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Effects of Chestnut Flour on Staling Characteristics of Gluten-Free Breads

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Abstract. The effects of chestnut flour and a xanthan-guar gum blend-DATEM mixture on staling of gluten-free rice breads were studied. Staling properties of the bread were assessed using moisture loss, retrogradation enthalpy and mass crystallinity values. Moisture loss, retrogradation enthalpy and total mass crystallinity values for all bread samples increased significantly during storage. The replacement of rice flour with chestnut flour and the addition of xanthan-guar gum-DATEM mixture in formulations delayed staling of gluten-free breads significantly by decreasing moisture loss, retrogradation enthalpy, and total mass crystallinity.

Keywords: Chestnut flour, gluten-free, bread staling, xanthan, guar gum, datem

1. Introduction

Various components in bread dough undergo complicated changes during bread making, which makes staling an extremely complex phenomenon to describe [1]. Gluten forms a viscoelastic network that is responsible for slowing down the movement of water and retaining gas produced from yeast fermentation during baking. Therefore, gluten-free breads have low volume, poor texture and flavor and stale faster. Chestnut flour has high-quality proteins with essential amino acids (4–7%), relatively high amount of sugar (20–32%), starch (50–60%), dietary fibre (4–10%) and low amount of fat (2–4%). It also includes vitamin E, B group vitamins, potassium, phosphorous and magnesium [2]. Different techniques such as rheological techniques, differential scanning calorimetry (DSC) and X-ray diffractometry can be used to understand the staling phenomenon. The objective of this study was to investigate the influence of replacement of 30% rice flour with chestnut flour and the effects of addition of xanthan-guar gum blend-DATEM mixture on staling characteristics of gluten-free breads.

2. Materials and Methods

2.1. Dough preparation and baking

The basic dough recipe on a 100 g flour basis was 8% sugar, 8% shortening, 1% instant yeast, and 2% salt. Bread formulations were prepared from rice flour and by 30% replacement of rice flour with chestnut flour. On flour basis, the amount of added water in different formulations varied between 150%-173%. Xanthan–guar gum blend was prepared by mixing equal amount of each gum and the gum blend and emulsifier DATEM were added as 0.5% (w/w) of flour amount. Dough was fermented in an incubator at 30℃ for 40 min and four gluten-free dough samples (100 g each) were baked in a conventional oven

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(Arçelik A. Ş., İstanbul, Turkey) at 200°C for 25 min. Bread prepared using only rice flour without xanthan-guar gum blend-DATEM mixture addition was used as control

2.2. Analysis of bread

For analysis, breads were allowed to cool down for 1 h; then covered with a stretch film, and kept in a plastic bag at 22 ± 2 ℃. During storage for different times (1, 24, 48, 72, and 96 h) moisture loss, DSC, X-ray diffraction analyses were performed. For DSC and X-ray measurements, gluten-free bread samples, which were stored at different times, were frozen at -80 ℃ (Beko, 7103 DF, Istanbul, Turkey) and then freeze-dried (Christ, Alpha 1-2 LD plus, Germany) for 48 h at a pressure below 1 mbar. Samples were ground in a coffee grinder (Sinbo, SCM-2909, Istanbul, Turkey) and sieved through a 212-μm screen. The moisture content of bread crumb samples was determined by drying bread samples in an oven at 105 ℃ until constant weight was obtained. DSC (TA Q20 model from TA Instruments, New Castle, DE, USA) was used to measure the retrogradation enthalpies of breads. X-ray diffraction analysis was done using CuKa (λ=1.54056) radiation on a D8 Focus X-ray diffractometer (Bruker, USA) at 40 kV and 40 mA.

3. Results and Discussion

Moisture contents, retrogradation enthalpies (ΔH_r) and the total mass crystallinity grades were significantly affected by both storage time and formulations ($p \leq 0.05$). Significantly higher moisture contents were obtained in breads containing chestnut flour and xanthan-guar gum blend-DATEM mixture (Table 1). This may be due to higher water binding ability of chestnut flour and xanthan-guar gum blend-DATEM mixture [2]. Replacement of rice flour with chestnut flour and addition of xanthan-guar gum blend-DATEM mixture significantly reduced the retrogradation enthalpies of the amylopectin during storage ($p \leq 0.05$) meaning that staling was retarded (Table 1). Chestnut flour has higher fiber content and presence of fiber and hydrophilic additives bind available water for gelatinization of starch granules and force them to melt at higher temperatures. Such a diluting effect of gelatinized starch may also decrease availability of starch for crystallization and modify the structure of the formed crystals [3]. In addition, the replacement of rice flour with chestnut flour decreased the total starch content in the sample. The formation of a gel structure due to starch retrogradation could be related to the development of crystallites by the inter chain association of the amylose and amylopectin fractions.

As illustrated in Table 1, higher crystallinity values were observed in breads stored for longer periods. The lowest crystallinity values were obtained in gluten-free breads prepared with the chestnut flour and xanthan-guar gum blend-DATEM mixture. Due to their hydrophilic nature, gums like xanthan and guar gum have the ability to bind water that prevent water loss during storage and decrease the effective water content associated to starch, which is needed for amylopectin recrystallization. DATEM was reported to have anti-staling effect on breads [1]. The retarding mechanism of DATEM might be related to their anti-firming ability due to their effect on cell wall thickness and elasticity of breads. In addition, the formation of a complex between amylose and DATEM may interfere with crystallization of the amylopectin and/or may retard water distribution, hence retrogradation [4]. Therefore, the observed decreases in total mass crystallinity values of bread samples with the addition of xanthan-guar gum blend-DATEM mixture may be related to the decrease in the interaction of starch fractions. In the presence of chestnut flour, starch retrogradation might be delayed as result of the possible hydrogen binding between fiber and starch, which decrease the availability of organized starch for crystallization. Furthermore, the starch content of rice flour (79.9% in flour basis) was higher than that of chestnut flour (47.8% in flour basis), therefore the replacement of rice flour with chestnut flour decreased the total starch content in the sample, hence probably the amylose content of breads. In high-amylose starches, the amylose fraction has been indicated to have synergetic effects on the amylopectin retrogradation [5]. In the literature, it was also indicated that the incorporation of even small amounts of flour, which had no amylose content, decreased starch retrogradation of rice breads [6]. Consequently, breads prepared with chestnut flour had lower retrogradation and staling tendency due to their higher of fiber and lower starch content.

RB: Rice bread, RB-X-G-E: Rice bread containing xanthan-guar gum blend-DATEM mixture, CRB: Chestnut-rice bread, which was prepared by replacement of 30% of rice flour with chestnut flour, CRB-X-G-

E: Chestnut-rice bread which was prepared by replacement of 30% of rice flour with chestnut flour and containing xanthan-guar gum blend-DATEM mixture

Table 1: Moisture content, retrogradation enthalpies (ΔHr) and the total mass crystallinity grades of gluten-free bread formulations at different storage times.

Time (h)	Bread Type	Moisture content (%)	ΔH_r (J/g)	Total mass crystallinity grade
1	RB	47.5±0.12	-	0.24±0.003
	RB-X-G-E	49.5±0.13	-	0.20±0.005
	CRB	52.3±0.14	-	0.21±0.007
	CRB-X-G-E	54.7±0.13	-	0.19±0.001
24	RB	45.7±0.14	2.02±0.08	0.25±0.005
	RB-X-G-E	47.8±0.19	1.14±0.02	0.21±0.007
	CRB	48.0±0.12	1.24±0.03	0.22±0.004
	CRB-X-G-E	51.3±0.09	0.99±0.35	0.19±0.006
48	RB	44.1±0.17	2.60±0.14	0.26±0.007
	RB-X-G-E	46.6±0.16	1.53±0.08	0.22±0.004
	CRB	47.4±0.10	1.81±0.11	0.23±0.005
	CRB-X-G-E	49.9±0.11	1.27±0.05	0.20±0.013
72	RB	43.6±0.14	2.88±0.11	0.26±0.008
	RB-X-G-E	46.1±0.10	1.76±0.08	0.24±0.005
	CRB	46.7±0.13	1.93±0.10	0.25±0.001
	CRB-X-G-E	49.2±0.14	1.56±0.11	0.23±0.009
96	RB	43.4±0.12	3.02±0.21	0.28±0.009
	RB-X-G-E	45.9±0.08	2.06±0.16	0.25±0.001
	CRB	46.5±0.17	2.11±0.14	0.25±0.006
	CRB-X-G-E	48.9±0.12	1.63±0.08	0.24±0.001

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5. Conclusions

The presence of chestnut flour retarded staling of breads. Furthermore, addition of xanthan-guar gum blend-DATEM mixture decreased moisture loss, retrogradation enthalpy, and total mass crystallinity of gluten-free bread samples significantly. Thus, the usage of chestnut flour and xanthan-guar gum blend-DATEM mixture can be recommended to be used in gluten-free bread formulations.

6. References

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