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TEXTURAL AND RHEOLOGICAL CHARACTERISTICS OF DOUGH FOR COOKIES WITH CHESTNUT FLOUR

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ABSTRACT

Chestnut and chestnut-based food has beneficial nutritional and organoleptic qualities. The biochemical composition of chestnut flour is close to that of many cereals and it can be used instead of wheat flour for people who suffer from celiac disease. The aim of this research is to characterise rheological and textural properties of dough for cookies in function of the amount of chestnut flour (20, 40 and 60%) and moisture content (20, 22 and 24%). The addition of chestnut flour leads to less flexibility of dough and worse ability to recover because of bad connection and brittle consistency of the dough, which is a consequence of reduced gluten content. The gradual substitution of wheat flour with chestnut flour contributes to the elasticity of the dough, due to chestnut starch granules ability to bind water. Extensibility and resistance to extension decrease with increasing addition of chestnut flour as a result of reduction gluten content. The increase in the share of chestnut flour from 20 to 60% resulted in an increase of hardness of the dough.

Keywords: chestnut flour, cookies, rheological properties, textural properties

INTRODUCTION

The technology of cookies is based on the characteristics of flour as the main raw material, which with fat, sugar, water and other additives forms the dough appropriate rheological characteristics and gives the product optimal physical and sensory properties [1]. Today, in food industry much attention is given to the healthier nutritional products which contain innovative, natural and cost effective ingredients.

Chestnut and chestnut-based food has beneficial nutritional and organoleptic qualities. Chestnut flour (CF) is obtained by grinding the dried fruit chestnut with a stone or hammer mill in two stages. The CF can be stored for several months at room temperature or several years at 4 °C. Despite great nutritional value is characterized by

the absence of cholesterol and low protein content [2]. The biochemical composition of CF is close to that of many cereals [3]. Starch is the main component and the protein and lipid contents, mineral salts, dietary fibres and vitamins (B1, E and C) make CF a very good substitute for people on a gluten-free diet. Indeed, CF can be consumed by people who suffer from celiac disease, i.e. permanent intolerance to gluten [4].

The aim of this work was to investigate physical (extensibility and resistance to extension and hardness) and rheological (viscous and elastic moduli, creep and recovery) characteristic of the dough for cookies. Wheat flour in the formulation of cookies was partially replaced with chestnut flour on the levels of 20, 40 and 60% and the dough samples made with different water content (20, 22 and 24%).

MATERIALS AND METHODS

Materials

Wheat flour for cookies and biscuits (T-500 "Jaffa", Crvenka) and commercial chestnut flour ("Mollino Rossetto", Padova, Italija) were used for preparation of dough for cookies. Wheat flour showed (% dry basis) moisture contents of 12.29, starch of 73.75, reducing sugars of 1.83, protein of 9.7, ash of 0.45 and fat of 0.84. CF showed (% dry basis) moisture contents of 5.71, starch of 62.4, reducing sugars of 21.10, protein of 5.54, ash of 2.06 and fat of 3.19. Chemical composition data of these flours were obtained according to standard AOAC methods [1]. Vegetable fat "Vitalina" was obtained from "Dijamant", Zrenjanin. Salt, sodium bicarbonate and ammonium bicarbonate were obtained from "Centrohem", Stara Pazova. Powdered sugar ("Centroproizvod", Beograd) was purchased in a local food store.

Dough preparation

Control samples were prepared only with wheat flour and in other samples 20%, 40% and 60% of wheat flour was substituted with chestnut flour. Cookies dough was prepared according to the following formula: flour (i.e. flour blend) 199.39 g, vegetable fat 41.88 g, sugar 69.79 g, NaHCO₃ 0.6 g, NH₄HCO₃ 0.4 g and NaCl 1.09 g. The amount of water was calculated in relation to the water content of the flour blends in order to obtain dough samples with 20%, 22% and 24% moisture content. The measured amount of flour was mixed in a mixer for 0.5 min, and after the addition of the total amount of fat and powdered sugar, the mixing was continued for 5.5 min at low speed (60 min⁻¹). All other components dissolved in distilled water were added into the mixer, the mixer closed and the dough mixed for 15 min.

Dough viscoelastic measurement

Oscillatory and creep-recovery tests were carried out with a Haake Rheo Stress 600 (Karlsruhe, Germany) by plate-plate sensor geometry (60 mm in diameter with a 1-mm gap) at 25 °C. The excess of dough was removed and Vaseline oil was applied to cover

the exposed sample surfaces. Before the measurement, the dough was rested for 15 min to allow relaxation.

Stress sweep tests (1 Hz at 25 °C, modulating shear stress values from 1 to 100 Pa) were carried out to determine the linear viscoelastic region of the samples. On the basis of determined LVE regime measuring for frequency sweep conditions were defined [5]. Dynamic oscillatory measurements (frequency sweep parameters) were observed modulating the ω -value from 6.28 to 62.8 rad/s (frequency 1–10 Hz) in a constant value of shear stress (30 Pa). The storage modulus (G'), loss modulus (G''), and loss tangent ($\tan \delta$) were observed.

For creep and recovery test constant stress applied on the dough at creep phase was 30 Pa ($\sigma=30$ Pa). This phase lasted 150 s. After that, the dough was recovering in 300s. The final data were expressed as creep compliance ($J(t)$ (Pa^{-1})= γ/σ , where γ is shear deformation) over time (t) [6].

Dough texture analysis

Textural properties of dough were determined by Texture Analyser TA. XT Plus (Stable Micro Systems, Surrey, U.K.). Dough hardness was determined using the penetration test by application of measuring accessories P/6 (cylinder diameter of 2 mm) which penetrate to a depth of 2 mm in the dough set to a solid metal platform. The maximum force registered at the depth of 2 mm represents hardness. Measurements were performed in five replicates at 25 °C using load cells of 5 kg and following operating parameters: pre-test speed: 1 mm/s; test speed: 2 mm/s; post-test speed: 10 mm/s; distance: 2 mm.

To define extensibility and resistance to extension of dough, micro-method Kiffer Extensibility Rig [7] was used. Measurements were performed in five replicates at 25 °C using load cells of 5 kg and following operating parameters: pre-test speed: 2.0 mm/s; test speed: 3.3 mm/s; post-test speed: 10 mm/s; distance: 75-mm; trigger force:auto-5 g.

RESULTS AND DISCUSSION

Viscoelastic properties of the dough

Viscoelastic properties are very important because they affect the characteristics of the dough during the production process and the quality of the finished product. Figure 1a, b and c show storage or elastic (G') and loss or viscous (G'') module values with frequency for control and samples. Figure 1a show viscoelastic properties of dough for control and samples with 20% moisture content, figure 1b with 22% moisture content and Figure 1c with 24% moisture content.

In dough samples containing 20% of water the substitution 60% of wheat flour with chestnut flour resulted in the increase of both dynamic moduli compared with control sample, while difference between control sample and samples with 20% and 40% substitution of wheat flour were not significant. The highest dosage of CF (60%) in the

dough sample causes an increase in the elasticity of the dough, which is reflected in the increase of its hardness. Similar results were observed by Moreira et al. [8] who pointed out that the addition of CF increases elasticity of the dough as a result of a higher degree absorption and retention of water by chestnut starch granules.

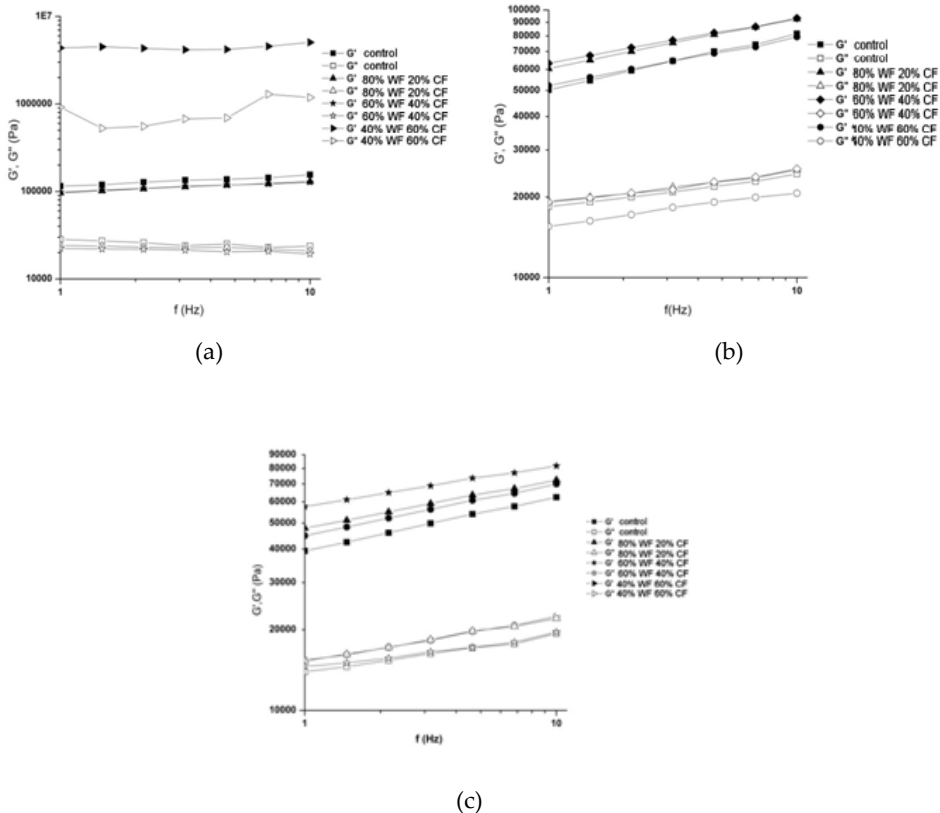


Figure 1. elastic (G') and viscous (G'') moduli values with frequency for control and samples (a-dough with 20% moisture, b-dough with 22% moisture, c-dough with 24% moisture)

With an increase in moisture content from 20% to 22% do not detect significant changes in the values of G' and G'' in the samples with CF compared to the control sample. Increase the moisture content in the dough compensates increase in the elasticity caused

by the introduction of CF in formulation. As water content of the dough increases, both moduli decrease [9]. Values of these modules are significantly lower than in the dough containing 20% of water.

Based on shown changes of moduli of samples with 24% water and different amount of chestnut flour, can be seen that there is reducing in difference between elastic and viscous moduli. This means that we have the dough samples which are less hard then samples containing 20% and 22% of water. Also there is increasing of elastic moduli values with an increase of CF amount.

For all samples dominated elastic moduli over the viscous. Values of $\tan \delta < 1$ (results are not shown), which is characteristic for dough as viscoelastic system with the dominant elastic component. With the increasing water content, the hardness of the dough decreases and the ratio of moduli (values of $\tan \delta$) increases. Also, in the samples with the same water content, the increasing of CF content causes decrease of $\tan \delta$ values.

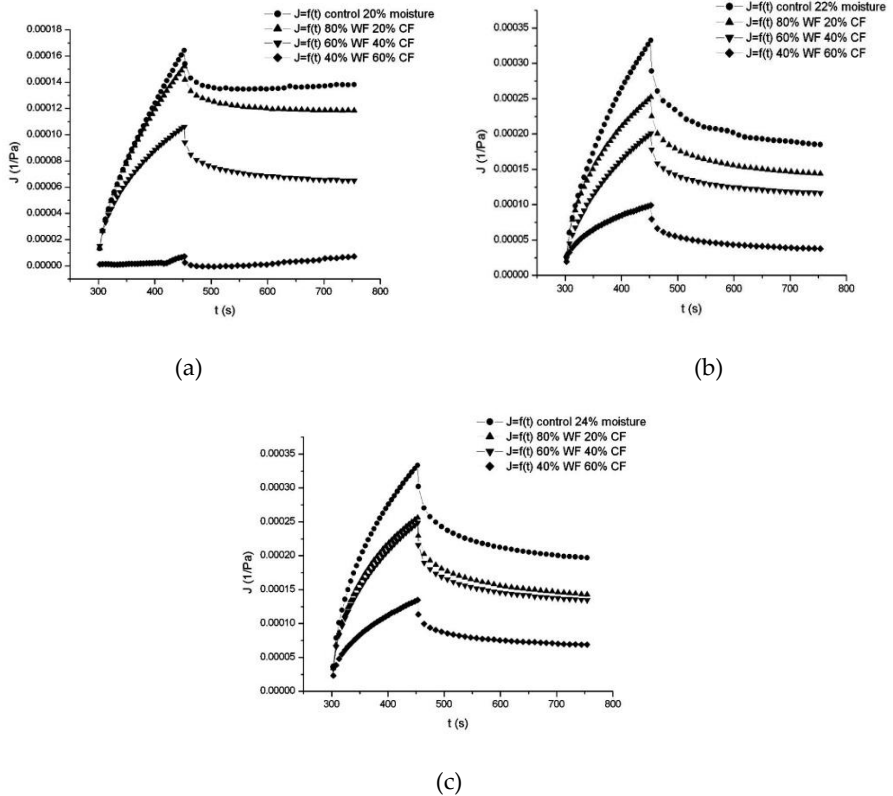


Figure 2. Creep and recovery curves of dough samples

Creep and recovery curves (Figure 2 a, b and c) show the characteristic viscoelastic behaviour of the dough, with some ability to recovery and partial return to initial state after stress exposure. From the Figure 2a (dough samples containing 20% of water), can be seen that sample with 20% CF has the most similar consistency to the control sample. Creep and recovery curves of these samples with 40% and 60% of CF are significantly lower, which means that these samples have less flexible structure to the stress influence.

The influence of CF on viscoelastic properties of the dough samples containing 22% of water is shown at Figure 2b. The flexibility of the dough decreases with increasing levels of CF. Also, it is evident that there is smaller difference between sample with 60% CF and control sample. Creep and recovery curves of the dough samples containing 24% of water are shown at Figure 2c. As with previous samples it is evident that the control sample has the most flexible consistency, which is a consequence of the largest amounts of the gluten in the dough. Increasing the amount of chestnut flour in the dough contributes to lower connection and brittle consistency. As water content of the dough increase, the resistance that dough provides to the application of force decreases and possibility of recovery increase.

Textural characteristics of Dough

The results of extensibility and resistance to extension and hardness of the dough samples with the addition of CF and different content of water are given in Table 1. At all samples with increasing content of CF extensibility of the dough decreases, which is a consequence of reduced gluten content. Resistance to extension decreases, too. As water content in the dough increases, values of these parameters increase. It is because extensibility and resistance to extension depend on the gluten content and quality and on the content of starch in the dough. Starch granules bind a portion of water, which contributed to the increase dough resistance with increasing its content. The effects of substitution wheat flour with chestnut flour on the physical characteristics of the dough are expressed at samples with high content of chestnut flour (40% and 60%) which resulted in the impossibility of registering the characteristic curves of extensibility. Absence of measurement for these samples can be consequence of reducing gluten content in the dough and higher content of saccharose in the CF which intensifies interaction saccharose-starch.

The increasing water content in dough samples, as expected, contributes to the decreasing of dough hardness. The hardness of the dough samples without CF is higher compared to samples with CF addition at all water content. CF affects on reducing dough connection, since substitution wheat flour with CF contributes to reducing gluten content. Starch granules need a sufficient amount of water for hydrating, which is not case at the dough samples containing 20 % of water, so the hardness of these samples increases. Higher hardness value has the dough sample containing 60% of CF and 20% of water, which is consistent with published data. Demirkesen et. al. [10] indicated that chestnut flour has the higher ability of water absorption due to the presence of dietary

fibre, which hydroxyl groups bind water molecules and reducing the amount of free water in the dough.

Table 1. Textural characteristics of dough samples

Sample	Extensibility (mm)	Resistance to extension (g)	Hardness (g)
<i>Dough with 20% moisture</i>			
Control	3.51±0.36	15.67±0.89	236.05±20.23
80% WF 20% CF	2.84±0.41	13.94±1.34	171.55±8.34
60% WF 40% CF	2.62±0.41	12.32±0.92	181.35±12.6
40% WF 60% CF	n.d.	n.d.	229.85±8.94
<i>Dough with 22% moisture</i>			
Control	8.01±0.72	15.58±0.53	130.21±5.05
80% WF 20% CF	6.22±1.1	14.32±1.55	106.55±4.32
60% WF 40% CF	4.15±1.07	10.05±1.34	86.65±4.05
40% WF 60% CF	n.d.	n.d.	90.33±6.02
<i>Dough with 22% moisture</i>			
Control	11.38±0.78	19.16±0.54	86.52±4.92
80% WF 20% CF	7.83±0.6	14.02±0.71	76.69±2.99
60% WF 40% CF	7.82±8.88	10.41±3.91	75.92±2.0
40% WF 60% CF	n.d.	n.d.	69.02±4.38

CONCLUSION

For all samples, as expected, dominated elastic module over the viscous, which is characteristic for dough as viscoelastic system with the dominant elastic component. The addition of CF increases elasticity of the dough as a result of a higher degree absorption and retention of water by chestnut starch granules. Creep and recovery curves show that the control samples have the more flexible consistency compared with the samples with CF addition. Increasing the amount of CF in the dough contributes to lower connection and brittle consistency. As water content of the dough increase, the resistance that dough provides to the application of force decreases and possibility of recovery increase. The increasing amount of CF contributes to decreasing the dough extensibility and resistance to extension, which is a consequence of reduced gluten content. The hardness of the dough increases as CF content increases.

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