EVALUATION OF THE SORPTION PROPERTIES OF MIX FOR READY-BAKE GLUTEN-FREE BREAD

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ABSTRACT

This study was primarily designed to show the characteristics of the finished mixes to bake gluten-free bread. The scope of the research included the assessment of selected physicochemical properties and characteristics of the sorption properties.
The evaluation of the physicochemical properties of the tested products was based on the evaluation of loose and tapped density, coefficient of Hausner HR and Carr index I_{Carr}.
The products have been tested in terms of evaluation of their sorption properties using static method as well as dynamic method based on the sorption kinetics of the steam process. For the mathematical interpretation of the process of water vapor isotherms adsorption the BET equation has been used.
Based on studies performed, it was alleged that differences in the sorption properties as well as the physicochemical properties of the tested mixtures for baking gluten-free bread have been largely determined by the heterogeneous composition of the raw materials of the examinated products.
Keywords: sorption kinetics of water vapor sorption isotherm, Hausner'a ratio (HR), index Carr'a (I_{Carr}).

INTRODUCTION

Commercially available ready-mix flour, other raw materials containing protein, replacing the wheat flour, can be used to produce bread and cakes, for people requiring appropriate diets. Due to the increase of celiac disease, there is a search for ready-mix recipes to produce gluten-free bread, which should meet certain requirements. First of all gluten-free bread needs to be prepared on the basis of gluten-free ingredients. Thus, an important problem is the price of these products, their quality and their market availability [Jurga 2007, Ruszkowska 2014]. Economically worthwhile to bake this kind of bread is to use ready-made mixes

(mixes) available in the range of gluten-free food producers and baking on your own which allows receiving larger quantity of bread much cheaper than buying ready products.

The main aim of this work was to create the characteristics of the selected ready-mix for baking gluten-free bread.

The characteristics of the ready-made gluten-free mixes based on an assessment of selected physicochemical properties provide detailed information for the further marketing, transportation, storage of products, and evaluation of sorption properties enabling knowledge of processes that determine the stability and the quality closely linked to the presence and condition of water in food.

MATERIAL AND METHODS

The objects of the studies were two ready-mixes for baking gluten-free bread: the product I - Extra concentrate flour Cracow Premium-company Balviten, Product II- super mix for bread-produced by Glutenex. The conditions of the choice of objects were popularity and widespread accessibility of products on the Polish market. Shelf life of the tested products was similar. The tested mixtures into the baking gluten-free bread was characterized by a similarity of composition of raw materials (Table 1).

Table 1. Composition gluten-free product, declared by the manufacturer on the packaging

Product	The composition	The food value into 100 g	
I	Gluten-free wheat starch, corn starch, corn flour, dextrose, thickener: guar gum and E464, fiber, raising agent sodium bicarbonate, acidity regulator E579	Energetic value (kJ/kcal)	1448/346
		Protein (g)	0,5
		Carbohydrates (g)	85,8
		Fat (g)	0,1
II	Corn starch wheat gluten, powdered sugar, fiber, thickener E464-, mono and diglycerides of fatty acids - emulsifier.	Energetic value (kJ/kcal)	1423/335
		Protein (g)	0,3
		Carbohydrates (g)	82,7
		Fat (g)	0,14

Source: based on data from the package/

The content of water was determined by the thermal drying with a method to a fixed mass [Krełowska-Kułas 1993] and the water activity was determined with an AquaLab (Series 3 model TE, Decagon Devices, Inc. Pullman, WA, USA) apparatus with an accuracy of ± 0.003 at 20°C.

The evaluation of the physicochemical properties of ready-mix for baking gluten-free bread, was based on: evaluation of the bulk density of loose and tapped [PN-ISO 8460-1999.], Hausner ratio HR, Carr index I_{Carr} [Ruszkowska, Palich 2010].

The evaluation of the sorption properties of the tested products was made using dynamic and static methods. The method consisted in determining the dynamic vapor sorption kinetics at a constant temperature of 20°C±1°C and in an environment with constant a_w= 0.44 and 0.69 using the measuring position enabling maintenance of the stability of temperature and water activity during the 48 h measurement time. Static method consisted in define sorption isotherms of water vapor. Samples were stored in hygrostats at a temperature of 20°C±1°C, with saturated salt solutions with a water activity from 0.07 to 0.98 [Tyszkiewicz 1987].

Equilibration time of the test was 45 days. On the basis of the initial product mass and water content changes the equilibrium water content were calculated and plotted against water vapor sorption isotherm.

The development of research results sorption properties were performed using computer programs Microsoft Excel 7.0, Jandel Table Curve 2D-v 5.01. The mathematical interpretation of the process of water vapor sorption was shown with BET (1) [Ościk 1983, Paderewski 1999] in the range of water activity $0.07 \le a_w \le 0.33$. The fitting of empirical data to the BET equation was characterized based on determination coefficient (R^2) and standard error of estimation (FitStdErr) and the F statistic value, as determined using the Jandel-Table Curve 2D v 5.01.

$$a = \frac{\nu_m c a_w}{(1-a_w)[1+(c-1)a_w]} \tag{1}$$

where: a – adsorption, [g/g]; v_m – monolayer water content [g/g]; c – constant energy [kJ·mol^{-1}]; a_w – water activity[-].

On the basis of water content estimated in the monolayer adsorbed at a temperature lower than the boiling temperature and the so-called “water cross-section”, the specific surface area of adsorbent was calculated according to the equation (2):

$$a_{sp} = \omega \frac{v_m}{M} N \tag{2}$$

where: a_{sp} – surface area of sorption [m^2/g], N – Avogadro number [6,023·10^{23} molecules/mol], ω – water setting surface [1,05·10^{-19} m^2/molecule], M – water molecular mass [18.015 g/mol].

ANALYSIS OF THE RESULTS

The evaluation of water content showed that higher initial water content and activity were characterized by product and - a blend of gluten-free bread baking company Balviten. The average water content in the product I was 11.44/100 g d.m.

and water activity reached the level of $a_w = 0.437$. On the basis of the water activity value of the tested products I and II, it was found that the level of water activity in both their products provide microbial stability [Figura, Teixera 2007].

Table 2. Water content and activity of the tested products

Product	Average water content [g /100 g d.m.]	SD	Water Activity [-]	SD
I	11.44	0.007	0.437	0.006
II	10.36	0.056	0.402	0.009

Source: Own correlation.

The assessment of physicochemical properties of ready-mix for baking gluten-free bread, was based on the classification of cohesiveness and flowability according to the statement presented by Samborska et al. [2011]. On the basis of the evaluation, the product II was characterized with a higher bulk loose density and bulk tapped density (Table 3). On the grounds of the results (Table 3) based on the list proposed by Samborska et al. [2011], it was alleged that both products were characterized by high cohesiveness and poor flowability.

Table 3. The physicochemical properties of the tested products

Produkt	Bulk density loose, [g/cm^3]	Bulk density tapped, [g/cm^3]	Hausner ratio, HR [-]	Carr Index I_{Carr}, [%]
I	0.44	0.69	1.56	38
II	0.50	0.77	1.53	37

Source: Own correlation.

The assessment of dynamic vapor sorption process was based on the analysis of the kinetics curves (Figure. 1) showed an increase in the water content of both products, in relation to the initial content (Table 2), in the conditions of medium water activity a_w=0.44 and 0.69. Thus, the process takes the form of water vapor adsorption and the course of the kinetic curves have been subject to a potential difference of moisture thereby creating a driving force for the adsorption of water vapor.

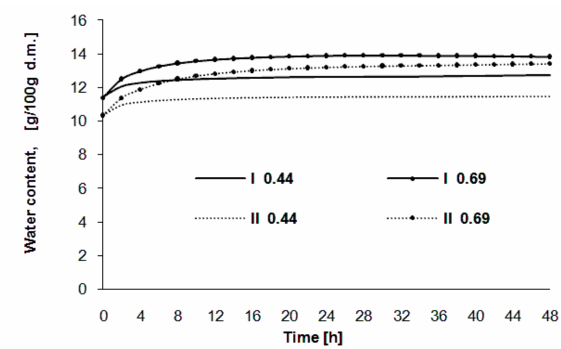

Figure 1. The vapor sorption kinetics of the test of gluten-free mixes I and II (Table 1).

Empirically determined sorption isotherms of water vapor, based on a static method of assessment of the sorption process (Figure 2) reflect the physical sorption process occurring on the bodies of porous while the shape of a sigmoid curve phenomenon indicated the formation of macromolecular layers of water on the surface of the test products. The preliminary assessment of the sorption properties was made by comparing relative position of the isotherms. In the area of water activity a_w=0.98 higher sorption capacity was alleged with product II. It is expected that in the evaluated variant of research, design and the position of the tested water vapor adsorption isotherms were the result of differences in the fiber composition of the tested products.

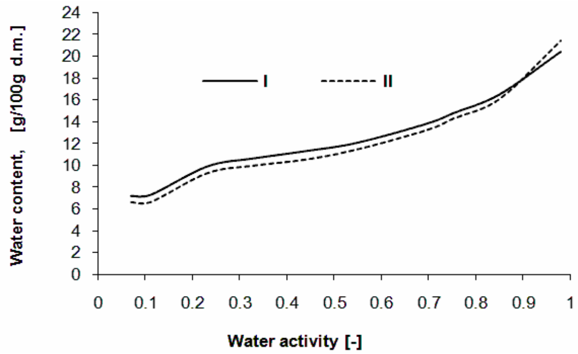

Figure 2. Sorption isotherms of product I and II (Table 1)

The course of sorption isotherms in the water activity range of a_w= 0.07-0.33 enabled determining parameters of the BET equation (V_m, a_w) by assaying the degree of its fit (R^2, FitStdErr, Fstat) to empirical data (Table 4.)

In this study a higher capacity of monolayer, is characterized by the product I, which proves the existence of a greater amount of hydrophilic functional groups in this product is capable of interacting with molecules of water. The study of sorption properties revealed that the value of the constant c, characterized by the particular nature of the changes is dependent on hygroscopic product. Lower value of the constant c was alleged in Product II, which shows a smaller amount of heat released from the product in the process of sorption (Table 4). The specific surface area of sorption calculated from the BET equation being a derivative of the capacity of monolayer showed higher values in product I - Extra concentrate flour Cracow Premium-company Balviten (Table 4).

Table 4. The BET equation parameters

Product	Parameters		R^2	FitStdErr	Fstat	Specific surface of sorption [m^2/g]
	V_m [g/100g]	C_e [kJ·mol^{-1}]				
I	7.47	95.64	0.94	0.54	30.70	261
II	7.04	73.74	0.93	0.57	26.86	246

V_m – monolayer capacity; C_e – constant energy, R^2 – determination coefficient, FitStdErr-standard error, Fstat – value of F – statistic.

Source: Own correlation.

CONCLUSIONS

1. The shape of water vapor sorption kinetic of mix for ready bake gluten-free bread depends on the water activity of the environment and the initial water content in the tested product.
2. Sorption isotherms of the tested mixes for ready-bake gluten-free bread had a sigmoidal shape and were characterized by a similar course.
3. The tested mixes for ready-bake gluten free bread were characterized with high cohesiveness and poor flowability.

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