Effect Of Charcoal Powder On Farinograph Properties Of Dough And Wheat Bread Quality

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***Abstract* — The effect of charcoal powder (CP) on farinograph properties of wheat dough and quality of bread was explored. The addition of activated charcoal powder leads to an increase in the dough development time. The addition of 1 % activated charcoal powder improves stability of dough. With addition of 1 % charcoal powder, bread volume, specific volume and mass were close to those of the control sample. The addition of 1 and 2 % charcoal leads to an increase in the H/ D indicator. The addition of low percentages (1 %) of CP in bread making make the results close to the control sample, with a slight negative effect on the sensory profile of bread.**

Keywords — charcoal powder, dough farinograph properties, wheat bread, quality

I. INTRODUCTION

Activated carbon (AC) is a solid substance that contains about 85 to 95 % of carbon. There are various renewable resources such as sugarcane, almond shells, rice husk, rice straw that can be used as alternatives. The material is gasified and pulverized, then activated at various temperatures from 680 to 950 °C using a rotary kiln. According to study, the physical (bulk density, yield, burning, hardness) and chemical properties (pH, conductivity, ash) of the activated samples were analyzed using standard methods. It was established that, to be steam activated at 950 °C, it shows satisfactory physical and chemical properties [1, 2].

Charcoal is a black substance that resembles coal and is used as a source of fuel. It is generally made from wood that has been burn, or charred, while being deprived of oxygen so that what's left is an impure carbon residue [3]. Nowadays, charcoal products, from croissants to capsules, are commercialized everywhere, with some studies reporting that activated charcoal can boost your energy, brighten your skin and reduce wind and bloating, i.e., that these products can detoxify the body [4].

For decades, activated carbon has found utility in the food industry [5]. Activated carbon is apply in bread making, in a minor aspect. Charcoal imprints a really black color to bread crumb, with a stable and wide crust. The motivation behind the fabrication of black bread is merely aesthetic and hedonist as the obtained bread exhibits blackness stronger than traditional black breads made, for instance, with rye flour and extracts of black rice [6]. The reason is that the color characteristics of activated vegetal charcoal are highly stable under the baking conditions, in contrast to traditional ingredients based on natural dyes and pigments (e.g., extracts from black tea and black rice flour [7].

Different authors investigate the effect of different types of flour and substances on bread quality [8, 9, 10, 11].

Gonzalez et al. (2020), make a study to assess the effects of activated vegetable charcoal on the physicochemical, textural and in vitro digestibility properties of bread, and the rheological properties of dough [2]. From this study it was concluded that, the charcoal, an additive primarily intended for imparting a black color to bread, had other positive and negative effects on the quality of wheat bread [2].

Other studies demonstrated that, addition of active charcoal has a significant effect on dough rheology as well as loaf volume, color characteristics and bread texture [1, 12].

The specific loaf of bread decreased with an increase in the amount of added activated carbon, probably due to the ability of AC to adsorb the gas formed during dough fermentation, depleting the available gas to hold the gluten network. At the same time, bread hardness increases with an increase in the amount of AC [13].

Some authors indicated that the addition of activated carbon in bread recipe significantly affects the value of most bread quality indicators. From the study authors concluded that, bread with activated carbon has a smaller volume (7 %) and higher oven loss. The new bread was characterized by a higher ash content and the taste and aroma with coal was similar to the control sample [14].

The addition of a relatively low amount of AC (1 g/100 g of flour) leads to improved starch digestibility, a lager increase in bread hardness and suitable black color. These results define AC as an attractive suitable ingredient with innovative potential application in bread making [13].

For Labutina, higher amounts of AC gradually reduce the bread specific loaf volume. A decrease in enzymatic hydrolysis was also observed by the author [1].

Some authors indicated that the bread crumb with active charcoal was characterized by good elasticity. The nutritional value in 100 g of the final product with the addition of AC was determined: proteins – 8.1 g; fat – 4.0 g; carbohydrates – 49.9 g, as well as energy value – 268 kcal [15].

According to some authors, the addition of AC in bread recipe has a beneficial effect and give a pleasant aromatic taste [1]. By all indicators, wheat bread with active charcoal meets the requirements of the state standard [16].

Therefore, the aim of the present study was to explore the effects of activated charcoal powder on the farinograph characteristics of dough, and quality characteristics of wheat bread.

II. MATERIALS AND METHODS

Materials

For the preparation of the bread samples, the following raw materials were used:

• Commercial wheat flour (type 500) – „Sheri 61" Ltd. (average chemical composition: fat 0.9 g/100 g of which saturated 0.3 g; carbohydrates 70.3 g/100 g, of which sugars 3.4 g, fiber 4.0 g/100 g; protein 10.8 g/100 g), moisture content 10.6 %;

• Commercial charcoal powder from „Himaks Farma";

• Water – according to ISO 6107-1:2004;

• Compressed yeast – supplied by Lesaffre Bulgaria Ltd;

• Salt – according to Codex Standard for Food Grade Salt CX STAN 150-1985.

Methods

Preparation of dough and bread samples

Kneading was performed by a one-phase process of dough preparation to obtain a dough with a homogeneous mass and an initial temperature of 26 – 27 ℃. First, knead the mix of wheat flour and charcoal powder, yeast, salt and water in kneading machine (Labomix 1000, Hungary). The control sample (CS) was prepared only with wheat flour and the other bread samples tested were prepared with charcoal powder (CP) replacing 1 % (CP 1 %: WF 99 %), 2 % (CP 2 %: WF 98 %), 3 % (CP 3 %: WF 97 %), 4 % (CP 4 %: WF 96 %) of wheat flour. The dough thus prepared matured for 30 min at 30 °C. Then the dough was divided into pieces of 230 g. After shaping, the dough was subjected to a final fermentation at 33 – 34 ℃ for 60 min in a fermenting chamber (Tecnopast CRN 45-12, Novacel Rovimpex Novaledo Trento, Italy). The dough was then baked in an electric floor oven Salva E-25 (Salva Industrial S.L.U., Lezo, Spain), preheated to a temperature of 220 – 230 ℃, for 17 – 18 min. After baking, the breads were allowed to cool for 3 h at room temperature. The bread formulations are given in Table 1.

TABLE 1. Formulations of bread samples

Bread recipe	Bread samples				
	Wheat control sample of bread (WCS)	Samples of bread with charcoal powder (%)			
		CP 1	CP 2	CP 3	CP 4
Wheat flour, g	**500**	**495**	**490**	**485**	**480**
Charcoal powder, g	**-**	**5**	**10**	**15**	**20**
Water, ml	280	280	280	280	280
Yeast, g	10	10	10	10	10
Salt, g	6	6	6	6	6

Farinograph properties of the doughs

The following dough characteristics were determined by a farinograph (Brabender GmbH&Co. KG, Duisburg, Germany): water absorption (%), development time (min), stability (min), degree of softening (FU) and consistency (FU), with AACC Method 54-21.02 [17].

Bread Quality

Physical Properties

The quality of the prepared breads was assessed by the following characteristics. Bread loaf volume was determined after baking and cooling the breads for 3 h at room temperature by a rapeseed displacement method [17]. The specific volume was calculated by the ratio between volume (cm^3) and mass (g) of each sample. Bread height and diameter were measured by a caliper, and the shape stability (Height/ Diameter) was calculated [18]. Bake loss (%) was determined following weighing each loaf before and after baking [19].

Sensory Analysis

Sensory analyses of the obtained breads were performed by a descriptive panel consisting of 25 panelists (52 % women and 48 % men) aged 22 – 60 years, who were familiar with sensory analysis of foods but not specifically trained in the evaluation of sourdough breads. The analyses were carried out according to ISO 6658:2017 [20]. The panelists were asked to score six parameters, namely appearance, crumb color, porosity, chewability, aroma and taste. They expressed the intensity of each attribute on a 9-point hedonic scale (9 – extremely good; 1 – extremely bad).

Statistical analysis:

For all samples, the analyses were carried out at least in triplicate and the results are expressed as the mean values and ± standard deviations (SD). Statistical evaluation was performed by using one-way analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

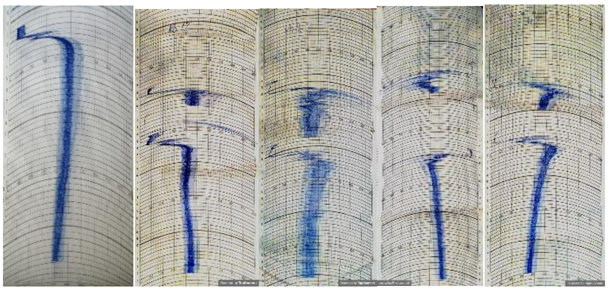
Effect of activated carbon flour on dough farinograph properties

Dough farinograph properties determine its behavior during the technological operations. For this reason that their determination is very important. One of the most widely used wheat test tools in the world is the Brabender farinograph [21]. The results from the farinograph properties of the dough obtained with addition of active charcoal powder are depicted in table 2, according to the methodology described in section materials and methods.

TABLE 2. Farinograph properties of wheat dough with addition of charcoal powder

Samples	Water absorbtion, %	Consistency, F.U.	Dough developme nt time, min	Stability, min	Dough softening F.U.
WCS	64.0	500	1.5	13	170
CP 1	64.5	500	2.0	16	50
CP 2	65.1	510	2.5	10	120
CP 3	66.1	510	2.5	6	130
CP 4	67.0	510	3.0	3	200

The table shows that with the addition of activated carbon, the dough water absorption significantly increases. From the obtained data, it is clearly observed that addition of 20 % activated carbon, the amount of water for dough formation increases to 67 %. This shows that the difference between the control sample and the sample with the highest amount of activated carbon (4 %), expressed as a percentage, is 4.6. In the future, this is will be positively affecting the yield of dough and bread. The graphical representation of the results shows that the addition of 1 % activated carbon does not change the dough consistency. Higher amounts lead to a small increase, which is in the correlation with the method standard error. From the data obtained, it was clearly seen that with the addition of activated charcoal, the dough development time was relatively increased. The dough development time for the control sample was a minute and a half, and the dough development time for the test sample CP4 to form dough is double that of the control sample (3 min). The dough development time was determined by the rate at which the water is mixed with the flour. CP2 maintains good stability and close to that of the control sample. The difference between them was 3 min. Analyzing the data obtained, it was concluded that addition of 2 and more pourcent of activated carbon powder, leads to relatively deteriorates dough stability. The difference between addition of 1 and 4 % is as much as 13 min. The CP4 sample has the highest values for dough softening. The difference between the control sample and sample CP4 is 30 FU. The lowest results were observed, for dough with the addition of activated carbon powder 1 %. The difference between the control sample and CP1 is 120 FU. The other authors indicated that, addition of AC had a significant effect on dough rheology [2].



WCS CP1 CP2 CP3 CP4

Photo: Farinograph profile of wheat dough with added flour from charcoal powder

Effect of activated charcoal powder on wheat bread quality

To assess the baking characteristics of the wheat breads with added charcoal powder, bread floor was prepared from each bread variety. Fermentation and baking of all dough samples were carried out under equal conditions, according to the adopted technology. Results from the quality assessment of their baking characteristics are presented in table 3.

TABLE 3. Baking characteristics of wheat bread with addition of charcoal powder

Bread samples	Masse, g ± SD	Volume, cm^3 ± SD	Baking loss, % ± SD
WCS	206 ± 1.00	860 ± 1.41	10.4 ± 0.54
CP 1	199 ± 1.73	760 ± 1.15	13.5 ± 0.39
CP 2	207 ± 1.73	580 ± 1.63	10.0 ± 0.32
CP 3	208 ± 3.46	500 ± 1.87	9.6 ± 0.20
CP 4	210 ± 2.64	470 ± 1.73	8.7 ± 0.27

From the results obtained for the mass of bread, it was noted that there is almost no visible difference. There was a difference in bread volume. Increasing the addition of activated charcoal powder, the volume of final bread samples products decreases. This could most likely be due to the low gas formation properties of flour in combination with the activated charcoal powder. The highest volume was obtained in the control sample bread – 860 cm^3. Sample CP1 had close results to those of the control sample (760 cm^3). The difference between the control sample and the sample with the maximum added amount of CP4 was 390 cm^3, expressed as a percentage – 82.9. In summary, it can be concluded that with the addition of a smaller percentage of activated charcoal powder (1 %) it was obtained the results close to the control sample. It is interesting to note that the test samples CP2, CP3 and CP4 had lower baking loss compared to the control sample and sample CP1. These results are also confirmed by other authors. The addition of activated carbon to bread significantly affects the value of most bread quality indicators. Bread containing activated carbon has a higher oven loss and a smaller volume of about 7 % [14].

Figure 1 shows the specific loaf volume of the control wheat bread and test samples.

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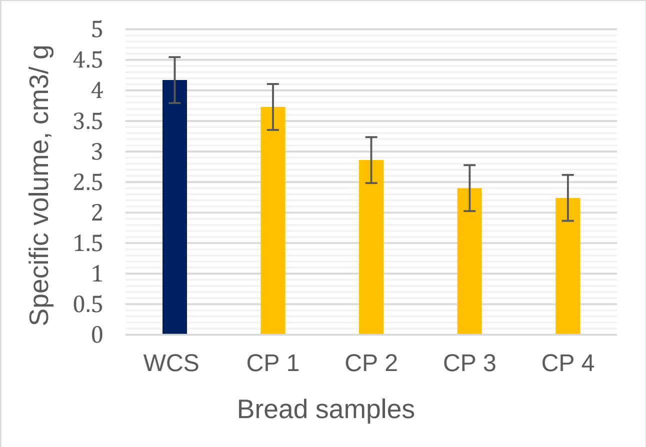

Fig. 1. Specific loaf volume of wheat bread with addition of charcoal powder

The figure 1 show that as the percentage content of activated charcoal powder increases, the specific loaf volume significantly decreases. These results are confirmed by the study of Belikov, according to which the specific volume of bread decreases with increasing of AC, probably due to the ability of AC to adsorb the gas formed during dough fermentation, depleting the available gas to hold the gluten network [9]. Control sample was with highest results (4.17 cm^3/ g). On the other hand, in experimental sample AB we also get values close to that of the control (3.73 cm^3/ g). This shows a 10.5 % reduction. Literature data on the effect of ACP on the specific volume of wheat breads are in one direction. According to some authors the addition of AC had a significant decreasing effect on bread specific volume, probably due to the ability of AC mesoporous structure to adsorb the gas formed during dough leavening, depleting the gas available for gluten network retention [2]. Labutina reported that higher amounts of AC gradually reduce the bread specific loaf volume [1].

The indicator marked with H/ D and was determined by the ratio between the height and diameter of bread, after baking. In terms of shape stability, the data obtained from this indicator (H/ D) for control and experimental samples are expressed in figure 2.

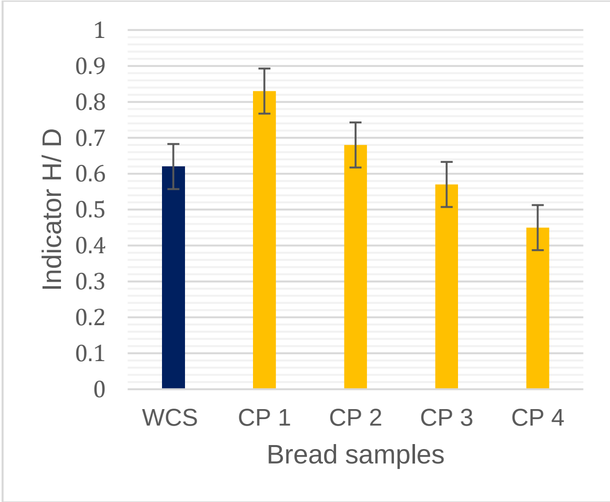

Fig. 2. Indicator H/ D of bread with addition of charcoal powder

From the obtained results for shape stability, it is interesting to note that with the addition of a lower pourcent of activated charcoal powder (1 and 2 %), it was obtained higher results compared to the control sample, and the difference between CP1 and the control is 0.21 units. Analogously to the previous analyses, a decrease was observed in the samples with a higher amount of activated carbon (3 and 4 %). With these samples, dimensional stability is obtained – 0.53 and 0.43.

Sensory profile of wheat bread with addition of charcoal powder

The tests samples are evaluated by 25 independent analysts after familiarizing yourself with the research methodology. The results are graphically illustrated in figure 3.

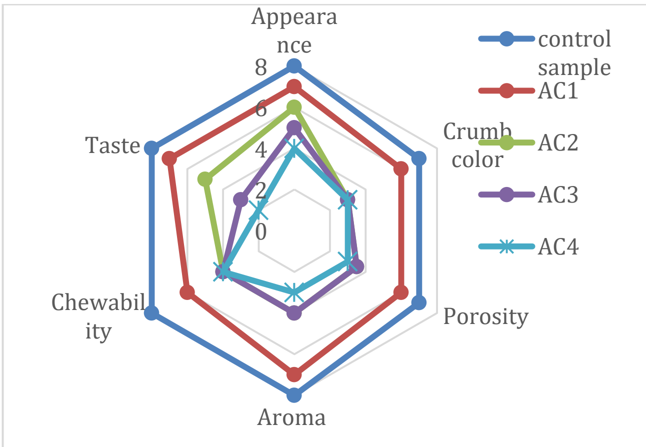

Fig. 3. Sensory profile of wheat bread with addition of charcoal powder

It was established that the highest score given by the control sample. The evaluators noted a slightly atypical taste and aroma of the tested samples (especially in sample AB 4 %). In all samples, the aroma is a "light" pleasant aroma, the taste is pleasantly unobtrusive. When comparing the experimental samples with the control sample, it can be seen that the bread with 1 % added activated charcoal powder gets close results to those of the control. From the analysis, it can be established that the darker colored bread receives a lower points for crumb and also crust color. This is may be due to the atypical color that the consumer is not used to. In summary, it can be concluded that the addition of a small percentage of activated charcoal powder (1 %) in the recepy of wheat bread leads to results close to the control sample, with a slight negative effect on the sensory profile of bread.

IV. CONCLUSIONS

From the results obtained in the present study, it was found that:

1. The addition of activated charcoal powder leads to an increase in the dough development time. The addition of 1 % improves the dough stability.
2. The obtained bread with 1 % activated charcoal powder in wheat bread recepy, had an effect for volume, specific volume and mass which is close to these of the control sample. The addition of 1 and 2 % leads to an increase in the indicator H/ D.
3. The study demonstrated that addition of low percentages (1 %) in bread making make the results close to the control sample, with a slight negative effect on some bread sensory characteristics.

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