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IMPACT OF *Salix viminalis* CARBON AS A BIOACTIVE COMPONENT: DEVELOPED A NEW PROPOSAL OF APPLICATION IN FUNCTIONAL BREAD

Summary

Health-promoting foods are becoming more and more popular, and products with functional properties have become products desired by consumers. In this work, activated carbon obtained from wicker (Salix viminalis) was used as a functional addition to mixed bread. An assessment of its impact on the physicochemical indices of the dough and final product as well as nutritional value was made. Flour characteristics, nutritional value, bread quality and sensory evaluation were performed using chemical, physical and physico-chemical methods. 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%. The novel bread was characterized by a higher content of macronutrients and a higher energy value, as well as a higher ash content. The taste and aroma of bread with coal was similar to control bread. The addition of carbon did not affect the perception of off smell and taste. Activated carbon promoted water retention and hindered the growth of gluten as a result of fermentation. It has been shown that wicker activated carbon can be a valuable functional additive to bread, which increases its health value and does not adversely affect sensory properties. Due to the fact that bread is a group of products commonly consumed in the daily diet, they are products that can be carriers of functional ingredients, i.e. activated carbon from wicker, which is characterized by beneficial adsorption properties for health. Novel bread with charcoal may be a response to the demand for functional bread with action related to cleaning the intestinal lumen from unwanted compounds and metabolites.
Keywords*: activated carbon, bioactive component, functional bread, Salix viminalis, sensory evaluation*

WĘGIEL AKTYWNY Z *Salix viminalis* JAKO DODATEK BIOAKTYWNY: OPRACOWANIE NOWEGO ZASTOSOWANIA W PIECZYWIE FUNKCJONALNYM

Streszczenie

Żywność prozdrowotna staje się coraz bardziej popularna, a produkty o właściwościach funkcjonalnych stały się produktami pożądanymi przez konsumentów. W opisanych badaniach zastosowano węgiel aktywny pozyskany z wikliny (Salix viminalis) jako dodatek funkcjonalny do pieczywa mieszanego. Celem badań była ocena wpływu dodatku węgla na wskaźniki fizykochemiczne ciasta i wyrobu finalnego oraz wartości odżywczej. Za pomocą metod chemicznych, fizycznych oraz fizykochemicznych dokonano charakterystyki mąk, oceny wartości odżywczej, oceny jakości pieczywa oraz oceny sensorycznej. Dodatek węgla aktywnego do pieczywa istotnie wpływa na wartość większości wskaźników jakości pieczywa. Chleb zawierający węgiel aktywny cechuje się większą stratą piecową oraz mniejszą objętością o około 7%. Nowe pieczywo charakteryzowało się wyższą zawartością makroskładników i wyższą wartością energetyczną, a także wyższą zawartością popiołu. Walory smakowo-zapachowe pieczywa z węglem były zbliżone do chleba kontrolnego. Dodatek węgla nie wpłynął na pojawienie się obcego zapachu i smaku. Węgiel aktywny sprzyjał zatrzymywaniu wody i utrudniał rozrost glutenu w wyniku fermentacji. Wykazano, że węgiel aktywny z wikliny może być cennym dodatkiem funkcjonalnym do pieczywa, który podnosi jego wartość zdrowotną i nie wpływa negatywnie na cechy sensoryczne. Z uwagi na to, że pieczywo to grupa produktów powszechnie spożywanych w codziennej diecie, są to produkty, które mogą być nośnikami składników funkcjonalnych, m.in. węgla aktywnego z wikliny, cechującego się korzystnymi dla zdrowia właściwościami adsorpcyjnymi. Nowe pieczywo z węglem może być odpowiedzią na zapotrzebowanie na pieczywo funkcjonalne o działaniu związanym z oczyszczaniem światła jelit z niepożądanych związków i metabolitów.
Słowa kluczowe*: węgiel aktywny, dodatek bioaktywny, pieczywo funkcjonalne, Salix viminalis, ocena sensoryczna*

1. Introduction

The bakery products portfolio is currently various, due to new technological solutions, introducing new recipes, additives applied as well as the growing consumers' demands. The demand on bakery products depends not solely on the bread quality, but also their tastiness, variety, freshness, stability and pro-health properties. As a result, nowadays the bread assortment is still enriched in novel products with increased nutritional value, lengthened stability, dietetic bread and special one due to its flavour and form as well as a functional bread with beneficial health effect [1, 2, 3]

The attention to bread enriching is paid by the consumers themselves, who in relation to civilisation disease development, plans to compose their diet correctly, from a nutritional point of view, using products with additional nutritional effect in organism [4, 5]. The increasing of nutritional value in bread is applied, using adding raw materials or natural additives that possess a source of determined nutrients. This allows to obtain the nutritional products with functional food properties. The usually applied are: grains and cereal preparations from non-bread cereals and pseudocereals, oilseeds, milk and milk products, vegetables, fruit and their preparations, herbs and spices [6, 7]. It was observed that dark bread attracts high interest [1, 2]. Dark bread is obtained from wholemeal flours, but products that are made with colouring additives such as coffee, caramel or the addition of coconut shell ash or banana or squid ink are also gaining popularity [8, 9]. New method of giving the bread colour could be an application of activated carbon at the manufacturing stage. Activated carbon has not found any application in bakery, so far. The application of activated carbon in food, links with the necessity of methods improvement of its receiving and also the assessment of its impact on manufacturing processes and final product quality. The using of activated carbon gives not colour, solely, but also the post-digestion effect due to its adsorbable surface [9]. Medicinal charcoal in activated form is a thermally treated organic-derived material that due to the microstructure possesses high adsorbability of gases, toxic substances and many drugs from the lumen of the digestive tract. The porous charcoal surface is considered to be capable to adsorb bacterial toxins [10, 11]. The basic premise to apply medicinal charcoal is a neutralisation in digestive tract the toxic doses of several drugs and chemical substances taken in overdose e.g. paracetamol, tricyclic antidepressants. According to summary of product characteristics, medicinal charcoal preparations can be used in treatment of serious diarrhea in adults and children over 12 years of age [12]. After oral administration, the medicinal charcoal acts locally in the gastrointestinal tract and is not absorbed from the gastrointestinal tract. Characteristically stains stool black, which can sometimes mask gastrointestinal bleeding. To rare side effects of medicinal charcoal, connected with among others electrolytes binding, can be accounted headaches, nausea, vomiting and constipation [11]. Therapeutic charcoal is contraindicated in vomiting or unconscious people, but not intubated, due to the risk of lung aspiration, in patients with slow intestinal motility due to the risk of intestinal obstruction or perforation, as well as after surgery, in electrolyte imbalance, and dehydration, immediately before endoscopic examinations. In healthy people, medicinal carbon as an ingredient in food products, may have a beneficial detoxification effect, as mentioned above, allowing the removal of adverse compounds and substances from the intestinal lumen. It is believed that the consumption of active carbon for health purposes that allows the removal of toxins should not exceed the maximum daily dose of 500 mg and a beneficial effect can be obtained at a dose of 100 a even 50 mg per day. Due to the large adsorptive properties of charcoal, recommended is replenishment of electrolytes and prebiotics after carbon intake [12]. An excellent source of activated charcoal is wicker *Salix viminalis*, which cultivation in Poland is highly concentrated in Wielkopolska region.

The aim of work was to assess the feasibility of wicker (*Salix viminalis*) activated carbon application as a functional additive to mixed bread and assess its effect on physicochemical indicators of dough and final product and it nutritional value.

2. Materials and methods

2.1. Research material

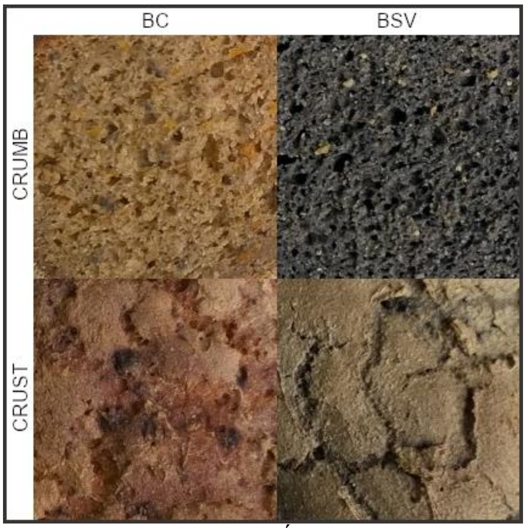
Material was flours made of organic cereals, originated from Organic Farming Cooperative "Dolina Mogilnicy" in Wolkowo, Kamieniec district, where they were ground to flours. In analyses wheat flour type 750, light rye flour type 720, bread wheat flour type 650 were used. In preparation were also used pressed yeast, salt and sugar purchased in detail network of city of Poznan.

Research material was wicker biocharcoal obtained from Organic Farming Cooperative "Dolina Mogilnicy" in Wolkowo, Kamieniec district. Particles size was in range between 200-300 μm. Charcoal preparation contained also other ingredients such as Mn (1.33 ug/g), Fe (22.44 ug/g), Zn (1.85 ug/g), Cu (<1 ug/g ug/g), Mg (3.61 mg/g), Ca (13.84 mg/g), K (8.86 mg/g), Na (2.65 mg/g).

2.2. Bread preparation

For baking were used 300 g wheat flour type 750, 100 g light rye flour type 720, 100 g bread wheat flour type 650, 50 g fresh pressed yeast, 12 g salt, 6 g sugar, 450 ml lukewarm water. Bread baking was conducted using direct monophase method. Dough was obtained by admixing the ingredients in laboratory kneader GM-2 (ZBPP, Bydgoszcz). Fermentation in temp. 37ºC at relative humidity 80% lasted 1 h (with puncture after 30 min). Bites of dough weighting 250 g were placed in fermentation chamber until optimal growth (temp. 37ºC, rel. hum. 80%). Baking was conducted 30 min in temp. 210ºC in convection oven in absence of steam, with hot air (RATIONAL SCC201E, Germany).

Bread with addition of activated carbon was prepared with the preparation at amount .% in relation to flour weight, and samples were encoded, respectively: BC – control bread, BSV – bread with addition of wicker charcoal (Fig. 1).



Source: own study / Źródło: opracowanie własne

Fig. 1. Bread crumb and bread crust from BC and BSV samples

Rys. 1. Miękisz oraz skórka chlebów BC i BSV

3. Methods

3.1. Flour characteristic

The flours were subjected to determination of basic parameters, such as water absorption according to PN-EN ISO 5530-1:2015-01; humidity using drying method, according to PN-EN ISO 712:2012; falling number according to PN-ISO 3039:2010 and quantity and quality of gluten according to PN-EN ISO 21415-1:2007.

3.2. Bread nutrition value

Protein content in product was determined using Kjeldahl's method, according to PN-EN ISO 20483:2014-02 standard. Analysed sample was mineralised in sulphuric acid, in presence of copper as a catalyst, in temperature 420°C by 90 minutes. Mineralised sample was distilled and the total nitrogen content was assayed. Then, the protein content was calculated using special coefficient. Fat content was determined according to PN-EN ISO 11085:2015-10 standard. Method bases on sample extraction with organic extractant. The resulted fat sample was next dried in extracting flask in temperature 105ºC, and after that point was weighted with accuracy to 0.001 g. Mineral salts content was conducted according to PN-A-74108:1996. In bread the aqueous extract of crumb sample was titrated with silver nitrate against potassium chromate neutralized salt solution. For bread samples the salts were extracted using hot water and then chloride titration was conducted with silver nitrate against potassium chromate as an indicator. Dry mass content was done according to PN-A-88027:1984. The test based on weight designation of sample mass during drying. Analysed sample was kept in dryer at temperature 105°C until it reached stable mass. Dried samples were cooled in desiccator and weighted with accuracy to 0.001 g. Ash content determination was conducted according to PN-EN ISO 2171:2010. The sample was firstly combusted and then the weight determination of mineral residues was done. Carbohydrates content was calculated using following equation:

Total carbohydrates = 100 – (water + protein + fat + ash).

Total dietary fibre (TDF), insoluble (IDF) and soluble dietary fibre fraction (SDF) were determined using Asp's enzyme-gravimetric method [13]. Sample was digested using enzymes: thermostable amylase (termamyl) and pancreatin, and then weight determination of nondigested residues was conducted. Fatty acids methyl esters were analysed quantitatively using gas chromatography technique. Fat sample (10 mg) was dissolved in 1 ml hexane and then subjected to transesterification process with 0.4 M sodium methoxide solution. Obtained esters were analysed with help of gas chromatograph Agilent Technologies 7820A GC, with FID detector and capillary column SP-2560 with dimensions 100 m, 0.25 mm, 0.20 μm (Supelco). Elution of methyl esters was conducted in temperature gradient starting from 140°C (5 minutes) to 240°C (temperature growth 4°C/min) in 40 minutes time, in split (1:10) mode. Injector and detector temperature was 260°C. Carrier gas was helium at flow 1 ml/min. Fatty acids were identified according to the standards retention times. Nutritional value (NV) in products was calculated using the following equation:

NV = (protein content x 4 kcal) + (fat content x 9 kcal) + (carbohydrates content x 4 kcal).

3.3. Bread quality assessment

Baked bread was subject to analysis. Firstly, dough yield was assessed and loaf volume and crumb specific mass was determined after baking (on fresh but cooled bread). The mass of the bread after removing from the oven and 24 hours after baking was used to calculate the oven loss (baking) and bread efficiency. The specific mass of bread and the previously mentioned parameters were determined according to the methodology described by Jakubczyk and Haber [14].

3.4. Sensory assessment

Sensory profiling of bread samples was conducted in sensory laboratory meeting the requirements specified in the PN-EN ISO 8589:2010 standard. A quantitative descriptive analysis method, another called sensory profiling, was used and conducted by 20-person team specially trained for this purpose. Assayed were individual qualitative determinants of taste, aroma, consistency and colour, chosen in preliminary study. Intensity of each qualitative mark was determined with help of 10-cm unstructured linear scale with appropriate edge markings. Obtained results were converted into numerical values given in contractual units (points).

3.5. Statistical analysis

All presented values presents the mean values from three independent experiments conducted in threefold repetition. Experimental data was analysed using unidirectional analysis of variance ANOVA ($p<0.05$), so as to determine differences between mean values of tested samples, as well as using Turkey's multiplicative interactions test. Pearson's correlation coefficients were also calculated. Differences were considered as significant at $p<0.05$. Analysis was performed using Statistica TMPL 10.0 (StatSoft) software.

4. Results and discussion

Wheat flour type 750, rye flour 720 and bread wheat flour type 650 used in study, possessed good baking properties. Water absorption and moisture content of flours were respectively 55.8%, 47.4% and 59.6%, and 14.8%, 14.1%, 14.7%. Gluten content obtained using manual washing method was, respectively 28%, 15% and 32%, while it gluten featured a relatively high spreadability of 9 mm, 3 mm and 10 mm. Amylases activity was poor (the falling number was 344 s, 180 s and 332 s).

Table 1 shows technological parameters of experimental bakings and changes in them affected by activated carbon.

It was noted that addition of activated carbon to bread had an impact on a majority of bread quality parameters. Significantly higher bread performance was noted in case of traditional bread, while no significant differences were observed in performance of obtained doughs. The impact of coal in experimental bread was observed in the baking loss of the so-called roasting, and obtained results were significantly lower compared to the control. As a result of the addition of carbon in bread, the volume of loaves decreased by about 7%. In Table 2 nutritional value information of newly developed bread is presented.

Table 1. Characteristics of technological properties of model bread containing *Salix viminalis* carbon

Tab. 1. Charakterystyka właściwości technologicznych modelu chleba zawierającego węgiel aktywny z wikliny (Salix viminalis)

Parameter	BC	BSV
Dough performance [%]	172.76ᵃ±2.34	170.22 ᵃ ±1.55
Oven loss [%]	7.75 ᵇ ±0.12	7.12 ᵃ ±0.09
Bread performance [%]	155.65 ᵇ ±2.51	143.76 ᵃ ±2.87
Bread volume [cm^3/100 g]	286.87 ᵇ ±3.51	267.87 ᵃ ±1.83
Crumb specific mass [g/cm^3]	0.81 ᵃ ±0.02	0.89 ᵇ ±0.01

Mean values marked with different lowercase letters in the same line shows significant differences ($p \leq 0.05$).

Source: own study / Źródło: opracowanie własne

Addition of activated carbon affected the nutritional value of bread. Novel bread possessed higher content of macroelements such as protein, fat and carbohydrates, and therefore higher energy value. No significant differences were noted in dietary fibre content and fatty acids content, as well as salt content. Bread with addition of activated carbon had higher ash content which is the same as mineral elements provided by charcoal.

Food sensory properties are determinant of the economic success of the product on the market. Functional products, except properties originating from functional additives applied, must have acceptable sensory properties. For tested bread a characteristics of basic sensory descriptors was conducted. Analyses results are shown in Fig. 2.

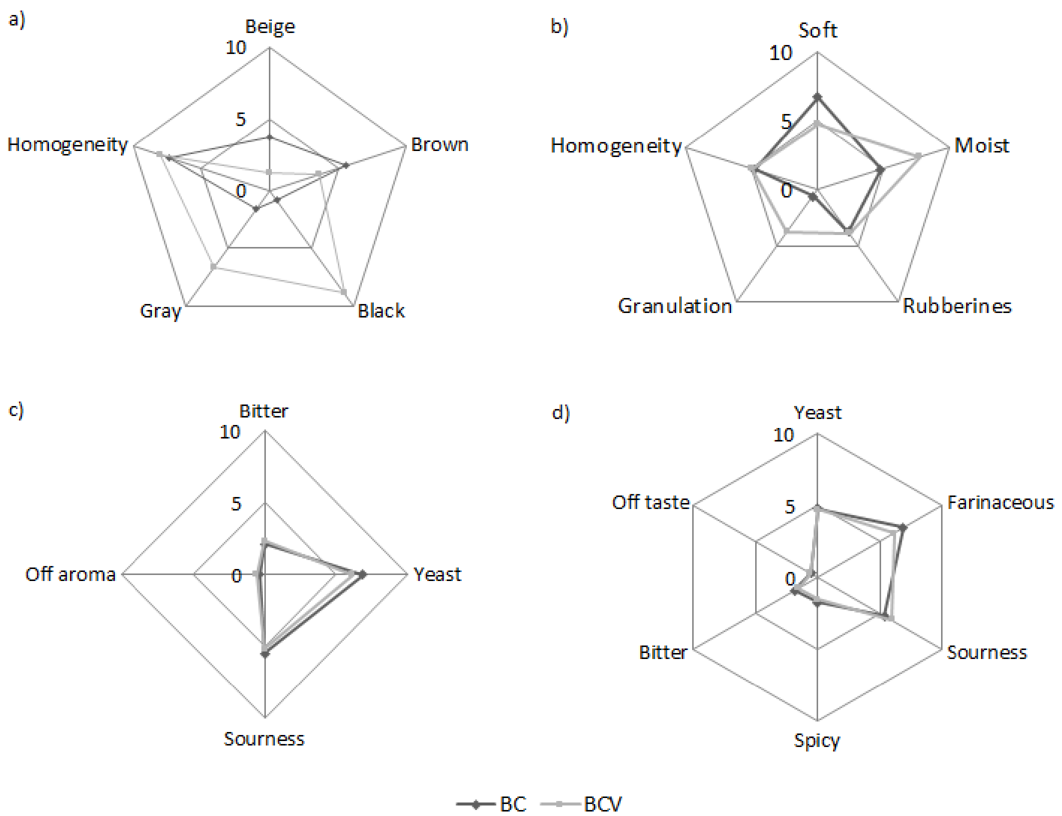
Table 2. Nutritional value of bread

Tab. 2. Wartość odżywcza pieczywa

Product	BC		BSV	
	Mean	SD*	Mean	SD
Energy value [kcal/100 g]	195	-	210	-
Fat [g/100 g product]	0.74	0.09	0.77	0.01
Saturated fatty acids [% in 100 g fat]	31.49	2.59	30.19	0.01
Unsaturated fatty acids [% in 100 g product]	0.25	-	0.23	-
Carbohydrates [g/100 g product]	43.55	0.58	45.51	0.82
Fibre content [g/100 g product]	19.90	0.12	19.60	0.20
Protein [g/100 g product]	4.81	0.19	5.36	0.21
Salt [g/100 g product]	2.44	0.03	2.66	0.03
Dry mass [g/100 g product]	51.08	0.74	54.26	0,94
Ash [g/100 g product]	2.58	0.07	2.62	0.12

Mean values marked with different lowercase letters in the same column shows significant differences ($p \leq 0.05$).

Source: own study / Źródło: opracowanie własne



Source: own study / Źródło: opracowanie własne

Fig. 2. Sensory profiles of tested bread samples: a) colour, b) consistency, c) aroma, d) taste

Rys. 2. Profile sensoryczne badanych prób chleba: a) kolor, b) konsystencja, c) zapach, d) smak

In sensory assessment the bread with addition of activated carbon obtained higher marks in black and grey colours and moisture and granulation, than the control bread (Fig. 2). Taste and aroma attributes of bread with addition of charcoal were similar to the control bread. Addition of charcoal did not cause the appearance of off smell and taste.

The quality of bread is a complex and difficult to define. It contains a set of various characteristics such as: nutritional value, healthiness, palatability and durability, as well as attractiveness for the consumer. Bread belongs to perishable products and adverse physical and chemical changes begin to appear in it immediately after baking and are the result of, among others water loss. The problem of bread moisture has been a matter of great interest for bakers and consumers for years [15, 16, 17]. As shown in the paper, the addition of carbon can increase the sensory humidity of bread, but also determines a smaller volume of bread, which in turn increases the amount of water in the product. The impact assessment of the functional additives used is relevant in food design [15]. Added ingredients not always may affect bread properties clearly. Kang et al. [16] stated that addition of a majority of hydrocolloids affects negatively bread volume, while Pourfarzad et al. [19] noted that application of inuline and some fibre fractions as ingredients may increase the volume. Applied additives may affect the formation and quality of the gluten complex [5]. Used technological additives may act multidirectionally giving divergent effects. For instance, proteins cause the effect of diluting the amount of wheat proteins forming the gluten structure through protein-protein complexes, and on the other hand, reduces the strength of the bubble membranes or causes their porosity so that they form a weaker barrier to the produced fermentation gases [3, 17]. The impact of charcoal on bread structure can be explained by the formation of intermediary interactions during the creation of a structure built of multiple components, and the carbon that is a porous structure promoted water retention and hindered the growth of gluten due to fermentation. Therefore increased moisture can be interpreted as a positive effect of proposed application. Moreover, a meaningful observation is the lack of a clear impact of charcoal on the taste and smell of novel bread.

5. Conclusion

Bread is a food product of exceptional importance to mankind. Its basic function is associated with ensuring the proper state of health of society. As it is a product widely consumed in the daily diet, it can also be a carrier of functional ingredients. Such ingredient can be activated carbon obtained from wicker, which positive effect is caused by adsorptive properties. Novel bread with charcoal can be a response to the demand of functional bread with the activity associated with the purification of intestinal lumen from unwanted compounds and metabolites. Activated carbon obtained from wicker can be a valuable bread ingredient, affecting its moisture and therefore its texture, and at the same time has few effect on the taste and smell of the new product.

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