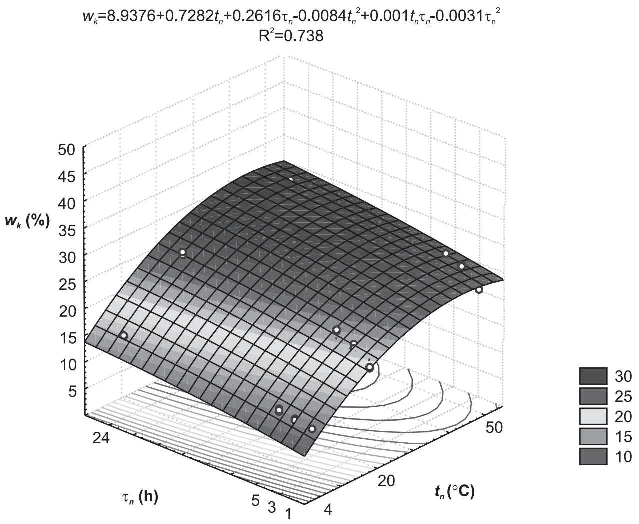

FIGURE 1. Range of changes in moisture content w_k of the wheat grain moistened in red beet juice at differentiated time and temperature parameters: τ_n – moistening duration, t_n –moistening temperature.

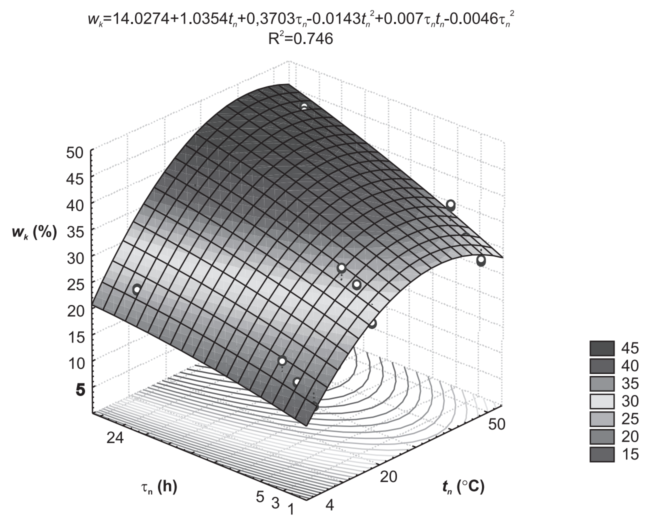

FIGURE 3. Range of changes in moisture content w_k of the wheat grain moistened in a solution of cochineal red dye at differentiated time and temperature parameters: τ_n – moistening duration, t_n – moistening temperature.

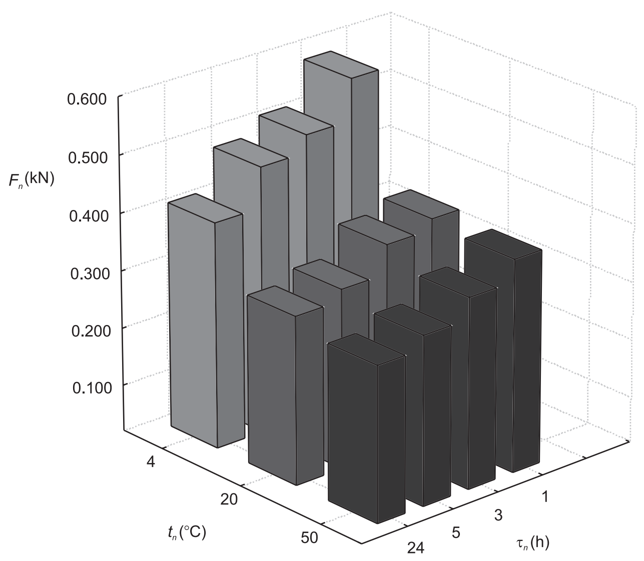

FIGURE 4. Range of changes in average values of compressive force F_n for hulled wheat grain soaked in a natural solution of red beet juice, depending on differentiated temperature t_n and wetting duration τ_n.

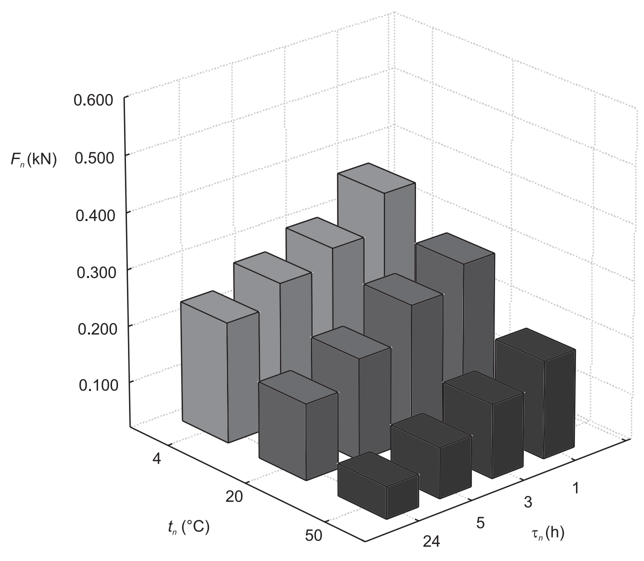

FIGURE 6. Range of the changes in average values of compressive force F_n for hulled wheat grain soaked in a cochineal red dye solution, depending on differentiated wetting time τ_n and temperature t_n.

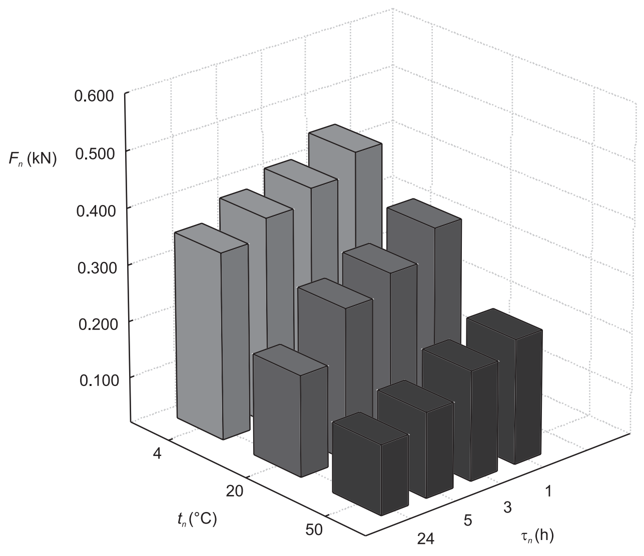

FIGURE 5. Range of changes in average values of compressive force F_n for hulled wheat grain soaked in an orange yellow dye solution, depending on differentiated temperature t_n and wetting time τ_n.

ditions and wetting duration as well. Moreover, during the experiments a close interaction between the solution and immersed grains was noted, which appears – among the others – in more or less intensive colour diffusion. Hulled wheat grain soaked in solutions, apart from the level of temperature and moistening duration, was characterised not only by considerable moisture content increase, but also by evident, fast following drop of the force F_n value, being an assumed indicator of their hardness (Figures 4, 5, 6).

The highest values of the tested force (for all time intervals) were observed for grain moistened in natural solution of the red beet juice. It should be emphasized that even the longer durations of moistening (τ_2 = 3 h, τ_3 = 5 h) did not affect the considerable drop of grain strength features. That dealt mainly with the grain soaked at the temperature of t_{n1} = 4.0°C.

Analysis of the results obtained showed close interdependence between the moisture content of hulled grain and the changes of compressive force F_n values. For all experimental variants these relationships were of reverse notation character, *i.e.* the higher the water absorption dynamics and, consequently, the moisture content of moistened grain, the lower were the values of force F_n characteristic for strength properties of grain. From the practical point of view, the knowledge of these relationships and determination of possibly optimum ranges of grain moisture content, are the basic information of special importance in the processes of flaking or grinding of the wheat grain or other grainy materials. Finally, one ought to state that the proposed method of wheat grain moistening (saturation) in food additive solutions may be a manner of processing (preparation) ensuring an attractive appearance of cereal products. That enables also to produce new generation of grain flakes, coloured and saturated with natural or synthetic taste–flavouring substances. The grains, saturated and coloured in such a way may be successfully subjected to further preparation, such as flaking or thermal treatment (roasting).

The obtained study results and their analysis indicate the possibility of wheat grain saturation with various food additive solutions, which enables modifying the organoleptic features of grain, such as the colour, and taste. After such preparation the grain may constitute an excellent initial raw material for the production of various coloured and naturally aromatized flakes, semolinas, groats *etc*.

CONCLUSIONS

1. The study determined the range of changes in moisture content for hulled wheat grain soaked in various food additive solutions. On that basis, preliminary analysis and evaluation of hygroscopic properties for this raw material were done. Also the changes in structural-mechanical (strength) features of such material, important for its further processing, were determined.

2. Results of the study indicate that the quantity of water absorbed by wheat grain was closely dependent on soaking duration, kind of solution used and moistening conditions. Differentiated reaction of grain concerning the moisture content and mechanical strength indicated that some of the proposed solutions, the synthetic ones in particular, affected more intensively the hygroscopic characteristics of hulled wheat grain. The obtained experimental data may be a basis to select the near-to-optimum duration of grain moistening before its flaking process (economic aspect of energy consumption).

3. Analysis of experimental results showed that the moistening–saturation method applied to hulled wheat grain may also be useful in changing other organoleptic features of this raw material (colour, taste, *etc*.).

4. The obtained results may also supply valuable information concerning the selection and determination of initial processing parameters for grain assigned (after further processing stages) as an additive to other food products (*e.g.* yoghurts, grain flakes mixtures, bakery products, some confectionery *etc*.). Continuation of this research seems to be justified, including also the problems of mutual interactions between the mass of food additive solutions and grains and the range of changes in the quantity of nutritive substances transferred during the moistening process (the tasty, flavouring and colouring compounds inclusive).

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ANALIZA WPŁYWU NAWILŻANIA OBŁUSZCZONEGO ZIARNA PSZENICY NA ZMIANĘ JEGO CECH FIZYCZNYCH

Marian Panasiewicz

Katedra Inżynierii i Maszyn Spożywczych, Akademia Rolnicza w Lublinie

W pracy przedstawiono zakres zmian wilgotności i siły ściskającej potrzebnej do zgniecenia obłuszczonego ziarna pszenicy, przetrzymywanego w wodnych roztworach wybranych dodatków spożywczych. Określano zdolności absorpcyjne i zmianę wytrzymałości mechanicznej ziarna w zależności od czasu i temperatury przetrzymywania go w trzech roztworach spożywczych. Badania ukierunkowano pod kątem oceny możliwości modyfikowania wybranych cech organoleptycznych ziarna pszenicy i ewentualnego wykorzystania tak preparowanego surowca do innych produktów spożywczych. Wyniki badań i ich analiza wskazały na ścisłą zależność pomiędzy warunkami nawilżania, a zakresem zmian wybranych cech fizycznych ziarniaków pszenicy (wilgotność, wytrzymałość na ściskanie). Stwierdzono, iż ziarniaki nawilżane w naturalnym soku z buraka ćwikłowego mniej intensywnie absorbowały wodę, co potwierdzone zostało niższymi (w porównaniu do pozostałych roztworów) poziomami wilgotności końcowej.