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Possibilities for utilization of dietary fiber-rich supplement from pepper (*Capsicum annum L.)* processing waste in bakery products

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Abstract
By the application of processes of stabilization through drying, separation of seed and grinding of remaining placenta dietary fiber-rich powdered product was obtained from pepper (*Capsicum annum* L.) processing waste. Effects of dosing of pepper placenta-based supplement (1, 2 and 3%) on farinograph, extensograph and amylograph parameters, as well as test baking, were conducted in this study.
Addition of pepper placenta-based supplement resulted in an increase of farinograph water absorption in obtaining of darker and more intensively colored bread crust and in smaller and more evenly distributed pores of breadcrumb. It also inhibited the firming of breadcrumb during bread shelf life. The main negative effects of the application of placenta-based supplement were the increase of dough resistance and the decrease of breadcrumb cohesiveness.

1. INTRODUCTION

In the process of pepper (*Capsicum annum* L.) industrial processing significant quantities of waste consisting of pepper seed and placenta are generated (Lee et al., 2017). Pepper seed and placenta are currently disposed of as organic waste. Pepper processing waste might can be treated as a nutritionally valuable byproduct. Which, after the stabilization, be used as a functional ingredient for diverse food products.
Contemporary trends promoting sustainability of food production chains, environment protection, and incorporation of ingredients with functional properties into the food products resulted in a number of diverse solutions for utilization of food waste in food applications (Belović et al., 2017). Development of processes for obtaining safe secondary food products from the food waste has been in the focus of interest of many researchers for a long time. However, the non-food applications that might be also considered as wasting food, are still the most common way of the food processing by-product utilization (Raak et al., 2017). Food byproducts are a valuable source of compounds deficient in human nutrition but the main challenge for their successful utilization in further food manufacturing is the need for their immediate processing in order to avoid microbial growth and deterioration (Struck et al., 2016; Raak et al., 2017).
Although pepper waste composition points out at its high nutritive value, the utilization of this waste stream in further processing was very rarely considered, most probably due to its high moisture content resulting in fast safety deterioration. For utilization of pepper processing waste, the process for obtaining of protein extract with antimicrobial properties has been patented (Ziegenfuss et al., 2000). One of the attempts to initiate the utilization of pepper processing waste was presented quite a long time ago by (Ćirić et al., 1973). In this research, the possibility of processing of pepper waste into feed and oil was presented. In suggested pepper waste processing, the procedure the first step was the extraction of oil with diethyl ether

followed with the utilization of reaming solids as feed concentrate with high dietary fiber content (over 35%). In dietary patterns of contemporary consumers, there is an evident deficit of dietary fiber, both, soluble and insoluble (Desai et al., 2016). Based on this fact both, researchers and food supplements producers are inventing and offering numerous solutions for novel sources of dietary fiber (Filipovic et al., 2007; Huang et al., 2016). Bakery products are the group of food products is often emphasized as the potential source of dietary fiber, either based on the increase of production of wholemeal products (Popov-Raljić et al., 2009) or based on the addition of supplements rich in dietary fiber bakery products made from white flour (Filipovic et al., 2007; Arufe et al., 2017). Based on high dietary fiber content pepper processing waste could also be used as a dietary fiber-rich supplement for bakery products. To enable its distribution and incorporation in bakery products, pepper waste has to be stabilized and transformed into easily applicable form. The aim of the present research is to test the effects of utilization of dietary fiber-rich supplement prepared in a pilot plant from fresh pepper waste on wheat dough rheological properties and bread quality.

2. MATERIAL AND METHODS

2.1. Material

Pepper (*Capsicum annum* L. cultivar Anita) waste consisting of seed (35%) and placenta (65%) was obtained from the vegetable processing company Voćar-promet d.o.o., Kalesija, Bosnia and Herzegovina. The waste was refrigerated and transported to the pilot plant at the Faculty of Technology Zvornik, Bosnia and Herzegovina where it was immediately processed.
Drying of pepper waste was conducted using the dryer (Hyppocampus, Essiccate 6T, Italy) with convectional heat transfer. The waste was evenly distributed on perforated shelves in a thin layer and dried at the temperature of 65 °C for 15 hours. During the first 8 hours of the drying process, the complete air recirculation was applied to avoid the over-drying of surface layers of pepper waste. In later drying stages, the recirculation of air was reduced to achieve a sufficiently dry product. In dried pepper waste seed and placenta were mechanically separated by application of pressure and vibration forces, followed by separation of seed by sieving through the metal perforated sieve with round 3 mm compressions diameter apertures. Seed fraction was used for investigation of other applications while placenta fraction was ground using a hammer mill. Obtained pepper placenta powder had more than 90 % of particles passing through 250 μm sieve.

2.2 Methods

Proximate composition of the obtained supplement from placenta fraction from pepper processing waste was analyzed according to the standard methods: gravimetric methods were used for determination of moisture and total minerals content (AOAC, 2000) 925.09 and 923.03. Protein content was determined according to the Kjeldahl method, fat content according to the Soxhlet method, while the determination of dietary fiber was performed according to the AOAC 985.29.2003 method and determination of soluble and insoluble fiber according to AOAC 991.43.2000 method. The prepared dietary fiber-rich supplement was added to the wheat dough with different shares and analysis of dough rheological properties, fermentation properties and baking properties was conducted. Dough rheological properties were analyzed according to standard ICC methods (ICC, 1996) 114/1, 126/1 and 121 using farinograph, extensograph, and amylograph (C. W. Brabender, Duisburg, Germany). For the purpose of determination of fermentation properties dough piece of 100 g was placed right after mixing into the graduated cylindrical container and the height was recorded every 15 minutes for 120 minutes in total.
Bread making process was conducted according to the procedure suggested by (Mastilović et al., 2017) with slight modifications: 300 g of wheat flour, 6 g of yeast, and 6 g of salt and water volume necessary for obtaining dough consistency of 400 BU were mixed for 5 min in a farinograph mixer. The dough fermented for 120 min at 30 °C, divided into 150 g pieces and put in well-greased pans. The dough was proofed for 70 min at 30 °C and 75% relative humidity and baked for 17 min at 220 °C. The loaves were removed from the pans, cooled and stored at room temperature until the quality assessment was conducted 4 h and 24 h after baking. Crust and crumb colour was determined in CIE L*a*b* system using a colourimeter (Chroma Meter CR-400, Konica Minolta, Japan). Breadcrumbs texture profile analysis (TPA) was performed by a Texture Analyzer TAXT2i (Stable Micro Systems, Surrey, UK). A 25-mm-thick piece with diameter 35 mm was taken out of bread slice and compressed up to 75% of its original height at a crosshead speed of 1 mm s-1 and pause of 5 s between two with a cylindrical aluminium flat probe for compression SMS P/75. Values were mean for five replicates for crust and crumb colour and three

replicates for TPA. For breadcrumb structure analysis bread slices were scanned (300x300 dpi) and digital image analysis was conducted using the ImageJ software.

3. RESULTS AND DISCUSSION

3.1. Proximate composition

The results of proximate composition of the obtained supplement from placenta fraction from pepper processing waste (Table 1) confirmed its high dietary fiber content. Dietary fiber of the pepper placenta-based supplement consists predominantly from the soluble dietary fiber. This fact makes it an excellent combination with wheat fiber which is predominantly composed of insoluble fiber (p).

Table 1. Proximate composition of the supplement from placenta fraction from pepper processing waste

Constituent	%
Moisture content	6,3
Protein content	17,5
Fat content	3,8
Mineral content	0,60
Dietary fiber content	58,9
- soluble	56,5
- insoluble	2,4

Other carbohydrates besides dietary fiber are not determined, as they are not considered important, therefore the sum is less than 100%. Dietary fiber of nearly 60 % points out that a relatively low amount of supplement added would enable the production of increased fiber content bread. Besides dietary fiber, prepared pepper placenta-based supplement is characterized with relatively high protein content, while low moisture and fat content enable its long shelf life.

3.2. Effects on dough rheological and fermentation properties

As presented in figure 1 there was no significant influence of addition of pepper placenta powder on the dynamics of dough rising, even during prolonged fermentation. This observation points out that addition of placenta powder did not cause the deterioration of dough structure which would result in increased release of developed CO2 from the dough. In order to investigate the influence of addition of pepper placenta-based supplement independence of added quantity farinograph, extensograph and amylograph were conducted with the addition of 1, 2 and 3% of prepared supplement (Table 2). Obtained results point out that the addition of pepper placenta powder has several effects on wheat dough properties. First of all, pepper placenta powder addition significantly increases the water absorption of wheat dough and enables the production of dough with higher water content.

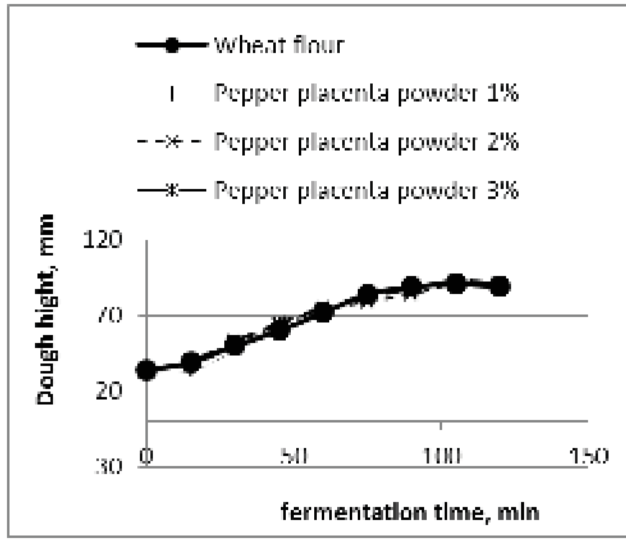

Figure 1. Effects of addition of pepper placenta powder on dough rise during fermentation

This effect is important from two aspects, from the aspect of bread yield which will be much higher in the case of addition of pepper placenta powder and from the aspect of bread shelf life in terms of preservation of sufficient moisture content of breadcrumb during a longer time. The second effect on dough mixing properties recorded on farinograph is the effect on dough development time which even with the lowest tested share of pepper placenta powder increases from 2 up to 8 minutes. However, with further increases of supplement share, dough development time does not increase further. This observation points out that for the doughs in which pepper placenta powder is added longer mixing procedures should be applied to obtain a well-developed dough. Further effect noted based on farinograph measurements is a significant increase of dough softening degree. This points out that short time dough processing procedures might be more suitable for the production of bread with pepper placenta powder addition. However, the increase of dough softening degree is not accompanied with significant amylograph maximal viscosity decrease. Pointing that the increase of softening degree is not the consequence of amylitic enzymatic activity but rather the consequence of the partial release of initially absorbed water in the dough. On another hand, this could be due to the proteolytic enzyme activity. The addition of pepper placenta powder alters also the properties of the dough recorded by extensigraph analysis. Although there are no significant changes in extensograph energy, it can be noted that dough resistance significantly increases while dough extensibility slightly decreases, but still remains in an acceptable range. Obtained results related to the influence of addition of pepper placenta powder on wheat dough are aligned with findings of other authors that reported the results of investigations related to the addition of diverse dietary fiber sources on wheat dough properties. In the investigations conducted by (Gómez et al., 2003) it was noted that purified dietary fibers from different origins like orange, pea, cocoa, coffee or wheat all demonstrate effects on higher water absorption, mixing tolerance and tenacity and smaller extensibility.

Table 2. Rheological properties

	Control	1%	2%	3%
FARINOGRAPH				
Water apsorption, %	59,4	62,0	63,3	64,9
Dough development time, min	2,2	8,9	7,0	6,9
Softening degree, BU	3	57	98	129
EXTENSOGRAPH				
Energy, cm^2	151	171	146	148
Resistance (R), BU	386	667	708	673
Extensibility (E), mm	178	145	128	142
Ratio R/E	3,8	6,5	6,7	5,5
AMYLOGRAPH				
Maximal viscosity, BU	1307	1138	1074	1012

Similar trends regarding the dough rheological properties were reported also by (Huang et al., 2016) when fenugreek fiber was added to the wheat dough.

Photographs of cross sections of bread produced without supplement and with the addition of 1,2, and 3 % pepper placenta powder are presented in Figure 2. The quality of bread produced with the addition of 1, 2 and 3% of pepper placenta powder in comparison to bread produced without additive was analyzed in terms of crust and crumb colour, crumb structure and texture, as well as in terms of changes of crumb texture properties during bread shelf life. Addition of pepper placenta powder resulted in changes of bread crust colour (Table 3). The lightness of bread crust (L*) decreased proportionally to the increase of the share of pepper placenta powder addition. The intensity of red (a*) and yellow (b*) tone in crust colour also increased with the increase of the share of added pepper placenta powder. These results point out that the bread with added pepper placenta powder is characterized with darker and more intensively coloured crust.

Table 3. Effects of addition of pepper placenta powder on bread crust and crumb color

Pepper placenta powder	0%	1%	2%	3%
Crust				
L*	72,76	65,06	62,63	60,92
a*	4,89	7,13	9,17	10,44
b*	29,57	30,60	32,58	33,05
Crumb				
L*	58,2	56,26	59,64	55,56
a*	-0,41	-0,35	-0,28	0,2
b*	10,17	11,36	12,74	14,79

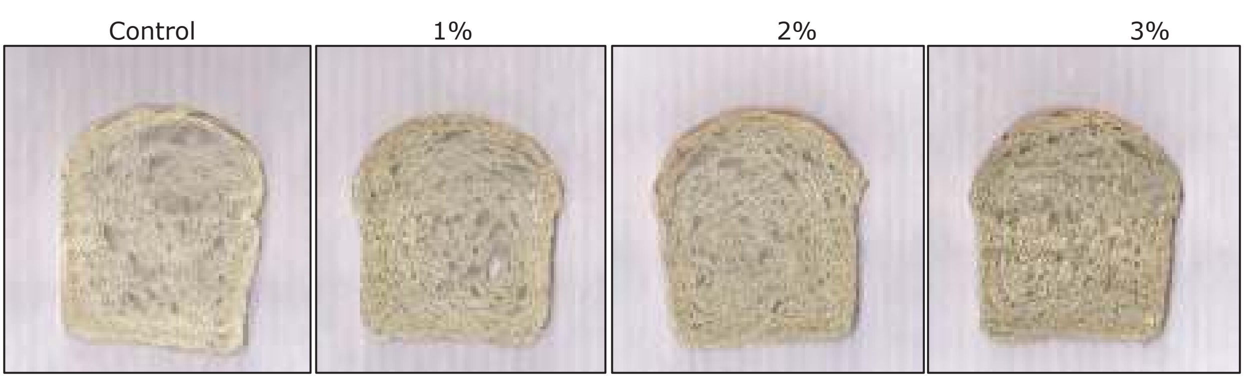

Figure 2. Cross sections of bread produced with 1, 2 and 3% pepper placenta powder in comparison to bread produced without any additives

Breadcrumb colour changes were much less expressed. Only slight, insignificant variations in lightness (L*) and red tone (a*) intensity were recorded while the intensity of the yellow tone (b*) increased proportionally to the share of added pepper placenta powder, with the increase much less expressed than in the case of crust colour. The addition of pepper placenta powder influences to the large extent the structure of the pores in breadcrumb (Table 4).

Table 4. Effects of addition of pepper placenta powder on number, size and distribution of pores in breadcrumb structure

Pores	Control	1%	2%	3%
number /cm²	20	25	26	29
average size	0,414	0,492	0,313	0,278
minimal size	0,100	0,107	0,106	0,101
maximal size	3,243	3,350	1,657	1,430
St. deviation	0,692	0,759	0,347	0,267
CV	167,0	154,2	110,9	95,9

The number of pores per crumb surface area unit increases, most probably due to the less expressed phenomena of forming of larger pores through the integration of pores during fermentation when pepper placenta powder is added to the wheat dough. Average pore size, after the initial increase at the addition level of 1% pepper placenta powder decreases and the distribution of the pores becomes more even, as confirmed by lower standard deviation of pore size and coefficient of variation (CV).

Table 5. Effects of addition of pepper placenta powder on breadcrumb texture properties and their changes during the shelf life of bread

Pepper placenta powder	Firmness	Elasticity	Cohesiveness
4 h after baking			
0%	10,586	0,976	0,778
1%	12,013	0,999	0,758
2%	11,775	0,983	0,746
3%	12,726	0,965	0,718
24 h after baking			
0%	13,678	0,963	0,636
1%	11,537	0,963	0,639
2%	10,586	0,944	0,606
3%	10,823	0,964	0,573

The maximal pore size also decreases with increased levels of pepper placenta powder addition indicating that the appearance of large pores is suppressed. The results of measurement of texture properties of the crumb of bread produced with the addition of investigated shares of pepper placenta powder are presented in Table 5. It is obvious that addition of pepper placenta powder, similarly to other fiber-rich ingredients result in obtaining of a firmer crumb of fresh bread. However, the effect of firming of breadcrumb during the shelf life, which characterizes breadcrumb of wheat bread is not expressed in bread produced with the addition of pepper placenta powder. Moreover, the crumb of bread becomes less firm after 24 hours with a decrease of firmness being more expressed as the share of pepper placenta powder increases. The effect of enhancement of shelf life of bread for bread with added fiber from different sources was reported also by Gómez et al. (2003). No major differences in breadcrumb elasticity were recorded independently of the time of bread shelf life as the result of the addition of pepper placenta powder. On the other hand, the cohesiveness of the breadcrumb decreased with the increase of the share of pepper placenta powder for both, fresh bread and bread 24 hours after baking.

4. CONCLUSIONS

Obtained powdered pepper placenta was tested as a fiber-rich supplement for bakery products. Addition of up to 3 % of powdered pepper placenta resulted in a proportional increase of farinograph water absorption and a increase of dough softening degree, while the extensograph energy and amylograph maximal viscosity were not affected significantly. Addition of powdered pepper placenta significantly increases dough development time and resistance independently of a share of added supplement. Addition of powdered pepper placenta results with darker and more intensively coloured bread crust, while in breadcrumb only the yellow tone slightly increases. The breadcrumb pores of bread produced are smaller and their size distribution is evener. Breadcrumb of fresh bread with powdered pepper placenta is somewhat firmer in comparison with the firmness of crumb of bread without the supplement but the undesired firming of the breadcrumb is avoided when powdered pepper placenta is added with the share of up to 3%.

Obtained results confirm that powdered pepper placenta obtained from the pepper processing waste can be used as a supplement in wheat bread that will improve its composition in terms of dietary fiber content and extension of shelf life.

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