Eszter Benes[1], Ildikó Szedljak[1]

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Comparison of chemical characteristics and technological parameters in durum wheat based breads enriched with hemp seed flour

KEYWORDS: Wheat bread, Triticum durum, Cannabis sativa, trial loaf, shape quotient, titratable acidity, polyphenol, antioxidant capacity

SUMMARY

Society is getting increasingly food-conscious these days. It can be observed that, in addition to basic cereals such as wheat, rye or maize, the grains of other cereals, pseudocereals and other types of plants that had not been on the market in significant amount have also been appearing. The nutritional values of these plants contribute greatly to the improvement of flour quality. By making various flour blends, we can help produce complete bakery products that are more valuable than the usual ones.Bread is a food whose production uses simple ingredients such as wheat flour, salt, yeast and water. This is why, in many countries, it is the most commonly consumed cereal product that serves as the basis for the diet of many people. Due to its simplicity and widespread consumption, bread is suitable for enrichment with ingredients that provide additional health benefits to consumers. In order to prevent diseases [1], laypeople, as well as professionals consume increasing amounts of foods considered to be healthier than average these days, with the intention, inter alia, of preventing or at least reducing the use of medicinal products obtained in order to maintain or improve their health. Foods with a higher polyphenol content, which may contribute to the prevention of harmful oxidation processes in the human body, may be suitable for this purpose [2]. In the spirit of the above, for the breads prepared by us, flour blends of various compositions were made using durum flour (Triticum durum L.) and hemp seed flour (Cannabis sativa L.). Certain chemical parameters were analyzed in the course of the measurements during the preparation of the breads.

RAW MATERIALS USED

For our study, we used durum flour produced by Júlia Malom Kft. of Kiskunfélegyháza, and a commercial hemp seed flour (Nature Cookta Kendermagliszt).

HEMP SEED FLOUR

Since hemp seed does not contain gluten-forming proteins, therefore, at the end of the production process, the volume of the bread made from it will be much smaller than that of the volume of bread made from wheat flour, for example. However, hemp seed flour is a valuable addition to bakery products because of the proteins found in it and its high fiber content. Hemp seed flour is produced by the crushing of defatted oilcakes **[3]**. The polyphenols contained therein were identified by high performance liquid chromatography (HPLC) by Teh et al. According to their experimental results, hemp seed flour contains mainly quercetin, caffeic acid and luteolin **[5, 6, 7]**.

[1] Szent István University, Faculty of Food Science, Department of Grain and Industrial Plant Processing

Durum flour

Today, about 50% of the energy intake, as well as 45% of the protein intake of the population of Earth comes from cereals. Cereals are important sources of vitamins, minerals and complex carbohydrates, including dietary fiber **[8]**. Polyphenolic compounds of durum wheat were determined by Dinelli et al. using HPLC-TOF-MS (HPLC-time-of-flight mass spectrometry). Similarly to hemp seed flour, this cereal also contains luteolin, as well as vanillin, coumarin, apigenin, ferulic acid and other compounds **[10]**.

Methods used

Three different flour blends of different composition were prepared from the flours available to us, and a control sample was prepared from the durum flour. For the measurements, four breads of different composition were prepared, the exact compositions of which are summarized in ***Table 1***.

Preparation of a trial loaf

For the preparation of the trial loaves, 300 g of flour, 9 g of yeast, 6 g of table salt and 1.5 g of sugar and a sufficient amount of water to obtain a suitable texture (146 ml on average) were used for each bread. By increasing the amount of hemp seed flour, the water uptake capacity of the flour blends decreased. After weighing the ingredients, the mixture was kneaded for 5 minutes with a kneading machine. The dough obtained was allowed to mature in a thermostat at 31 °C, then 400 g of dough was pinched off and it was shaped with twenty rounding motions. The dough was placed in a floured pot, and it was allowed to rise for 30 minutes at 31 °C. After rising, the already raised dough was placed on a baking sheet, its surface was cut and moistened. The oven was preheated to 220 °C during the rising process, its atmosphere was saturated with water, and the breads placed in the oven were baked for 25 minutes. The measurement was carried out according to standard MSZ 6369-8:1988 **[11]**.

Analysis of the bread samples

Physical measurements

After the loaves were allowed to cool, their volume was measured using the seed displacement method and shape quotients were determined **[14]** in order to get an impression of the effects of flour blend composition.

Determination of titratable acidity

The titratable acidity of the loaves was also determined from the crumbs of the cooled breads by a potentiometric method. According to Chapter 9 of standard MSZ 20501-1:2007, acids in the crumbs were dissolved using acetone and water. Following this, the acid content of the solution was determined after dilution by titration with a 0.1 M sodium hydroxide solution. The endpoint of the titration was monitored by a pH meter **[15]**.

Extract preparation and chemical measurements

During the technological process, three samples were taken in each case:

- after kneading,
- after the rising process,
- and after baking.

Samples were homogenize with a hammer grinder and then their moisture content was determined. For the determination of water-soluble polyphenol content and antioxidant capacity, extracts were prepared. Measurements were carried out in triplicate. For the preparation of the extracts, 0.15 g of the sample was weighed into an Eppendorf tube, 1,500 µl of distilled water was added and it was centrifuged at 4 °C and 10,000 rpm for 15 minutes. The supernatant was removed and used for further analyses.

Water-soluble polyphenol content was determined by a photometric method which was based on a method developed by Singelton and Rossi for wine analysis, using Folin-Ciocalteu reagent. The results obtained are expressed in gallic acid equivalent (GAE, mg gallic acid/g dry matter/dough).

Water-soluble antioxidant activity was determined by the FRAP (Ferric Reducing Antioxidant Power) method **[13]**. For this, a 300 mmol/l sodium acetate buffer was prepared with the addition of 16 ml of acetic acid per liter (pH = 3.6). Also were prepared 10 mmol/l 2,4,6-tripyridyl-s-triazine, 40 mmol/l hydrochloric acid and 20 mmol/l ferric chloride ($FeCl_3 \cdot 6H_2O$) solutions. For the FRAP reagent, 25 ml of acetate buffer, 2.5 ml tripyridyltriazine solution and 2.5 ml of ferric chloride solution were mixed prior to the measurement.

In the FRAP reagent, the tripyridyl-s-triazine complex is reduced by the antioxidant content of the sample in a reaction with color change. The intensity of the resulting blue color can be measured at 593 nm using a photometer. The blue color developed within 5 minutes after mixing the sample and the FRAP reagent.

Experimental results and their evaluation

Test baking

During the test baking, four breads of different compositions were prepared, the composition ratios of which are shown in ***Table 1***. Samples were

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compared to the control sample (100D) and to each other. ***Figure 1*** shows the bread loaves baked in the course of the experiment.

Physical examination

After the breads were allowed to cool, the volume of the breads was measured using the seed displacement method. The data in ***Table 2*** clearly show that the volume is reduced with the addition of hemp seed flour, which can be explained by the fact that this type of flour does not contain gluten-producing proteins. In the absence of these, breads will be more dense and they rise less as an effect of the yeast. This is also reflected in the structure of the crumb, as it becomes less airy and more inflexible. This is confirmed by the pictures taken by us. ***Figure 2*** shows the crumb of the test loaves.

The addition of hemp seed flour not only reduces the volume but also the height of the breads. This is also supported by the determined shape quotients. The results show that both height and width decreased with increasing amounts of hemp seed flour. According to guideline 2-81 of the Hungarian Food Codex **[14]**, the shape quotient of breads can be no more than 2.2. Below this, the product is considered flat. The shape ratios of the breads prepared by us all met this requirement, with the exception of sample 70D. This shows that if the amount of hemp seed flour reaches 30% of the total amount of flour, the bread will be flat.

Chemical measurements

Determination of titratable acidity

It is clear from the data in ***Table 3*** that the addition of hemp seed flour decreased the pH value continuously, however, there was no significant change. On the one hand, the titratable acidity of flour results from the oxidation of the fat content of flour: the older the flour, the more fat is decomposed, and the more fatty acids are released **[16]**. In this case, it probably does not indicate the age of the flours, but the fact that after the defatting of hemp seed flour the ground seeds still contain some fat. The oxidation of this fat contributes to the formation of free fatty acids, thus increasing the acidity. In addition, complex microbiological and biochemical processes that take place in the dough may also contribute to the change in acidity, however, it was not possible to investigate these in this study.

Results of the determination of water-soluble polyphenol content

In the case of both the determination of water-soluble polyphenol content and antioxidant capacity, three parallel measurements were carried out in five replicates. The required analytical curve was recorded before each measurement.

From the values shown in ***Figure 3*** it can be clearly seen that the water-soluble polyphenol content of the control samples increased during the rising process, and the value in the final product was lower than the one measured in the kneaded sample. The same tendency is exhibited by the sample containing 10% hemp seed flour, when examining all three technological steps. Increasing the amount of hemp seed flour to 60 or 90 g reverses the above-mentioned tendency. Nevertheless, the water-soluble polyphenol content was lowest in the finished product in each case.

Figure 4 summarizes the changes in the polyphenol content of the finished products, the crumb and the crust. We consider it important to examine the crumb and the crust of the finished products separately, as this allows for the observation of the distribution of the values. In each case, the polyphenol content of the crust was much higher than that of the crumb or the finished product. During baking, the outer surface of the dough is more exposed to heat, which may result in the formation of substances that do not arise in the crumb. It is assumed that the higher values found in the crust are a result if this.

Results of the antioxidant capacity determination

When measuring the antioxidant capacity of the dough, once again only the FRAP values of water-soluble components were determined. In this case, the appropriate analytical curve was recorded before the measurements as well.

The diagram in ***Figure 5*** depicts the changes in water-soluble antioxidant capacity in the samples taken during the technological steps. Based on the data similar changes can be seen in the chemical parameters of the control samples, and samples 70D and 80D: the initial value decreased during the rising process, and then it increased again. The antioxidant capacity of sample 70D, which contained the most hemp seed flour, exhibited a continuous increase during the breadmaking process. The highest value was found in the bread made with the addition of 90 g of hemp seed flour, which is an expected result.

Figure 6 shows that the antioxidant capacity was the highest in the crust for each sample, but unlike the polyphenol content, the antioxidant capacity in the crumb of the bread was much lower. The antioxidant capacity of the crust exhibited a decreasing tendency, which can be paralleled with the decrease in the amount of durum flour.

Summary

The objective of our study was to investigate the nutritional parameters and physicochemical properties of durum breads enriched with hemp seed flour. The maximum amount of hemp seed flour used was 30%. Changes in the chemical parameters were monitored during the breadmaking process. Water-soluble total polyphenol content (TPC) and water-soluble antioxidant capacity (FRAP) values were determined. Flour blends were prepared using different ratios of *Triticum durum* L. flour and hemp seed flour (*Cannabis sativa* L.).

The results show that both the water-soluble polyphenol content and the antioxidant capacity of the finished product can be increased by the addition of hemp seed flour.

It has also been found that the extremely complex microbiological and biochemical processes that take place during the technological steps of the breadmaking process have a beneficial effect on the nutritional values of the finished product.

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