CAROB FLOUR AND SUGAR BEET FIBER AS FUNCTIONAL ADDITIVES IN BREAD

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The effect of functional additives (carob flour and sugar beet fiber) on empirical rheological dough performance and bread quality was examined. Also the microbiological quality of bread was investigated during 16 days of storage. The study included 5 samples: control (CON), with preservative calcium propionate (CONP), with carob flour (CON-CAR), with sugar beet fiber (CON-SBF) and with a combination of carob flour and sugar beet fibers (CON-SBF-CAR). Samples with functional additives had a higher water holding capacity (2-10%) and extended dough development time due to the presence of dietary fiber. Dough resistance of these samples was significantly increased, especially in CON-CAR, in which the time of final fermentation is remarkably prolonged (20% in comparison to CON). The addition of the functional ingredients (due to hydration properties of dietary fiber) improved texture and sensory characteristics of bread. In sample CON-SBF crumb firmness was significantly reduced (by 70%) while elasticity was increased by 25% compared to CON. Positive effect of addition of sugar beet fiber was proved by improving the elasticity of the crumb and finer crumb structure (sample CON-SBF) in comparison with the addition of carob flour (sample CON-CAR). In bread sample with carob flour there was no microbiological contamination for 16 days of examination, which confirms the fact that carob flour can be used as a natural preservative.

KEY WORDS: carob flour, sugar beet fiber, bread quality, sensory properties, microbiological quality

INTRODUCTION

Functional foods are defined as those that have a positive physiological effect on human organism and in addition to the basic building function contribute to reducing the risk of diseases. For a long time, nutritionists have emphasized the importance of dietary fiber in achieving, maintaining and improving the health of people considering the deficiencies in the diet in highly developed countries (1). Bread is a component of daily nutrition in which by modification of raw material composition can be successfully adjusted

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to the deficit of nutrients and biologically valuable components. Presence of dietary fiber in bread enhances its nutritional and reduces its energy value. However, the addition of fiber causes a change in the rheological properties of dough and bread quality parameters (2). Earlier studies have shown that the addition of fiber generally leads to a decrease in volume of loaves, the result is a product with denser, less airy structure, firmer and darker crumb appearance. The influence of fiber on the quality of bread depends on the type (3, 4, 5), size, and amount of fiber (2).

The extracted sugar beet pulp produced during the technological processing of sugar beet is an excellent source of soluble and insoluble fiber (6). They are characterized by high water holding capacity, which is especially desirable in baking industry (7).

Carob (*Ceratonia siliqua* L.) belongs to the family of legumes and is widespread in the Mediterranean area (8). Carob seed pod has a high content of polyphenols with antioxidant properties (9). In addition, carob flour is rich in insoluble dietary fibers which take part in cholesterol lowering in animals (10) and in humans (11). Carob fiber is also an important raw material in the preparation of functional bakery products considering its chemical composition (4).

The aim of this study was to investigate the effect of addition of fiber from sugar beet and carob flour to the rheological properties of dough and bread quality, as well as their impact on the microbiological quality of the bread.

**EXPERIMENTAL**

**Materials**

Commercial wheat flour having moisture 13.3%, protein 11.1%, starch 79.9%, sugar 3.1%, fat 1.1%, total dietary fiber 3.1% and ash 0.46% was supplied by a local flour mill AD Danubius (Novi Sad, Serbia).

Commercial preservative calcium propionate - E282 (Propi San, PURATOS, Belgium) and commercial carob flour (MALINA IMPEX, Valjevo) were used. Sugar beet fibers were prepared according to Šoronja Simović et.al, 2010 (12).

**Methods**

The moisture, ash, fat, starch, reducing and total sugar content of wheat flour were determined according to methods described in AOAC, 2000 (13). Wheat flour was analyzed for gluten content according to standard AACC procedures (14). Total dietary fiber content was determined according to the AOAC method.

The empirical rheological properties of dough were determined by Brabender farinograph (Brabender SEW, Duisberg, Germany) according to AACC method (15). Extensibility of the dough and its resistance were determined according to the AACC method by Brabender extensograph (Brabender EXEK/7, Duisberg, Germany) (16).

Bread was baked according to the AACC method (17). The dough samples were prepared according to the following dough formula: wheat flour (100-80%), salt (1%), sugar
(5%), yeast (2%), milk powder (2.5%) and bakery fat (5%). Five bread samples were used in examination and they were defined by the content of ingredients (Table 1):

Table 1. The content of additives in bread samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carob (%)</th>
<th>Sugar beet fiber (%)</th>
<th>Preservative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CONP</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>CON-CAR</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CON-SBF</td>
<td>0</td>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>CON-SBF-CAR</td>
<td>10</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

CON – control, CONP – with preservative, CON-CAR – with carob flour, CON-SBF – with sugar beet fiber, CON-SBF-CAR – with sugar beet fiber and carob flour

All the ingredients were added to the mixer (MS-6). And then an optimal amount of water obtained from farinograph absorption, i.e. to 500 BU (49.5 – 60.0%) was added into mixing bowl and mixed for 4 minutes at a speed of 450 of rpm.

The dough was placed into a fermentation chamber at 30°C for 60 minutes. The dough was then divided into three pieces of 350 g, and rounded to rest for 10 min. Afterwards samples were placed into the baking pans for proofing (50 min at 30°C and 85% RH). Baking was carried out at 250°C. The baking process was done when the bread lost 10% of its weight. The loaves were cooled to room temperature. The quality of bread was characterized by bread volume and crumb quality 24h after baking.

Bread volume was measured by the rapeseed displacement method (18). Crumb quality was evaluated by five experienced panelists.

Texture profile analysis (TPA) was performed using a TA-XT2i texturometer (Stable Microsystems, Surrey, UK) equipped with a 2.5 cm probe. Crumb slices of 2 cm were 50% compressed. Four replicates from two different sets of baking were analyzed and averaged. The recorded parameters were firmness and springiness.

The selected samples were tested on the 4, 8, 12 and 16th day after the baking. Dichloran Rose-Bengal Chloramphenicol Agar (DRBC) was used to detect molds and yeasts. The level of contamination was set by following formula:

$$\text{LC} = \frac{D^2}{R^2}$$  \[1\]

where, LC represents level of contamination, D is diameter of colonies grown on petri-dish and R refers to diameter of petridish, as colony forming units were unable to count. The level of contamination was set by % of covered petri dish plate. The borders of low, medium and high contamination were set artificially. The corresponding intervals were used in order to present the obtained results in a concise and comparable form for easier understanding of differences between the samples.
RESULTS AND DISCUSSION

Based on the results of rheological examination it can be seen that the addition of preservatives (sample CONP) did not significantly affect the tested rheological parameters. By adding 20% carob flour (sample CON-CAR) produced changes in all tested parameters. The water absorption was slightly increased, while the dough development was extended four times compared to the control sample (Figure 1). Farinograph data clearly show that the addition of sugar beet fiber (sample CON-SBF) affected hydration of the particles during the mixing, which confirms the long dough development (10 min). The above-mentioned parameter in CON-SBF sample is 5 times higher than that in control sample, and compared with CON-CAR up 20%. Increased water absorption by 8% (compared to the samples CON and CONP), or about 5% compared to the CON-CAR confirms that dietary fiber has a high water holding capacity (19).

Figure 1. Effect of carob flour and sugar beet fiber on water absorption and dough development time

The changes of extensograph parameters in the sample CON-CAR were significant because there was an increase in energy for about 35% and resistance to extension by 70% (Table 2). The decrease of dough extensibility up to 40% caused the increase in the Ratio number of samples 3.5 (CON) and 3.3 (CONP) to as much as 10.2. These changes in the rheology parameters can be explained by the interactions between carob fiber and proteins with wheat gluten (20). Minor changes were observed in sample CON-SBF. The energy increased by 25%, also the resistance was higher by about 30% compared to the control sample, while it was by 15% lower compared with CON-CAR. The extensibility of the dough was, as well as of the sample CON-CAR, decreased up to 30%. The highest resistance and lowest extensibility was determined in CON-SBF-CAR, so that Ratio number for this sample increased by as much as 70%.
Table 2. Results of extensograph examination

<table>
<thead>
<tr>
<th>Sample</th>
<th>Energy (cm²)</th>
<th>Resistance (Ej)</th>
<th>Extensibility (mm)</th>
<th>O/R*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>142.9</td>
<td>530</td>
<td>152</td>
<td>3.5</td>
</tr>
<tr>
<td>CONP</td>
<td>143.3</td>
<td>520</td>
<td>157</td>
<td>3.3</td>
</tr>
<tr>
<td>CON-CAR</td>
<td>196.4</td>
<td>920</td>
<td>90</td>
<td>10.2</td>
</tr>
<tr>
<td>CON-SBF</td>
<td>171.9</td>
<td>770</td>
<td>102</td>
<td>7.5</td>
</tr>
<tr>
<td>CON-SBF-CAR</td>
<td>183.6</td>
<td>1080</td>
<td>84</td>
<td>12.9</td>
</tr>
</tbody>
</table>

*O/R – ration number of resistance and extensibility
CON – control, CONP – with preservative, CON-CAR – with carob flour, CON-SBF – with sugar beet fiber, CON-SBF-CAR – with sugar beet fiber and carob flour

The maturograph parameters (Table 3) indicate that the addition of carob flour had a pronounced effect on the ability of dough to retain the gases during fermentation. Sample CON-CAR has lower resistance of dough up to 30% and elasticity by 25%, indicating reduced ability to retain created gas. The assumption mentioned is confirmed by the longer final fermentation time by as much as 20% compared to the CON. On the other hand, it can be noticed that the addition of fiber from sugar beet caused a slight increase in dough resistance, as well as a decrease in elasticity. The impact of carob flour, as well as sugar beet fiber, was observed in the sample CON-SBF-CAR, which is confirmed by the lower value of the dough resistance by about 7.5%, and a decline in elasticity by 30%.

Table 3. Results of maturograph examination

<table>
<thead>
<tr>
<th>Sample</th>
<th>Final fermentation time (min)</th>
<th>Stability of fermentation (min)</th>
<th>Dough resistance (Mj)</th>
<th>Dough elasticity (Mj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>68</td>
<td>6</td>
<td>665</td>
<td>270</td>
</tr>
<tr>
<td>CONP</td>
<td>70</td>
<td>2</td>
<td>625</td>
<td>250</td>
</tr>
<tr>
<td>CON-CAR</td>
<td>88</td>
<td>8</td>
<td>460</td>
<td>200</td>
</tr>
<tr>
<td>CON-SBF</td>
<td>69</td>
<td>2</td>
<td>720</td>
<td>220</td>
</tr>
<tr>
<td>CON-SBF-CAR</td>
<td>77</td>
<td>8</td>
<td>615</td>
<td>190</td>
</tr>
</tbody>
</table>

CON – control, CONP – with preservative, CON-CAR – with carob flour, CON-SBF – with sugar beet fiber, CON-SBF-CAR – with sugar beet fiber and carob flour

On the basis of the TPA test, it is evident that the addition of preservatives (sample CONP) did not affect the values of textural parameters of bread. The supplement of carob flour in an amount of 20% (sample CON-CAR) caused an increase in crumb firmness by 10%, while the crumb springiness decreased by 15% compared to the control (CON), which is in accordance to the findings of Salinas et al. (20). On the other hand, the supplementation of sugar beet fiber had an opposite effect on the firmness and springiness of the crumb compared with carob flour. A significant decrease in firmness of the crumb (70% compared to the control bread) was observed by adding sugar beet fiber (sample...
CON-SBF), whereas the springiness increased by 25%. The addition of sugar beet fiber in combination with carob flour (sample CON-SBF-CAR) showed a decreasing trend in the firmness, and also in the springiness of the crumb by 30% and 5%, respectively, compared to the control bread. Based on these results it can be concluded that sugar beet fiber had a more pronounced influence on the textural parameters, and it can be assumed that this is the result of their hydrating properties.

The results of sensory properties examination of bread samples confirmed that the addition of carob flour and sugar beet fiber had an effect on specific loaf volume (Figure 2), as well as on the elasticity of the crumb and the fineness of pore structure after 24 and 48 h (Figure 3).

![Figure 2](image2.png)

**Figure 2.** Effect of carob flour and sugar beet fiber on bread loaf volume

![Figure 3](image3.png)

**Figure 3.** Effect of carob flour and sugar beet fiber on sensory properties of bread
The addition of the preservative (sample CONP) had a positive effect on the pore structure and elasticity of the crumb. However, the specific loaf volume was slightly reduced compared to the control sample. The addition of carob flour in an amount of 20% (sample CON-CAR) had the biggest impact on reducing the specific loaf volume of the bread (by 25%), while the combined supplementation of 3% sugar beet fiber and 10% carob flour (sample CON-SBF-CAR) caused a decrease in the specific loaf volume by 20% compared to CON. The result of adding sugar beet fiber (sample CON-SBF) improved elasticity of the crumb, and the bread had a finer crumb structure compared with CON-CAR.

The effect of additional ingredients on the microbiological quality of bread during the 16 days of storage was also investigated, where the microbiological analysis was performed every fourth day, and the criteria of contamination was defined: low 0 - 0.1, medium 0.1 - 0.3 and high > 0.3.

By observing the development of molds and yeasts it was noticed that in all bread samples there was low contamination present, whereby the sample CONP retained the value of contamination to 0.1 for all 16 days, and the contamination of CON-CAR was negligible, which was probably a result of the antioxidant effect of carob flour (9). It was similar to the sample CON-SBF-CAR, except for the last day of sampling where the contamination was registered at the level of contamination of the control sample, which was due to the combined effects of both additional ingredients. Only the sample CON-SBF showed higher level of contamination compared to the CON (up to 0.9) as can be observed in Figure 4.

Figure 4. Level of contamination of bread by molds and yeasts

The bread samples after the sixteenth day were kept for additional 6 days, and then visually ascertained the changes (Figure 5). It is noticeable that molds did not develop
only on the samples CONP and CON-CAR, indicating that carob flour has an antifungal effect, similar to a commercial preservative.

Figure 5. From left to the right: CON, CONP, CON-CAR, CON-SBF and CON-SBF-CAR

CONCLUSION

The addition of 20% carob flour slightly increased the water absorption and prolonged the dough development time by 4 times. Carob flour significantly increased the dough extension resistance by as much as 70%, which was resulted in a decreased ability of gas retention. The maturograph resistance and elasticity of the dough decreased by 30% and 25% respectively, while the final fermentation time was extended by 20%. The sample with 3% sugar beet fiber (CON-SBF) had 8% higher water absorption, due to the good hydrating properties, and 5 times longer dough development time in comparison to the sample without functional additives. The combined addition of 3% sugar beet fiber and 10% carob flour (CON-SBF-CAR) had an increased resistance and decreased extensibility of dough compared to the control sample.

The sample CON-SBF had the best bread quality, with the bread volume of 1013.33 ml, improved elasticity and fineness of crumb structure compared to the control sample, even to the sample CON-CAR. The volume of the sample CON-SBF-CAR was lower by 20%, while the minimum volume was obtained with carob flour (25% lower than CON). The textural characteristics of bread with carob flour were unfavorable, because of the crumb firmness increase by 10% and crumb elasticity decrease by 15%.

From the aspect of the microbiological quality of bread, the best results were achieved by adding 20% carob flour (CON-CAR). The highest level of contamination by molds and yeasts was observed for the sample CON-SBF, while the microbiological quality of the sample CON-SBF-CAR was preserved for 12 days.

The results confirm that the use of sugar beet fiber and carob flour in bread making is justified, because their effects on the rheological characteristics of the dough did not result in a significant deterioration of physical and sensory quality parameters of bread. Positive effects, primarily of carob flour on the preservation of microbiological quality of bread, confirm that its application as a natural preservative in bread making is justified and desirable.
Acknowledgement

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REFERENCES

У овом раду испитан је утицај функционалних додатака (бращно рогача и влакна шећерне репе) на емпиријске реолошке особине теста и квалитет хлеба. Квалитет хлеба дефинисан је одређивањем текстурних, сензорских и микробиолошких параметара. Испитивањима је обухватао 5 узорака: контролни (CON), са 0,4% конзерванса (CONP), са 20% бращна рогача (CON-CAR), са 3% влакана шећерне репе (CON-SBF) и са комбинацијом 10% бращна рогача и 3% влакана шећерне репе (CON-SBF-CAR). Узорци са функционалним додацима имају повећану способност везивања воде до 10% и 4-5 пута продужен развој теста у односу на CON због присуства прехрамбених влакана са израженим хидратационим својствима. Код поменутих узорака значајно је повећан и отпор теста, нарочито код узорка CON-CAR. Код поменутог узорка продужено је и време завршне ферментације за 20% у односу на CON што је последица смањене способности задржавања гасова.
Додатак функционалних сировина утица на побољшање текстуричних и сензорских особина хлеба. Код узорка CON-SBF значајно је смањена тврдоћа средине (за чак 70%), док се еластичност повећала за 25% у односу на контролни узорак. Позитивни утицај додатка влакана шећерне репе (CON-SBF) манифестовао се побољшањем еластичности средине и постигањем финије структуре пора. Додатак брашна рогача (CON-CAR) узроковао је смањење запремине хлеба за чак 25% у доносу на контролни узорак и за 15% у односу на CON-SBF. Са друге стране код хлеба са додатком брашна рогача током 16 дана испитивања није дошло до микробиолошке контаминације па је микробиолошки квалитет на нивоу квалитета узорка са хемијским конзерванском (CONP). Поменути резултати су врло значајни јер указују да се брашно рогача може користити као природни конзервант.

Кључне речи: брашно рогача, влакна шећерне репе, квалитет хлеба, сензорске особине, микробиолошки квалитет

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