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Influence of Non-Traditional Flours with Functional Properties on Changes of Sponge Cakes During Storage

KEYWORDS: non-traditional flours, sponge cake, storage, crumb moisture, structural and mechanical properties of cake crumb

Zhivka Goranova	Marianna Baeva	Violeta Slavova
University of Food Technologies, 26 Maritsa blvd., 4000 Plovdiv, Bulgaria	University of Food Technologies, 26 Maritsa blvd., 4000 Plovdiv, Bulgaria	Technical University - Sofia, College in Sliven, 59 Bourgasko Shaussee blvd.,8800 Sliven, Bulgaria

ABSTRACT *Confectionery products are an integral part of the human diet because they can be used as a high density food energy source, it improves the feeling and mood of consumers. Four formulations of sponge cakes made by a partial replacement of wheat flour which were formulation A (100% wheat flour), formulation B (35% cocoa husk powder (CHP)), formulation C (20% Jerusalem artichoke powder (JAP)), formulation D (50% einkorn wholemeal flour (EWF)). Investigated are the changes flowing during storage at 18 oC and 75% relative humidity. This approach evidenced that the evolution of the sponge cakes freshness closely depends on the dynamic of the water in the crumb during storage. The amount of water in crumb cakes reduced during the storage process. It was proved that, simultaneously with the changes in the water states, the qualitative characteristics (structural and mechanical properties) of the crumb of sponge cake had also changed. Higher values of shrinkage and springiness of cake D were read on the sixht day.*

Introduction

The enrichment of pastry food products with biologically components possessing functional properties can be realized by inserting in their composition wheat germ, whole grain flour and other flours, which are bearers of dietary fiber, minerals and vitamins (9). A new natural vegetable biologically active component is the cacao husks, which are themselves vegetable waste from the processing of cacao grains (6, 12). The cacao husks are considered (3, 6, 11) as a valued source of dietary fiber, mineral elements on the basis of potassium, magnesium, calcium, proteins with balanced amino acidic composition, and polyphenolic compounds which manifest a strong antioxidant activity. Consumption of dietary fibers offers health benefits including protection against cardiovascular diseases, cancer, reduction blood serum cholesterol and regulation of blood glucose levels (14).

Jerusalem artichoke powder (JAP) made from Jerusalem artichoke (*Helianthus tuberosus* L.) roots is a valuable product, rich in inulin, as well as vitamins and minerals (8). Products of fructans-containing plants such as Jerusalem artichoke become increasingly interesting for application in food as they do not contain bitter taste compounds and therefore constitute a palatable functional ingredient, which may be applied as substitute of cereal flour in bakery products. Fibres, and more particularly the soluble ones, like inulin and fructooligosaccharides (FOS), are known to provide health benefits like stimulation of beneficial colonic bacteria (prebiotic capacity), reduction in bowel transit time, increase mineral absorption, improve immune response, and prevent diseases like intestinal infections, colorectal cancers, obesity, cardiovascular diseases and type II diabetes (13, 15).

Einkorn (*Triticum monococcum* L.) is a diploid hulled wheat appreciated for its excellent nutritional properties, including high protein, carotenoids and antioxidants contents (1, 10), and as such is a promising candidate for the development of functional bakery products.

But flour replacement by functional health promoting ingredients changes the quality of the final product (7). Addition of different flours to bakery products creates an opportunity to combine beneficial technological properties with beneficial biological health promoting properties.

The objective of this work was to study the effect of different flours on the dynamic of the water in the crumb during ageing of sponge cakes changes during storage.

Materials and methods

Preparation of sponge cakes

Standard raw materials: wheat flour of type 500 - ash 0.5 % (GoodMills, Bulgaria EAD), granulated sugar (Zaharni zavodi AD), eggs (local market) used in the current study are authorized by the Ministry of Health, as was manufactured in Bulgaria. A control cake was also prepared, following a traditional technology and formulation (2). Ingredients based on flour weight: egg yolk - 43.23%, egg white - 96.77%, sugar - 83.87, wheat flour - 100.00%. In particular, a double mixing procedure was applied by partitioning whipping of whites and egg yolks. Jerusalem artichoke powder (JAP), cocoa husk powder (CHP) and einkorn wholemeal flour (EWF) were added into sponge cake flour at different levels 20, 35 and 50%, by replacing wheat flour, respectively. Each sponge cakes batter of 95 g was poured out in metallic forms and baked in an electric oven (Rahovetz - 02, Bulgaria) at 180°C for 30 min.

The sponge cakes stored at standard conditions (at temperature of 18 °C and 75 % relative humidity) was investigated up to the sixth day from production date according to standard requirements (5). Humidity and temperature were kept constant by means of desiccator supplied with psychrometer, and put in a thermostat with accuracy of ±0.5 deg.

Water Activity (a_w) and Moisture Content (MC) of cake crumb

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The a_w of the crumb samples at different ageing times was measured using Novasina EP-84 RTD-42 (Switzerland) at 20 °C. Crumbled samples were put in sample cups and hermetically covered before analysis to avoid moisture loss or gain. The a_w-metre was calibrated with a saturated sodium chloride (NaCl) salt solution. The MC of crumb cakes were measured according to BSS 3412-79 (4). The MC of crumb cakes were determined by drying 5 g the samples in an oven at 105°C up to a constant weight. Data are reported as the mean of three measurements on 1, 3 and 6 days during storage of cakes.

Structural and mechanical properties of the sponge cake crumb

The physical characteristics of sponge cakes were measured 2 h after baking. The indices of the structural and mechanical properties of the sponge cake crumb (shrinkage and springiness) were determined with an automatic penetrometer (model DSD VEB Feinmess, Dresden, Germany). A hemispherical body with a diameter 12.5 mm and total weight 300 g acted on the sectional surface of a sponge cake sample, 40 mm thick, determining the shrinkage at the 5 and 10 s. Relaxation was checked by means of a hemispherical body with a diameter 25 mm and total weight 50 g acting upon a 40 mm thick of crumb cake for 5 s. This procedure was used to determine crumb springiness (16).

Mathematical and staistical methods:

Depending on the type of the studied characteristic from 3 repetitions of each measurement were done. For the evaluation of results was used a method with a level of statistical significance p£ 0.05.

Results and discussion

The batter formulations of the control sample and the investigated sponge cakes containing non-traditional flours are four types: formulation A (100% wheat flour), formulation B (35% CHP), formulation C (20% JAP), formulation D (50% EWF).

Water Activity (a_w) and Moisture Content Measurements (MC) of sponge cake crumb

Moisture migration from crumb to crust and moisture redistribution between sponge cakes have significant changes during storage. The measurements of moisture loss in cake crumb were done of 1, 3 and 6 day of storage (Figure 1).

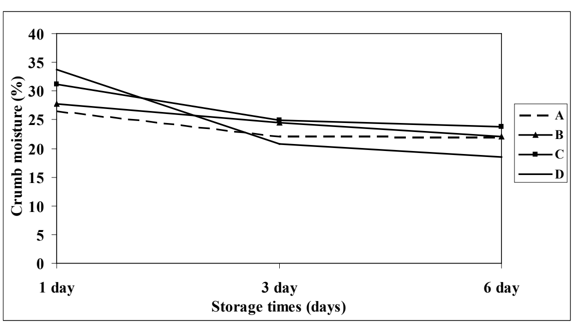

Fig. 1. Crumb moisture of sponge cakes during storage at 18°C and 75 % relative humidity

Figure 1 shows that moisture loss in the crumb of sponge cakes with non-traditional flours was biggest during storage, while in the sponge cake with wheat flour it has reduced smoothly. The overall mean moisture content of different cakes showed that formulation D has lowest moisture content during storage. As a result the highest values of rate constant for the processes of moisture changes were defined for the cake C. For example, the moisture loss measured on the sixth day of storage was 4.55 %, 5.69 %, 7.35 % and 15.13 % in the crumb of cakes A, B, C and D, respectively.

Test modifying a_w of the crumb cakes during storage (Table 1).

Table 1 Water activity (a_w) of the sponge cakes crumb during storage

Storage	Sponge cake type			
	Formulation A	Formulation B	Formulation C	Formulation D
1 day	0.807 ± 0.002	0.824 ± 0.005	0.804 ± 0.003	0.847 ± 0.003
3 day	0.647 ± 0.006	0.695 ± 0.008	0.844 ± 0.048	0.734 ± 0.011
6 day	0.609 ± 0.004	0.678 ± 0.002	0.649 ± 0.004	0.648 ± 0.017

Detected is a difference between a_w of the samples, such as a 6 day highest a_w is B, and the lowest - A. On the basis of these data it could be supposed that the water-retaining effect in the cake D was lowest, which was in correlation with the structural and mechanical properties of sponge cake crumb.

Structural and mechanical properties of sponge cake crumb

Fig. 2 show that the cake D had greater percentage retained moisture for first day than all other cakes, which lead to a difference in the indices for the structural and mechanical properties. During the storage of four cakes, the changes in their crumbs were examined by standard physical methods. At the end of storage times (on the sixth day) of cakes, crumbs was observed expressed as decrease of shrinkage and springiness.

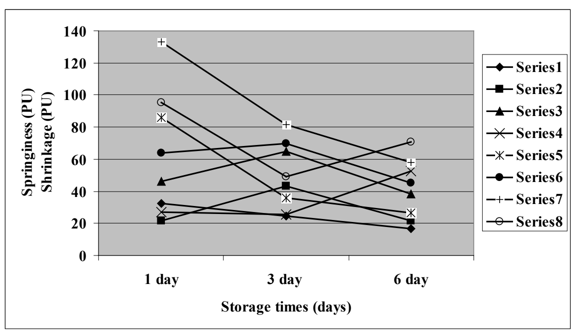

Fig. 2. Change of the shrinkage and springiness of sponge cakes crumb during storage for 6 days: Series 1, 2, 3, 4 – changes of the cake A, B, C, D shrinkage; Series 5, 6, 7, 8– changes of cake A, B, C, D springiness.

The analysis of the determined structural and mechanical characteristics showed that the shrinkage and springiness measured of cake A was reduced to the greatest extent between the first and third day of sample control storage while, smoothly during the whole period of storage (Fig. 2). On the sixth day, the shrinkages of cake A measured higher than that of the on other cakes. By analogy, the springiness of cakes with composite flours is higher than that of the control sample on the sixth of storage. Considerable changes in the springiness changes in B, C, D cakes were observed after the first day of their storage.

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The crumb of these cakes not only kept its higher values of springiness, but was also characterized with a sharper reduction between the first and the sixth day of storage. The cake D for first and sixth days of storage had a higher shrinkage, and higher springiness than all other cakes. The aspect that most greatly influences the moistness and soft feel of cake is water.

Conclusions

Water plays a major role in both the formation of the initial product structural and mechanical characteristics and the manner in which they change during storage. Results confirm the hypothesis based on molecular mobility of water with sponge cakes crumb during storage. The kinetics investigations on crumb moisture showed that use of flours with functional properties (JAP and CHP) has preserved the sponge cake freshness up to the sixth day of storage in comparison with control cake. That effect visible in cake B containing CHP, rich of dietary fiber having water-retaining effect. On the sixth day of storage, higher values of shrinkage and springiness for the cake D but with the minor differences in the structural and mechanical characteristics is cake B compared with the control cake.

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