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Effects of buckwheat flour combining phospholipase or DATEM on dough properties

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Abstract

Buckwheat is a highly nutritious pseudocereal whose seeds contain starch, protein, lipids and many valuable compounds such as mineral salts, vitamins, dietary fibre and many antioxidants. Asia originated buckwheat (*Fagopyrum esculentum* Moench) belongs to the family of Polygonaceae and is also recognized as a functional food. Buckwheat is a gluten-free pseudocereal and that can lead to a solution for celiac disease patients and their diet. Beside its functional properties buckwheat can also be used to produce bread. Dough stability, fine regular crumb structure, consistent bread volume and prolonged shelf life are essential for the baking industry, and emulsifiers can provide these properties. Emulsifiers stabilize air bubbles in the dough leading to larger bread volume. Enzymes such as phospholipase are recognized as a substitute for emulsifiers as hydrolyzing lipids. On the other hand buckwheat flour addition or usage can cause deterioration on dough characteristics. Farinograph and extensograph were used to identify dough properties. In this study we tried to determine the effects of buckwheat flour (BWF), buckwheat flour-DATEM and buckwheat flour-phospholipase (PLC) on the structure and quality of dough. Due to farinograph and extensograph data, especially water absorption and stability values, it is clear that DATEM and phospholipase improved dough quality. Buckwheat flour addition up to 40% increased water absorption values and reduced dough stability. DATEM and phospholipase addition provided improvements despite buckwheat flour addition, but buckwheat flour made more dominant effects in BWF including formulations. All these data show that usage of buckwheat flour reduces dough quality, but emulsifiers improve it.

Key words: Buckwheat, DATEM, phospholipase, dough, emulsifier, water absorption, stability, extensograph, farinograph, enzyme.

Introduction

Buckwheat (*Fagopyrum esculentum* Moench) is recognized a functional food in some countries, such as China, Japan and Taiwan [1]. Buckwheat belongs to the family of Polygonaceae, which originated in China; buckwheat is a highly nutritious pseudocereal whose seeds contain starch (65-75%), protein (10-12.5%), lipids (4.7%) and many valuable compounds such as mineral salts (K, P, Zn, Mg), vitamins B1 and B2 [2, 3] dietary fibre and many anti-oxidants[4].

Buckwheat proteins are rich in globulin and albumin but very low in glutelin and prolamin content [5]. Buckwheat is a gluten-free pseudocereal [6] and therefore a candidate to enter the diet for celiac patients; unless they show a specific intolerance to buckwheat seed protein (celiac disease is indeed sometimes accompanied by other adverse reactions). Buckwheat flour (BWF) is widely used to make buckwheat noodles in Asian and European countries but can also be blended with wheat to produce bread [7-9].

The baking industry needs consistent product quality, increased dough stability, fine regular crumb structure, consistent bread volume and prolonged shelf life. Emulsifiers stabilize air bubbles in the dough leading to larger bread volume and make complexes with gelatinized starch, thus reducing retrogradation and maintaining a soft crumb, which extends shelf life [10]. In a process for producing bread, emulsifiers (e.g. diactyltartaric acid esters of mono and diacylglycerols, DATEM) and enzymes (e.g. amylases, phospholipases) are used to improve dough properties and bread shelf life. The anionic oil in water emulsifier DATEM improves the handling properties of wheat dough and increases the volume of bread. The use of emulsifiers can totally or partially be replaced by the use of phospholipases (PLCs), which generate natural emulsifiers by hydrolyzing the lipids in the dough. The phospholipases (EC 3.1.4.4.) are a complex and crucially important group of enzymes that plays crucial roles in bread making. Phospholipase activities were shown to provide good emulsification in the dough [11-16].

The objective of this study was to evaluate the influence of buckwheat flour on dough quality made with wheat flour partially replaced by BWF, BWF-DATEM or BWF-phospholipase.

Materials and Methods

Materials and chemicals: Commercial wheat flour and buckwheat flour were obtained in Turkey. Buckwheat flour was obtained by milling whole grains. Phospholipase-PLC (Lipopan FBG) was introduced by Novo Nordisk A/S and DATEM (Admul™ DATEM

1982) was ensured by Quest International, Zwijndrecht, The Netherlands. Leaven and L-ascorbic acid were also commercial products ensured in Turkey. The kneading machine, which has 1 kg flour capacity, was a Diosna type and ensured by Güneş Makina.

Analysis methods: The moisture (AOAC method 44-01), ash (AOAC method 08-01), wet and dry gluten content (AOAC Method 38-10), sedimentation value (AOAC Method 56-60), falling number value (AOAC Method 56-81B), farinograph value (AOAC Method 54-21) and extensograph value (AOAC Method 54-10) analysis were made in wheat flour according to AOAC methods [17]. Farinograph and extensograph values were determined for wheat flour-buckwheat flour mixes. Buckwheat flour was used at 0.1 g/kg, up to 40%, in addition to phospholipase and otherwise DATEM was used at 2.5 g/kg in dough samples.

Results

The properties of the wheat flour used in making sample dough are given in Table 1. According to sedimentation values, the flour was of high quality. Also, a delayed sedimentation value confirms that the wheat crop was not damaged by the suni bug. The gluten content value was very good, but the falling number values showed that the flour had low amylase activity.

The farinograph data of wheat flour-BWF mixes used in the experiments are given in Table 2. It is clear that the development time is more than eight minutes in all formulations. The addition of buckwheat flour increased water absorption and the degree of softening; on the other hand it decreased stability. As can be clearly seen in Table 2, the 40% buckwheat flour addition significantly increased development time.

According to extensograph data in Table 3, the buckwheat flour addition caused a reduction in extensibility. A significant decrease in energy values was determined. This confirms that the addition of buckwheat flour in formulations caused a reduction in the gas holding capacity of the dough.

In buckwheat flour-containing dough samples, usage of phospholipase and DATEM significantly reduced water absorption values and it is evident that phospholipase is more effective than DATEM (Tables 4 and 5). Both additives reduced development time, but phospholipase caused additional negative effects on dough stability. The highest degree of softening values was in the 40% buckwheat flour and 30% DATEM concluding samples.

According to extensogram parameters, the worst quality was determined in samples containing 40% buckwheat flour and phospholipase. The results for these samples showed the lowest resistance, extensibility and energy values. In samples containing 40% buckwheat; additives caused reduced R_{50} values. This reduction was greater in phospholipase-added samples than in DATEM-added samples. The usage of additives did not have significant effects on energy values except for samples containing 40% buckwheat. The data demonstrate that the addition of buckwheat flour to formulations causes deterioration in dough quality.

Table 1. Properties of wheat flour used in wheat-buckwheat flour mixes.

Sample	Moisture (%)	Sedimentation (ml)	Delayed sedimentation (ml)	Wet gluten (%)	Dry gluten (%)	Falling number (sn)
Wheat flour	14.5±0.1	33.3±0.6	36.3±0.6	29±0.3	10.1±0.1	397±7

Table 2. Wheat-buckwheat flour mixes and their farinograph data.

Buckwheat flour ratio (%)	Water absorption (%)	Development time (d)	Stability (d)	Mixing tolerance index (B.U.)	Degree of softening (B.U.)
0 (Control)	58.7	11.0	13.2	66	90
10	70.1	8.0	8.0	65	110
20	81.5	10.1	7.3	82	133
30	87.8	10.6	5.8	55	140
40	91.0	18.2	5.1	60	200

Table 3. Wheat-buckwheat flour mixes and their extensograph data.

Buckwheat flour ratio (%)	Max. resistance R_m (B.U.)[1]	Resistance R_{50} (B.U.)[2]	Extensibility (mm)	Energy (cm^2)	Ratio (B.U./mm)
0 (Control)	479	352	163	115	2.94
10	334	283	144	73	2.32
20	257	244	117	46	2.21
30	235	232	86	30	2.75
40	251	243	64	25	3.95

[1] Maximum resistance to extension.
[2] Resistance to extension.

Table 4. Effect of phospholipase (PLC) and DATEM addition to wheat-buckwheat flour mixes to farinograph values.

Buckwheat flour (%)	Additive	Water absorption (%)	Development time (d)	Stability (d)	Mixing tolerance index (B.U.)	Degree of softening (B.U.)
0 (control)	No Additive	58.7	11.0	13.2	66	90
10		70.1	8.0	8.0	65	110
20		81.5	10.1	7.3	82	133
30		87.8	10.6	5.8	55	140
40		91.0	18.2	5.1	60	200
0	DATEM	59.0	1.8	11.6	66	51
10		69.7	2.2	5.6	55	167
20		74.0	5.6	7.1	55	210
30		78.2	9.1	6.2	125	258
40		79.8	9.9	9.7	120	255
0	PLC	59.2	1.7	3.4	65	98
10		66.2	2.3	5.2	47	138
20		73.0	3.9	6.7	25	184
30		76.1	6.5	6.9	72	228
40		77.1	9.5	8.4	134	270

Table 5. Effect of phospholipase (PLC) and DATEM addition to wheat-buckwheat flour mixes to extensograph values.

Buckwheat flour (%)	Additive	Max. resistance R_m (B.U.)	Resistance R_{50} (B.U.) [(1)]	Extensibility (mm)	Energy (cm^2)	Ratio (B.U./mm)
0 (control)	No additive	479	352	163	115	2.94
10		334	283	144	73	2.32
20		257	244	117	46	2.21
30		235	232	86	30	2.75
40		251	243	64	25	3.95
0	DATEM	743	604	121	113	6.13
10		447	394	110	67	4.08
20		351	345	95	47	3.78
30		238	242	75	25	3.19
40		221	148	59	20	3.76
0	PLC	518	550	128	112	4.06
10		409	365	115	66	3.56
20		332	326	97	47	3.48
30		241	179	60	22	4.05
40		198	101	47	15	4.26

Conclusions

In this study, it can be clearly seen that the buckwheat flour addition not only increased the dough's water absorption and development time, but also decreased dough stability. On the other hand, buckwheat flour reduced the extensograph values of the dough and increased extensibility, maximal resistance to extension and energy values. The farinograph and extensograph data confirm that the buckwheat addition to formulations damages dough quality. However, emulsifier additive usage can provide limited improvement and these improvements are mostly seen in formulations without buckwheat. Depending on the addition of buckwheat flour, the benefits of additives are also reduced. Phospholipase had positive effects on water absorption values, while it had negative effects on stability values.

This study showed that phospholipase and DATEM additions can make improvements to flour quality, but buckwheat flour is more dominant and its effect shades the positive interactions of the other additives. The findings of this analysis confirm that the addition of buckwheat flour damages dough quality and structure and usage of emulsifiers can improve this to limited effect.

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