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Effects of Hemp Flour, Seeds And Oil Additions on Bread Quality

Bădărău Carmen Liliana*, **, Apostol Livia***, Mihăilă Laura*
**(Department of Engineering and Management of Food and Tourism, Transilvania University from Brașov, 29 Eroilor Street, 500036, Brașov, Romania*
*** (Department of Biotechnology, National Institute of Potato and Sugar Beet, 2 Fundăturii Street, 500470, Brasov, Romania,*
**** (Department of Research and innovation, National Institute of Research and Development for Food Bioresources, Bucharest, 5 Baneasa Ancuta Street, 020323, Bucharest, Romania*
Corresponding Auther : Bădărău Carmen Liliana

ABSTRACT
The minerals, dietary fibers and essential fatty acids of several hemp products (flour, seeds and oil) represent valuable compounds sources that could transform the bread in a functional food. The aim of this work was evaluation the minerals and total row dietary fibers content of several bread variants and estimate their effects on some bread quality and nutritional indicators. In this research experiments, beside the minerals (calcium, magnesium, potassium) and row dietary fiber content, the analysis performed on bread (prepared using different hemp flour addition 10%, 15% and 25%) were sensorial and physic chemical analysis (product volume, crumb porosity, height/diameter ratio, moist and acidity). Experimental results indicated that 15% hemp flour, 4% hemp seeds and 8 % hemp oil added in the dough were the most indicate to be used in bread processing.
Keywords – bread, dietary fibers, hemp, minerals

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I. INTRODUCTION

There are many studies on ways of creating special foods necessary not only to make up for micronutrient deficiency in the diet and support the functions of the human body, but also to protect it from many diseases caused by environmental impact (immune, cardiovascular, respiratory and oncology diseases and aging) [1]. Many countries of the world (United Kingdom, Norway, Finland, USA and others) have large scale programs for population health improvement that include bread and bread products as a solution [2].

Hemp flour contains all minerals required by the human body: calcium, magnesium, iron, potassium and a record amount of

- magnesium, which has a positive effect on the body's stress resistance
- row dietary fibers that aid the regulation of the gastrointestinal tract.

The goal of this research work was to present the advantages presented by the use the seeds, flour and oils hemp (*Canabis sativa* L.) in bakery industry and the influence of these ingredients addition on several bread quality indicators.

Bread is one of the most important human food product, being needful for daily feed because their nutritive value and energizing substances content [3]. The effect of bread and bakery products consumption on the people health is major because this kind of food never miss from consumer's meal [4, 5]. Researcher target concerns to improve the quality of this kind of food, to obtain baking products with high nutritive value, with pleasant taste and flavor, which have the capacity to maintain themselves fresh for a long time, but also correction the bread products imperfections [6-7]. Moreover, the orientation of food producers to traditional, natural and healthy products is known and present in food technology research [3]. In this regard, the goal of this paper was to obtain several high nutritional value bread products, improving the bioactive compounds content by addition of hemp flour, seeds (material with high level of dietary fiber content and micronutrients) and hemp oils (a valuable functional food). The use of these adjuvants in common bread preparing could be justified because the complex composition in nutrients: sugars, proteins, microelements (calcium, potassium, potassium) and essential fatty acids [8].

A lot of benefits give to the hemp seeds and flour the qualities of an additive-enricher in foods. Hemp flour also contains:

- 20 amino acids essential for the human body.
- more fiber then other flour
- more protein than short patent wheat flour
- high level of valuable lipids, including essential fatty acids (omega-3 and omega-6).
- vitamins and deficient mineral elements [8]

The most important health benefits of hemp seeds and flour are explained by the fact that they contain a high amount of insoluble and soluble dietary fiber,

or row dietary fiber, which aid the body to remove wastes [11].

The experimental studies in this work research aimed to evaluate the effects of addition of hemp flour, seeds and oils in dough on the bread quality, on their chemical composition (particular on the level of row fibers and several mineral elements calcium, magnesium, potassium). So, by changing the classical bread recipe, these experiments aimed to verify if beside a better nutritive compounds contribution, the hemp flour, seeds and oils used contribute or not to obtaining a bread with a special taste and flavor.

II. MATERIAL AND METHODS

2.1. Hemp flour used for bread obtaining

The content of raw oil in hemp flour and seeds was calculated by using a Soxhlet extractor. Ash weight percentage was calculated by burning the grounded sample weight of the product until the substance is completely burned, followed by a quantitative measurement of the residue. Protein weight percentage was determined through the nitrogen content using the Kjeldahl method. Fiber was measured through a step-by-step application of acid solution, alkali solution and ashing the sample weight of the trial sample and a quantitative measurement of the organic residue by weight. Acidity was calculated through titration of the suspension of a sample weight of re grounded product in a 0.1 N solution of sodium hydrate with the addition of 5 drops of 1% phenolphthalein solution until it turns pink and remains pink for 1 minute. The samples of hemp flour were tested for evaluation the total content of dietary fibers and content of minerals (calcium, magnesium and potassium). Similar compounds content were tested in bread products.

2.2. Bread obtaining technological process

We used a common technological process and the recipe used was the following: flour 1000g; water 57%; yeast 2,5%; salt 2%; hemp oils (8%); hemp flour addition in different amounts: 10%, 15% and 25%. In several bread variants there was added hemp seeds (4%). In the same time, a control sample without hemp products addition was performed. After fermentation period, the dough was formed and baked.

The experimental variants identifications for the bread samples studied are presented in Table 1.

The parameters of the technological process were as follow: kneading 20 minutes/28^{o}C, fermentation 40 minutes /35^{o}C, baking 5 minutes/140^{o}C and 60 minutes /180^{o}C.

Table 1. Identifications of the experimental bread variants

Products	Control sample (Bread without hemp products addition)	Bread with hemp oils (8%)						
		without hemp flour addition	with hemp flour addition			with hemp seeds (4%) and hemp flour addition		
			10%	15%	25%	10%	15%	25%
ID of the variants	C	O	OF10	OF15	OF25	OFS10	OFS15	OFS25

2.3. Evaluation of the bread products quality

2.3.1. Bread sensory analysis

The bread variants obtained was subjected to sensorial examination: form, crumb aspect, bread aspect, volume, consistency and chewing comparison, smell, taste, microbiological alteration signs, foreign bodies (as SP-3232-97"Bread, loaf product and bakery specialties. Analysis methods") [12].

2.3.2. Bread physic-chemical analysis.

The bread variants obtained after the above described method were submitted to the physic chemical exam, testing the following indicators: the product volume, crumb porosity, high/diameter ratio, moist and acidity (according to SP-3232-97 "Bread, loaf product and bakery specialties. Analysis methods") [12].

The mineral content (calcium, magnesium and potassium) in bread samples were determined using an inductively coupled plasma mass (ICP-MS; Perkin Elmer NexION 300q) [13]. For calculate the sample minerals concentration (mg/100g) the following formula (1) was used:

$$C = \frac{(A - A_0) \cdot V}{b \cdot M \cdot 10} \qquad (1)$$

A = absorbance of the sample solution;
A_0 = absorbance of the blank solution;
b = slope of the calibration curve (L/mg);
M = sample weight (g);
V = volume of the sample solution (mL).

The total row fiber content was measured through a step-by-step application of acid solution, alkali solution and ash the sample weight of the trial sample and a quantitative measurement of the organic residue by weight [14]. The samples were dissolved using an acid detergent fiber ADF solution (20 g of N- acetyl -N, N, N – methyl ammonium bromide diluted in 1 liter of sulfuric acid, 0.5 mol / L) and special fiber sacks (Fiber bags). The most important part of this analysis is the boiling times and also the weighing procedures. After treatment with this solution, the insoluble residue is dried, weighed and then calcination. The difference between the ash mass resulting from calcination and that of the insoluble residue is the ADF content. The percentage of ADF was calculated using the value of insoluble portion of the sample remaining after

boiling in the acid detergent solution minus the ash content and it is calculated as follows, using equations (2) and (3):

$$\%ADF = \frac{\left((\chi - \alpha) - (\delta - \xi)\right) * 100}{\beta} \quad (2)$$

$$\zeta = \delta - \Psi \quad (3)$$

α = Fiber Bag wight (g)
β = sample weight (g)
χ = crucible weight and dryed Fiber bag after digestion (g)
δ = weight of the crucible and ash (g)
ζ = zero value of the Fiber bag without sample (g)
Ψ = weight of the crucible (g)

A Foss Fibertec Dietary Fibre Analysis System (Fibertec ™ 1023, Denmark) was used for evaluate the total dietary fiber content.

2.4. Results interpretation

Regarding the bread products, each set of comparable assay was conducted with the same ingredients, after the similar recipe (with the exception of the content of different hemp products addition to the dough). The bread indicators analysis were performed in three repetitions and the tests for evaluation total fiber content and minerals content were made in four repetitions.

III. RESULTS AND DISCUSSION

3.1. Hemp flour evaluation

For obtaining hemp flour, the hemp seeds were dust in a grain separator, washed out with tap water, sent to open grain roasters, dried for 15 minutes at a temperature of 80°C in the seed mass until the material reached level of the moisture up to 8% (method presented by Lukin and Bitiutskikh, 2017). Dried material was cooled to room temperature and ground into a powder. As in other research studies [11] the hemp flour obtained was a grayish-green powder with brown particles, a pleasant nutty taste and a slight crunch when chewing the outer layer particles.

Table 2. The nutritional value of two types of flour*

Indicator	Wheat flour	Hemp flour
Protein [%, w/w]	11.41 ± 1.09	26.60 ± 1,89
Fat [%, w/w]	2.11 ± 0.18	26.24 ± 1.54
Ash [%, w/w]	2.17 ± 0.23	2.93 ± 0.12
Total row fiber [%, w/w]	0.75 ± 0.09	39.57 ± 3.08
Calcium (mg/100g)	16.83± 0.83	204.37± 4.84
Magnesium (mg/100g)	20.52± 0.48	582.05± 10.09
Potassium (mg/100g)	142.72± 0.15	1071± 53.72

*Mean values for 4 repetitions ± standard deviation.

The hemp flour and wheat flour were compared and the results regarding the nutritional value of these two flour types are presented in Table 2. The increased health benefits of hemp flour is done by a high amount of insoluble and soluble dietary fiber, or row dietary fiber, which aid the human body to remove wastes. Compared to to wheat flour, hemp flour contains about 32 times more fiber, respectively 52 more fiber (Table 2). Hemp flour also contains 20 amino acids essential for the human body, half of which being essentials [8]. Two-thirds of hemp proteins is composed by edestin, belonging to low molecular weight globulins [9]. Content of 10–15% insoluble fibre [10] may be also reason for wheat flour fortification. Hemp flour is also rich in lipids, including the essential fatty acids in the omega-3 and omega-6 groups [8, 10]. The flour contains soluble vitamins and valuable mineral elements [8, 10]. Compared with wheat flour, the level of calcium, magnesium and potassium content was significantly higher. As shown in Table 2, the hemp flour contains 12.2 times more calcium, 28.4 times more magnesium and 7.5 times more potassium than the wheat flour used in our experiments. All these benefits give to the hemp flour the qualities requirement for transform a banal food in a functional one.

3.2. Bread products quality evaluation

3.2.1. Bread products sensory evaluation.

Points scale method was used. The sensory features of the bread products obtained according to the recipe (described in material and method) are presented in Table 3. These features are in accordance with standard SP-3232-97.

In all the experimental variants, the bread was well done, the shape was a correct one excepting the variant OF25 and OFS25 (addition hemp flour 25% with and without seeds), without deformation, crumb didn't have cracks. The inside was well done, with proper porosity, not wet. The color of the crumb was uniform, golden for the variant C, darker than the control for all the variants with hemp products addition and dark brown for the products with 25% hemp flour addition (Fig. 1B).

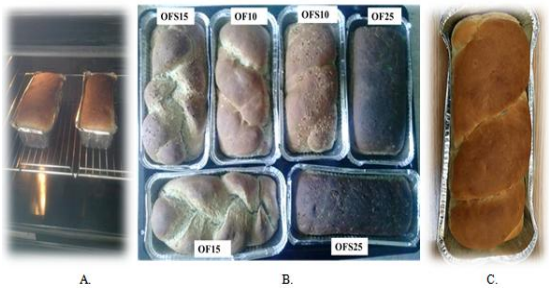

Fig. 1. Bread products (just after cooking): without hemp addition (A); bread obtained with hemp oils (8%) addition in dough, different % hemp flour addition, with and without hemp seeds addition in

dough – the samples identification is presented in Table 1(B). Bread products obtained with hemp oils addition, in dough (C).

Table 3. Sensorial analysis for the bread products supplemented with hemp products

Sensorial indicator	Bread variants							
	C	O	OF10	OF15	OF25	OFS10	OFS15	OFS25
Form, exterior aspect, volume	2	3	3	4	2	3	3	2
Crumb aspect	1.5	4	2.5	4	2.5	2.5	4	2.5
Consistency and chewing comparison	1.5	3	2.5	3	2.5	2.5	4	1
Bread aspect	2	3	2.5	3	2.5	2.5	3	1
Smell	2	3	2	3	2	2	3	3
Taste	1.5	3	2	3	2	2	3	3
Points	10.5	19	14.5	20	13.5	14.5	20	12.5
Qualification	Satisfactory	Very good	Good	Very good	Good	Good	Very good	Good

For the variants with hemp seeds addition, the color of the crumb was with little dark spots. The taste and the smell were pleasant, more intense for the bread with hemp seeds addition (variants OFS15 and OFS25). The best values of the sensorial properties were obtained for the bread variants O (with only hemp oils addition in the drought), OF15 and OFS15 (with 15% hemp flour addition in the drought).

3.2.2. Bread physic-chemical evaluation

The physic-chemical features for all bread variants products are presented in Table 4. Excepting the porosity values, all these indicators quality were in accordance with standard SP-3232-97 [12]. In all cases in which hemp products were added, the products were proportional, specific to assortment, the products were not excessively flattened or curved.

Analyzing the porosity values, the pores aspect was maintained especially for bread with hemp flour 15% (without seeds) and 25% (with and without seeds) addition and for variants O (only with hemp oils addition). As show in Table 4, the values for samples volume was higher than the control except the sample variant OF10 and OFS10 (10% hemp flour addition). Also, for sample with 15 % and 25% hemp flour addition, the porosity was more accentuated and the crumb was darker because of the Maillard compounds formed during baking. For 25% hemp flour addition sample (variants OF25 and OFS25), the elasticity was reduced by the bigger hemp products content and smallest flour content and their gluten content.

Table 4. Physic-chemical features for the bread products supplemented with hemp products*

Type of features	Bread variants							
	C	O	OF10	OF15	OF25	OFS10	OFS15	OFS25
Product volume (cm^3/100g product)	230.6 ±5.600	242.901 ±130	222.90 1±1.290	267.62 ±1.208	271.14 ±3.600	226.42 ±7.652	398.48 ±6.302	321.94 ±9.394
Crumb porosity (% volume) min. 74%**	80.14 ±0.138	79,12 ±0.682	70.82 ±0.253	73.42 ±1.738	78.14 ±0.405	68.11 ±0.612	69.54 ±1.557	75.14 ±0.941
High/Diameter ratio	13.275 ±0.025		12.2 5±0.050	12.4 ±0.100	13.1 ±0.100	10.6 ±0.050	11.4 ±0.100	13.1 ±0.100
Moisture (%) max 45%**	36.61 ±0.326	35.98 ±0.130	35.24 ±0.875	37.17 ±0.984	39.65 ±1.006	34.12 ±1.225	36.83 ±1.458	37.95 ±0.899
Acidity (acidity degrees/100g product) max 3%**	1.41 ±0.080	1.54 ±0.106	1.61 ±0.050	1.76 ±0.022	1.96 ±0.108	1.58 ±0.020	1.68 ±0.040	2.25 ±0.045

* The values in the table represent mean of 3 repetitions ± standard deviation
** The values of indicators in accordance with SP-3232-97

Excepting the variants OF10, OFS10 and O, the moisture of the samples with hemp products addition was higher than the control, between 36.83±1.458 (bread with 15% hemp flour addition) and 39.65±1.006% (bread with 25% hemp flour addition). This increase was because on the one hand of the colloidal processes (the coagulation of protein substances) from baking.

The acidity of samples with hemp products addition was higher comparing with the control, varying between 1.54±0.106 (bread with only hemp oils addition 8%) to 2.25±0.045 (bread with hemp flour addition 25%) maybe because of the presence of the organic acids (fatty acids from oils and from the other hemp products).

The looses after baking process of bread with hemp flour addition in proportion of 10%, 15%, 25%, were 10.4%, 14.8%, 15.2% and for the control 11.2%.

Preliminary experimental data obtained for sensorial and physical-chemical analysis for bread with hemp products added suggested that this hemp products addition could be used in bakery process. Figure 1 presents types of bread obtained with hemp products (Fig. 1B) and with only hemp oils addition (Fig. 1C).

3.3. Evaluation of the total row fiber content and minerals microelements in bread variants obtained with different hemp products addition

As show the values presented in Table 2, the hemp flour was rich in dietary fiber and registered high levels of fatty and proteins compounds (functional compounds, because of their content in essential fatty acids, respectively essential amino acids). Overall, the cooking techniques (bake in bread) and the level of hemp flour additions were responsible for a significant decrease in the amount of row dietary fiber content (expressed as weight percentage) when compared with the ingredient used (hemp flour). A sever decrease was observed for other nutritional indicator (proteins, fat acids weight percentage) level content too (Table 5). It should be noted, however, that the level of dietary fiber in

baked products was significantly different to the content present in raw hemp flour used. As seeing in Tables 2 and 5, the losses were significantly specially for the total fiber content in case of the highest level of hemp flour addition (25%) (change relative to raw hemp flour). A positive effect of hemp flour on the row dietary fiber content values of bread was observed. In all variants, compared with the control, the level of this nutritional indicator was higher. And the technological parameters were improved in all the experimental variants, too. Maybe, the fiber from hemp flour expands the gelatinized mass, increases the active surface, traps air bubbles caught when kneading, which increases the dough fermentation property. The fat contained in the hemp products also increases the gas-retaining capacity and improves the crumb's structural and mechanical properties. All of these aspects leads to a shortened proofing time, shortened baking time and lowered baking heat, and creates higher porosity and fine pored bread crumb in the bread variants, as in other research works [10, 11].

Table 5. Fat, protein, row dietary fiber and minerals content for the bread variants with hemp products addition*

Parameter tested	Bread variants							
	C	O	OF10	OF15	OF25	OFS10	OFS15	OFS25
Fat weight percentage (%)	1.6 ±0.605	1.80 ±0.130	3.09 ±0.290	3.62 ±0.208	4.14 ±1.602	2.42 ±0.652	3.98 ±0.302	5.94 ±0.394
Protein weight percentage (%)	6.14 ±0.138	6,12 ±0.682	7.02± 0.253	7.62 ±1.738	8.04 ±0.405	8.22 ±0.612	8.67 ±1.557	9.04 ±0.941
Row fiber weight percentage (%)	1.24 ±0.182	1.33 ±0.734	2.88± 0.325	3.92 ±0.308	5.64 ±0.474	3.78 ±0.612	4.54 ±1.072	6.14 ±1.081
Calcium (mg/100g)	43.61 ±4.482	43.98 ±2.822	74.32± 6.122	80.24± 9.038	90.38± 7.405	74.92 ±3.394	80.68 ±7.208	89.88 ±3.208
Magnesium (mg/100g)	47.00 ±5.802	47.32 ±3.208	101.90 ±11.738	113.64 ±5.208	132.38 ±12.912	100.84 ±5.782	124.16 ±9.253	133.08 ±14.122
Potassium (mg/100g)	187.70 ±9.506	187.83 ±10.208	270.50 ±19.357	284.25 ±16.908	300.64 ±20.003	268.12 ±18.184	274.26 ±15.297	301.05 ±23.116

* The values in the table represent mean of 3 repetitions ± standard deviation

The mineral content of the control and bread samples are presented in Table 5. A positive effect of hemp flour on the minerals content values of bread was observed. All bread samples prepared with hemp flour addition contain increased amount in micronutrients compared with the control: calcium (1.7-2.07 times), potassium (1.44-1.60 times) and magnesium (2.17-2.83 times). Despite severe loss of these compounds due to cooking, all the bread obtained with hemp products (particular with 15% and 25% flour hemp addition with and without seeds) retained amounts of all these bioactive mineral compounds due to higher initial levels of these ingredients.

The hemp products used in the experiments allows us to make bread variants with increased nutritional value, containing between 14.3-47.2% more protein, between 51.2-271.2% more fats and between 132.2-395.2% more fiber compared with the control. The new bread variants had higher mineral content: calcium content increased by 107.2%, potassium by 60.4% and magnesium by 183.1% (Table 5).

Breads obtained using hemp flour contain minerals required by the human diet: calcium, magnesium, potassium and high amount in dietary fibers (important compounds because they aid the regulation of the gastrointestinal tract). Thus, the presence of these compounds in bread products with hemp products addition could be useful for the consumers, opposite to the opinion create regarding the psychoactive and narcotic properties of cannabis (which really are present, but only in the stems and leaves of the plant). As reported by another research work [11, 15], hemp products made from the seeds are completely safe and could be used as addition in food.

IV. CONCLUSION

Using hemp products (flour, seeds, oil) supplement in the bread obtained with a classical method, results bread assortments with high nutritional value. In this way proteins, essential fatty acids, mineral and dietary fibers were added to the bakery products, improving their quality. Additionally, using hemp flour in bread dough could be substituted a quantity of flour from total height and total gluten content decreases. For this reason, these bread variants are recommended for the people with gluten low tolerance.

Beside improving the nutritional value, the advantages of hemp products addition (particular for the variants supplemented with 15% and 25% hemp flour), as secondary helping ingredient of the bread are: rinsing the bread volume, improving the crumb structure and increasing the shelf life of bread, an interesting color of the crumb as result of the natural sugars, organic acids content. Also, 15% hemp products addition has the best influence on the dough features, improving the crumb quality (porosity, elasticity).

Thus, the preliminary experimental data suggest that hemp products addition could be used in bakery for obtain special and challenge bread products.

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