

The effect of some additives on the rheology of dough and quality of bread

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Abstract: The technology of production of baking products today can not be imagined without the use of food additives. In this research it was aimed to investigate the use of some additives in wheat flour type 500 for bread production. The formulations and additives used in this study are: without additives for M0, emulsifiers (E 472e) for M1, calcium phosphate (E341 ii) for M2, L-ascorbic acid (E300) for M3 and Damil additive complex (antifouling E170 - 0.06 %; emulsifier E472e -0.08 %; antioxidant E300 -0.01 %; fungal α -amylase - 0.01 %) for M4 formulation. The results showed that the use of additives positively affects some rheological qualities such as water absorption capacity, stability and energy of the dough. M4 bread had a higher specific volume than all breads with $5.14 \text{ cm}^3 \text{ g}^{-1}$, while M1 and M3 breads were similar. From the total points accumulated for the sensory qualities the M4 bread with a total of 88.8 points accumulated had the best qualities with volume, external appearance and very good crust and crumb taste. It is therefore recommended to use the Damil additive complex in bread production.

Key words: additives; wheat flour; rheological characteristics; specific volume of bread

Učinki nekaterih dodatkov na reološke lastnosti testa in kakovost kruha

Izvleček: Tehnologije proizvodnje pekovskih izdelkov si ne moremo predstavljati brez uporabe aditivov za živila. V članku so predstavljeni rezultati raziskave, kakšna je uporabnost dodatkov pšenični moki tip 500 za proizvodnjo kruha. V tej študiji smo uporabili naslednje recepture in dodatke: M0 brez dodatkov, M1 emulgator (E 472e), M2 kalcijev fosfat (E341 ii), M3 L-askorbinsko kislino (E300) in M4 dodatek Damil. Rezultati so pokazali, da uporaba dodatkov pozitivno vpliva na nekatere reološke lastnosti, kot so sposobnost vpijanja vode, stabilnost in energija testa. Kruh M4 je imel večji specifični volumen od vseh kruhov s $5,14 \text{ cm}^3 \text{ g}^{-1}$, kruha M1 in M3 pa sta bila podobna. Od skupnih točk za senzorične lastnosti je imel kruh M4 s skupno 88,8 zbranimi točkami najboljše lastnosti za volumen, zunanji videz, zelo dobro skorjo in prijeten okus. Zato je pri proizvodnji kruha priporočljiva uporaba kompleksa aditivov Damil.

Ključne besede: aditivi; pšenična moka; reološke lastnosti; specifična prostornina kruha

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1 INTRODUCTION

Modern technology of production of baking products has enabled the use of ingredients of suitable quality and food additives with different functional properties. The use of food additives in the baking industry has facilitated the control of the technological process, has enabled the extension of shelf life and the maintenance of freshness for a longer period of time (Grujić, 2005). Baking technology plays an important role in the food industry and has increased interest in the use of these products by consumers (Eddy et al., 2007). However today it is impossible to imagine the production of baking products without additives. The addition of additives aims to give bakers the tolerance and flexibility required during the stages of the baking process (Hrušková & Novotná, 2003). It is common practice to use various additives such as emulsifiers, oxidants and enzymes to improve the quality of bread (Nanditha & Prabhasankar, 2009)

However, the technological quality of the flour is one of the main factors when considering which improver should be used. In order for dough improvers to work better, they are in most cases composed of oxidizing agents (Biebaut, 1991; Morita et al., 1960). It has been proven that oxidizing agents such as L-ascorbic acid (E300) will increase the level of water absorption in flour and the strength of the dough from the oxidized sulfhydryl groups (-SH) to the disulfide bond (SS).

Various empirical methods based on classical extensograph instruments, alveograph, farinograph and mixograph are currently used to obtain data on the rheological properties and baking properties of flour (Uthayakumaran et al., 2002; Dobraszczyk & Morgenstern, 2003; Tronsmo et al., 2003; Chiotelli et al., 2004).

Oxidation generally affects the strength and extensibility of the dough. Its effect can be clearly demonstrated by extension tests measured with extensographs (Šimurina et al., 2002). During the baking process to achieve a high quality bread, local producers used as usual additives in order to increase the energy of the

dough, to make the dough more elastic, to increase the volume of the bread, to improve the sensory values and to other purposes.

The purpose of this research was to study the rheological and sensory qualities of bread produced from mixtures of type 500 flour with various additives such as: emulsifiers (E472e), calcium phosphate (E341), L-ascorbic acid (E300) and Damil additive complex (wheat flour, emulsifier E472e -0.08%; antifouling E170 - 0.06%; antioxidant E300 -0.01%; fungal α -amylase - 0.01%).

2 MATERIALS AND METHODS

2.1 MATERIALS

Wheat flour type 500 was used for the production of bread, which was taken from the flour factory "Kokra e Art" - Tetovo, where physico-chemical properties were analyzed. The flour is supplemented with the following mixture of additives: emulsifier (E472e), calcium phosphate (E341 ii), L-ascorbic acid and additive complex "Damil" (wheat flour, antifouling E170 - 0.06 %; emulsifier E472e -0.08 %; antioxidant E300 -0.01 %; fungal α -amylase - 0.01 %) in quantities depending on the use of the additive as shown in Table 1.

Since our country does not meet the demands of consumers for food or bread, we are dependent on wheat imports. With the mixture of imported and local wheat, the technological value of the flour also changes, which also affects the rheological properties of the dough and the quality of the bread. Therefore, due to the variable technological quality of flour, the use of additives has become important to standardize the flour in terms of rheological properties, to increase the volume of bread to improve sensory values and for other purposes.

This experimental design is based on our knowledge from previous research of various authors such as Baratto et al. (2015), Sana & Sinani (2017) and (Hor-

Table 1: Flour samples design with flour type 500 and additives

Samples	Flour T-500 (%)	Emulsifier (E472e) (%)	Calcium phosphate (E341 ii) (%)	L-ascorbic acid (%)	Damil additive mixture (%)
M0	100	-	-	-	-
M1	100	0.3	-	-	-
M2	100	-	0.01	-	-
M3	100	-	-	0.02	-
M4	100	-	-	-	0.02

vat et al., 2007). Considering that previous studies are mainly based on the use of additives separately, the novelty in our study is the use of the complex additive "Damil".

Bread samples are prepared and baked in the bread production company "Deni" -Skopje, based on the amount of flour mixtures of 300 g, additives from 0.02 to 0.30 % according to the table above. The amount of water is according to the absorption of water in the farinograph, while the amount of salt and yeast is 1.80% and 2.80%, respectively. The production of bread is carried out in a standardized way with the direct method where all the ingredients are added to the mixer. The kneading lasted 5 min at medium speed and then separated and given their shape. The dough divided into pieces was placed in the fermentation chamber for 90 minutes at a temperature of 30 °C with 75 % relative humidity and was baked for 25 min at 180 °C in an electric oven. After the breads come out of the oven, they are cooled for 2 hours at room temperature and sent for further evaluation of the quality of the bread.

2.2 METHODS

Evaluation of physico-chemical properties of flour such as: protein content, moisture, ash and wet gluten of flour were performed with the Infratec 1241- FOSS. The device is based on NIR (Near Infra Red) technology and is designed to determine the basic chemical parameters of cereals and flour.

The analysis of the rheological properties of the formulated mixtures of flour and additives was performed in the laboratory of the enterprise "Kokrra e Art" -Tetovo. To determine the rheological characteristics of the mixtures were used 300 g of flour, salt, yeast and additive. The rheological properties of the dough are determined with Farinograph Brabender according to the standard methods of ISO 5530-1 were the instrument measures the dough stability and degree of softening (Dapčević Hadnađev et al., 2011). Extensograph standard methods ISO 5530-2 where used for determination of the physical properties of the dough. The extensibility, resistance and energy of the dough were determined from the curve of the extensogram (Xhabiri & Sinani, 2011; Freund et al., 2006).

Determination of moisture, ash, and energy value of bread was performed by standard methods ISO6492: 1999 (E), ISO5984: 2002, SOP628, SOP200). The sensory qualities of bread such as volume, appearance, aroma and taste of crust and crumb were also analyzed by a 15 member experienced sensory assessors. All the features of the analyzed breads were evaluated with 1-5

points, then the points obtained were multiplied by the coefficient of importance for each feature and the total points were obtained. The specific volume, V_{sp} ($\text{cm}^3 \text{g}^{-1}$) of bread was defined as the ratio of volume and mass of bread, where the mass was determined two hours after baking and cooling, while the volume of bread was determined by the method of removal of grains of millet (Kaluderski & Filipović, 1998).

Statistical analysis was performed using SPSS 16 software. The multiple comparison test and the level of significance of the differences between the treatments were taken into account ($p < 0.05$). All experiments were performed in three replications and the mean values were given together with the standard deviations. Datas were also subjected to statistical analysis (Duncan test - multivariate analysis, at significance level $p < 0.05$).

3 RESULTS AND DISCUSSION

3.1 CHEMICAL COMPOSITION OF FLOUR

The results of physico-chemical composition of flour used in this study are given in Table 2.

Based on the analysis, the moisture content in type 500 flour is $14.00 \pm 0.50\%$ which indicates that the moisture content in type 500 flour is within the maximum allowable limit (Official Gazette of Republic of Macedonia, 2014). The protein content in type 500 flour was $11.80 \pm 0.10\%$ and is approximate to the results of (Abdullahi et.al., 2016). Gluten has an important role in the quality of flour and affects water absorption, viscosity, elongation, elasticity, resistance to deformation, gas holding capacity and hardening properties of dough (Lazarido et al., 2007, Wieser, 2007). The content of wet gluten in t 500 flour was $28.90 \pm 0.20\%$, indicating that the flour is suitable for bread production. The ash content in type 500 flour was $0.55 \pm 0.08\%$, which indicates that only the endosperm part was obtained during processing.

Table 2: Composition of flour

Physico-chemical parameters (%)	(Mean \pm SD)
Moisture	14.00 \pm 0.50
Protein	11.80 \pm 0.10
Ash	0.60 \pm 0.08
Wet gluten	28.90 \pm 0.20

3.2 RHEOLOGICAL PARAMETERS OF THE DOUGH

Farinograph data of type 500 wheat flour with mixtures of additives are presented in Table 3. The results showed the dependence of the mixing of additives with type 500 wheat flour however they were also influenced by the additives that were used. As an important parameter that has the greatest practical value is the absorption of water, which is important in the evaluation of flour (Dapčević Hadnađev et al., 2011). Water absorption was highest in sample M3 with 57.20 ± 1.04 %, while the lowest in sample M1 with 53.90 ± 0.80 % and these differences are significant. From the data of table 3 it can be seen that the control dough M0 has no significant differences in ($p < 0.05$) with M1 and M4, but expresses significant differences with M2 and M3.

The dough development time was much longer in the control dough M0, compared to the formulations with mixture of additives, therefore we have a significant difference ($p < 0.05$). This indicates that the dough development time in type 500 wheat flour without additive increases with increasing proteolytic degradation of proteins (Dua et al., 2009). Regarding the stability of the dough, there is a positive effect of additives in improving the stability of the dough, where samples M3 and M2 had a significant ($p < 0.05$) higher dough stability than the control dough. A positive effect of the addition of additives on the M2 sample was observed at the degree of softening, which had a better rate of

43 ± 1.06 FU. The degree was the same as that of the control M0, and both had a significant difference ($p < 0.05$) from M1, M3 and M4 samples. Although many authors emphasize that gluten is the main ingredient of the dough that affects the rheological qualities (Torbica et al., 2007) as well as increases the volume of baked products (Rakita, 2017). The addition of additives to the flour did not change the qualitative number observed from all samples.

Data from extensograph analyzes are presented in Table 4 which shows that the use of some additives has influenced extensographic parameters. The lowest dough extensibility had M3 dough, while the other doughs had higher extensibility than M0 control dough. Martin et al. (2003) investigated the effect of pentosanase and oxidases on glutenin dough and macropolymer characteristics and reported higher dough extensibility. M1 and M2 dough had lower resistance than M0 control dough, while M3 and M4 dough had higher resistance. The results obtained correspond to those of Ghanbari & Farmani (2013).

The data show that the dough M1 had the same energy as the control dough M0, while in other doughs M2, M3, M4 the energy increased. The results obtained are comparable to those of Horvat et al (2007).

The ideal ratio for bread production should be 1.5-2.5 and in most dough mixtures it is within the allowed limits while the M3 sample had a higher ratio that reaches up to 3.46.

Table 3: Rheological properties of farinograph doughs

Farinograph parameters	M0	M 1	M 2	M 3	M 4
Water absorption (%)	54.50 ± 0.32^a	53.90 ± 0.80^a	56.80 ± 0.24^b	57.20 ± 1.04^b	54.80 ± 0.73^a
Dough development (min)	3.10 ± 0.16^b	1.30 ± 0.04^a	1.25 ± 0.02^a	1.70 ± 0.04^a	1.28 ± 0.02^a
Dough stability (min)	0.90 ± 0.16^a	1.05 ± 0.01^a	4.56 ± 0.07^b	5.10 ± 0.08^b	1.09 ± 0.07^a
Degree of softening (FU)	43.00 ± 1.41^a	52.00 ± 2.16^b	43.00 ± 1.06^a	77.00 ± 1.41^c	54.00 ± 1.34^b
Quality number	71.00 ± 1.01^c	67.00 ± 1.63^b	75.00 ± 0.25^c	80.00 ± 1.63^d	64.00 ± 0.75^a

Different letters in the same order differ significantly, Duncan $p < 0.05$

Table 4: Rheological qualities of doughs with extensograf

Extensograph parameters	M0	M 1	M 2	M 3	M 4
Extensibility (mm)	153.00 ± 2.88^b	165.00 ± 8.96^{bc}	170.00 ± 8.88^c	135.00 ± 9.64^a	156.00 ± 5.51^{bc}
Resistance (EU)	307.00 ± 18.61^a	272.00 ± 16.37^a	269.00 ± 8.51^a	546.00 ± 47.62^b	344.00 ± 39.51^a
Energy (cm ²)	85.60 ± 3.05^a	85.30 ± 12.58^a	88.30 ± 7.64^a	116.00 ± 15.51^b	102.00 ± 3.78^{ab}
Relation R / E	2.03 ± 0.23^a	1.63 ± 0.15^a	1.56 ± 0.15^a	3.46 ± 0.71^b	2.23 ± 0.31^a

Different letters in the same order differ significantly, Duncan $p < 0.05$

3.3 SPECIFIC VOLUME OF BREAD

The specific volume of M4 bread was higher than M0, while the specific volume of M2 bread was lower than the specific volume of M0 ($p < 0.05$). Similar results have been found by Ribotta et al (2010).

3.4 SENSORY PROPERTIES OF THE BREAD TYPES

The quality of bread depends on the quality of the protein in the flour (Lasztity, 2002) therefore high protein content has good effect on bread volume and performance (Pomeranz, 1988).

Based on the organoleptic analyzes performed on the quality of bread mixes with wheat flour type 500 and some additives, it was observed significant improvements in bread mixes compared to control bread M0. Khan et al (2011) had similar results. Improvements are particularly noticeable in the appearance, taste of the crust and crumb. Pomeranz (1988) confirms that all breads made with type-500 flour, with or without additives, have their own characteristic taste and aroma.

Better volume was in M4 and M3 bread rated with 4.8, while other breads have similar points to the control bread M0. This is also confirmed by the results obtained from the extensogram for the energy of the dough. M4 bread has better appearance while others have similar points to M0 control bread. Considering

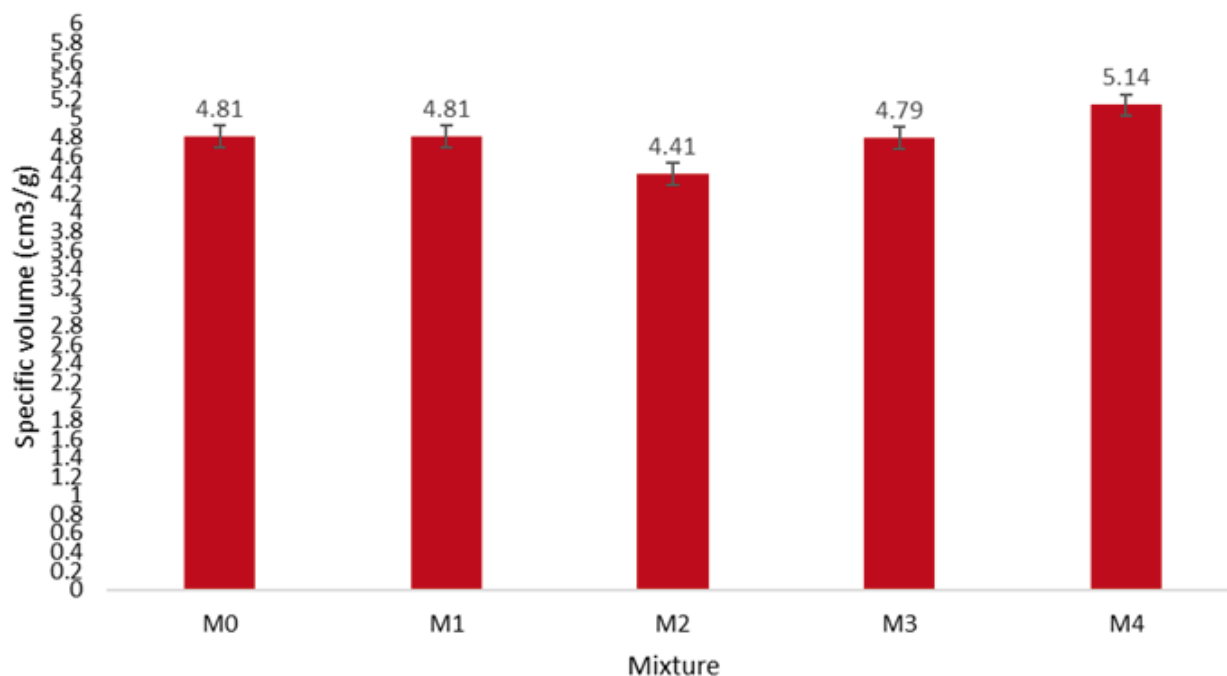


Figure 1: Specific volume ($\text{cm}^3 \text{g}^{-1}$) of bread types

Table 5: Sensory properties of the bread samples

Bread samples	Volume (k = 4)	Exterior (k = 3)	Appearance of the crumb (k = 5)	Aroma of the crust and crumb (k = 3)	Taste of the crust and crumb (k = 5)	Total
M0	4.3	4.3	4.6	4.1	4.3	86.9
M1	4.2	4.4	4.5	4.0	4.5	87.0
M2	4.3	4.3	4.5	4.1	4.5	87.3
M3	4.7	4.4	4.2	4.3	4.3	87.4
M4	4.7	4.5	4.4	4.0	4.5	88.8

k-coefficient of importance

the appearance of the pores created and their size, most breads including control bread M0 have similar points, while bread M3 has fewer points.

The aroma of crust and crumb was generally almost identical to M0 control bread, but M3 bread had a slightly higher. The taste was very similar to all breads, including the control bread. All bread with additives had more accumulated points than control especially the M4 bread had highest points, which corresponds to the findings of Grujić et al (2009).

4 CONCLUSION

The use of additives in wheat flour t-500 for bread production improved some rheological properties such as: water absorption capacity, dough stability and dough energy. M4 bread had shown much higher specific volume than M0 control bread, while M1 and M3 bread had similar specific volume. According to the sensory profile (volume, external appearance as well as better aroma and taste of crust and crumb) the additive containing bread had higher points. Therefore, the use of Damil additive complex (wheat flour, antifouling E170 - 0.06 %; emulsifier E472e -0.08 %; antioxidant E300 -0.01 %; fungal α -amylase - 0.01 %) for the production of bread with type 500 flour may be recommended.

5 ETHICS

The research does not involve human or animal subjects.

6 CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

7 ACKNOWLEDGMENT

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