Hungary-Serbia
IPA Cross-border Co-operation Programme

INFLUENCE OF SUGAR BEET DIETARY FIBERS ON COOKIES SHELF LIFE

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ABSTRACT

The structure and composition of sugar beet fibers, a unique combination of naturally occurring soluble and insoluble fibers and calcium, result in many beneficial physiological and functional properties. Sugar beet dietary fibers have also antioxidant properties, and have been successfully used in the formulations of cookies to improve their functional characteristics. The aim of this work was to investigate the influence of sugar beet fibers on cookies shelf life, comparing with commercially available sugar beet fibers - Fibrex. Control cookies and cookies with sugar beet fibers (0, 7, 9 and 11%) were tested every 7 days by DPPH radical scavenging activity, expressed as IC_{50} values, during 6 weeks of storage.
The obtained results indicated that the substitution of wheat flour with dietray fibers in the cookies upgrades their antioxidant activity and prolongs their shelf life. The highest antioxidant activity, and lowest IC_{50} values (about 0,49 g/ml) were measured in the cookies with 11% of sugar beet fibers three weeks of storage. The cookies containing 9% of Fibrex has the best antioxidant properties (IC_{50} 0.58 g/ml) after six weeks of storage.

1. INTRODUCTION

Nowdays it is impossible to imagine the diet without functional food. They are beverages wich beside their nutritive value, have good effect on human health [1, 2]. Possibility of dietary fibers application are wide-spread: bakery products, pastry, meat products, soup, snack products, sweets, müesli products.
It is recomended the daily intake of dietary fibers in amount of 25–35 g. These dietary fibers amount is very hard to reach by consuming the food rich in dietary fiber. In this case additiv from sugar beet is a very good solution [3]. They are different in structure and composition from cereal fibers. They do not contain phitic acid, that is the reason they do not inhibite the mineral resorption [4] but they have a very good water holding capacity. Drying method and fibers particle size has a great influence of water holding capacity [5]. Sugar beet dietary fibers behave themselves as a weak monofunctional resins with cationic exchange. Their ion-binding ability is proportional to concentration of non-metil residues of galacturonic acids [6]. Sugarbeet dietary fibers are good sources of antioxidants too [7]. Ferulic, gentisic and p-coumaric acid have been identified and reported to be predominant phenolic acids in the ethanolic extract of sugarbeet pulp [8]. They are proved to be relatively potent antioxidants [9]. Because cookies contain fat in their formulation, they could oxidize during storage, producing various oxidation products which cause rancidity and deterioration of their sensory properties [10] Therefore shelf-life is one of the major considerations in developing the formulation of cookies. Therefore sugar beet dietary fibers were used in the formulations of cookies to improve their functional characteristics. With sugar beet fibers as the source of dietary fibers, cookies achieve better sensory characteristics [11].

The project is co-financed by the European Union

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Due to the good results of antioxidant activity of the sugar beet fibers, it is indicated to investigate the effect of sugar beet dietary fibers on cookies shelf life.

2. MATERIAL AND METHODS

Materials - Sugar beet fibers are prepared from from sugar beet pulp obtained from sugar factory “Šajkaška”, Žabalj. The sugar beet pulp was dried, powdered and sieved. The sugar beet fibers powder used in cookies are with particle size under 150 μm [12]. The phisico-chemical characteristics of sugar beet dietary fibers are determined according to the AOAC methods [13]: dry substance 93.11%, protein 8.96%, minerals 4.28% in dry substance, total fibers 75.0%. The comercially available sugar beet fibers are Fibrex (Nordic Sugar, Sweden) with particle size smoller then 125 μm. The phisico-chemical characteristics of Fibrex are determined according to the AOAC methods [13]: dry substance 91.05%, protein 9.16%, minerals 3.81% in dry substance, total fibers 74.2%.

Preparation of cookies - Cookies were prepared according to the basic formula which was the formulation of control cookies without fiber as well (all ingredients are calculated on the % wet basis, w/w): wheat flour T-500 55.5%, powdered sugar 19.4%, vegetable oil 11.5%, table salt 0.3%, sodium bicarbonate 0.2%, ammonium bicarbonate 0.1% and water 13%. The 7%, 9% and 11% of wheat flour T-500 was substituted with sugar beet fibers (DF) or Fibrex (F). The mixture of flour, vegetable fat and powdered sugar was mixed using a laboratory type mixer for 5.5 min at low speed (60 min^{-1}). After that all other components dissolved in water were added and mixture was kneaded for 15 min. The dough was rested at 20 °C during 3h and was shaped into circular form of 46 mm diameter and 5 mm thick. The cookies were baked in oven at 230 °C for 15 min.

DPPH radical scavenging activity - DPPH (1,1-diphenyl-2-picrylhydrazyl) test was used to determine the antioxidant activity and it was examined with the aim of determining the capability of donating H-atoms, or "scavening" effect, using the DPPH method [7].

DPPH radical scavenging activity test were applied to cookies. Preparation of the methanolic extracts of cookies was carried out reported by Fan et al. [14] and according Sakač et al. [15]. scavenging activity test was carried out according to the modified method of Hatano et al. [16].

The ability to scavenge the DPPH (RSC – radical scavenging capacity in %) was calculated by the eq. (1):

$$RSC = 100 - (A_{sample} - 100 / A_{control}) \quad (1)$$

where A_{sample} is the absorbance of the test sample (DPPH solution plus test sample) and $A_{control}$ is the absorbance of the control (DPPH solution without sample). The IC_{50} value (mg/ml) was defined as the concentration of an antioxidant extract which was required to quench 50% of the initial amount of DPPH under the given experimental conditions. It was obtained by interpolation from linear regression analysis.

3. RESULTS AND DISCUSSION

The Figure 1. shows the required concentration of cookies with different quantity of sugar beet fibers, in order to achieve a reduction of 50% of present DPPH free radicals (IC_{50}) depending on the storage time. The lower IC_{50} values of cookies indicates a higher antioxidant activity, or better shelf life of the tested cookies.

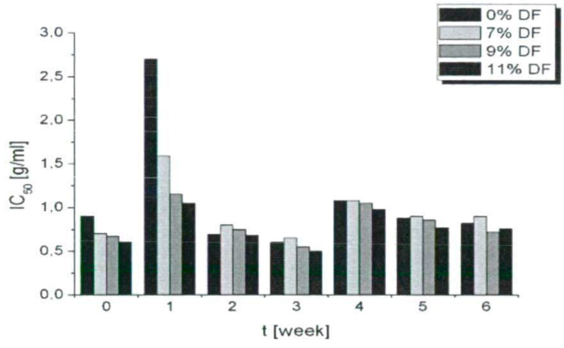

Figure 1. IC_{50} values of dietary fibers enriched cookies during six weeks stored

Based on the results presented in Figure 1. it is noted that the IC_{50} value generally decreases with the increase of quantity of dietary fibers in the cookies during the weeks of storage. Cookies with 9% of dietary fibers have the lowest IC_{50} value in the sixth week of storage. In the mentioned week there is a distinct trend of change in IC_{50} values depending on the share of dietary fibers in cookies compared to the other weeks. It is assumed that the change of antioxidant activity of cookies rich in dietary fibers in the sixth week is also a result of certain chemical changes in the cookies.

The lowest IC_{50} values, or the best antioxidant properties belong to cookies in the third week of storage. The IC_{50} value of cookies with 11% and 7% fibres in this week was 0.49 g/ml and 0.61 g/ml, respectively.

The obtained results confirm that an increasing the share of dietary fibers in cookies of 4% leads to a decrease of IC_{50} value for 0.12 g/ml.

Control cookies (without dietary fibers) during all six weeks of storage have a higher IC_{50} values compared to fibers enriched cookies, which confirms the assumption of a positive impact of dietary fibers on cookies shelf life.

The necessary concentration of cookies with Fibrex, in order to achieve a reduction of 50% of present DPPH free radicals (IC_{50}), depending on the storage time is shown in Figure 2.

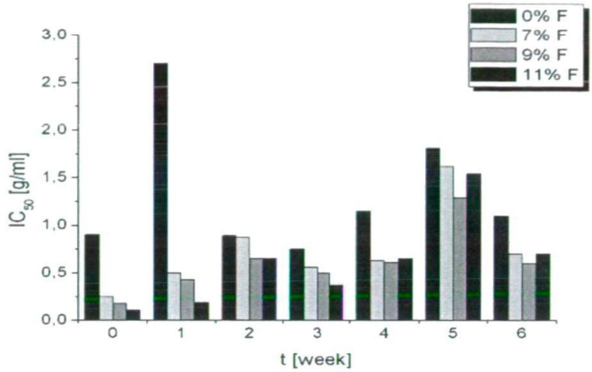

Figure 2. IC_{50} values of Fibrex enriched cookies during six weeks stored

The results indicate that the IC_{50} values also decrease with the increase in the share of dietary fibers in cookies till the fourth week of storage. It can be concluded that in the fourth week of storage the IC_{50} values for cookies with Fibrex share of 7%, 9% and 11% are almost equal, amounting to an average of 0.63 g/ml. In the fifth week of storage there is a significant increase in IC_{50} value above 1.2 g/ml. It is assumed that fifth week of storage leads to change of antioxidant capacity of cookies because of chemical changes occurring in them, while the best shelf life is achieved in the sample with 9% Fibrex.

IC_{50} values of Fibrex enriched cookies after seven days of storage (1 week) were the lower than the IC_{50} values in the next six weeks of storage. In that week the cookies with 7% of Fibrex have a value of IC_{50} in the range of 0.13 to 0.24 g/ml. Since the control sample has the highest IC_{50} value (0.90 g/ml) it is obvious that Fibrex has a positive antioxidant effect on cookies. In the sixth week it is observed decline of IC_{50} value in cookies with Fibrex added up to 0.58 g/ml. The best antioxidant properties, or the best shelf life is registered in cookies with the addition of 9% of Fibrex.

Control cookies without the addition of dietary fibers during the six weeks of storage have a higher IC_{50} values compared to cookies with Fibrex added, which confirms the assumption of better shelf life of cookies with the addition of dietary fibers.

The Figures 3. and 4. show the determination of RSC of cookies with the addition of dietary fibers and Fibrex depending on storage time and their share in cookies. Within the graphic there is regressive equation (2) with six members, which was obtained based on experimental values of storage time and share of fibers depending on the RSC.

$$RSC\ [\%] = b0 + b1*C+b2*t+b11*C*C+b12*C*t+b22*t*t \qquad (2)$$

In this equation b0, b1, b11, b12 and b22 are regression coefficients, C (%) is share of fibers in cookies and t (week) is storage time. The data obtained presented in Figure 3. indicate that the cookies with dietary fibers at the level of 10 - 11% have the highest antioxidant activity of about 55%.

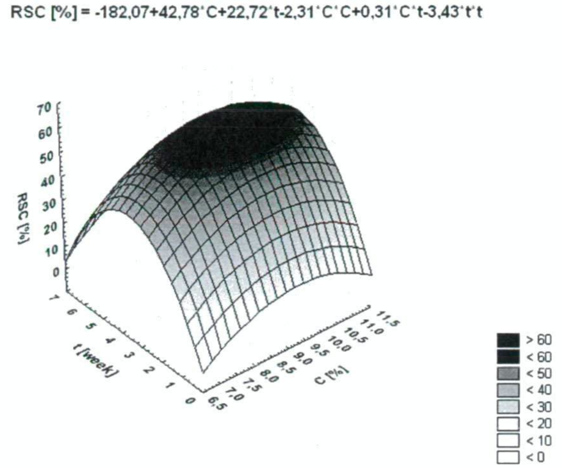

Figure 3. RSC values of cookies in the function of dietary fiber quantity and the storage time

Also, it can be concluded that the best results, or the most expresssed antioxidant activity in the fibers enriched cookies is achieved in the third week of storage. These observations are consistent with the conclusions derived from the results of determining the IC_{50} (Figure 1).

The results of RSC for cookies with the addition of Fibrex were presented in Figure 4. The greatest values of RSC, as well as in samples with sugar beet dietary fiber, can be achieved with the addition of 9 - 11% of Fibrex, in the initial week of storage. The mentioned values are at level of 90% that is significantly higher than the RSC values in cookies with dietary fibers in the third week of storage (55%).

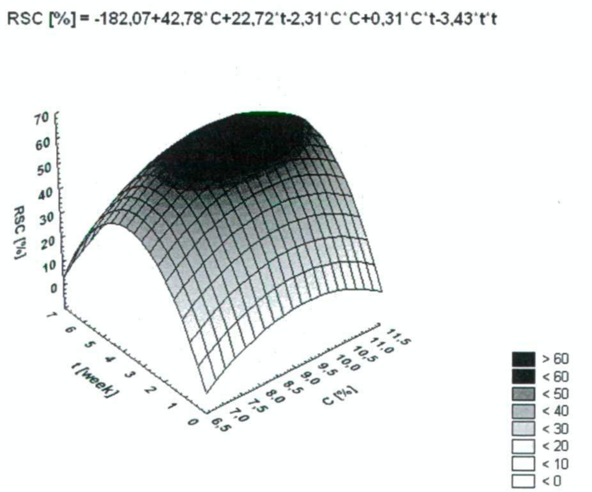

Figure 4. RSC values of cookies in the function of the Fibrex quantity and the storage time

In the sixth week of storage it is also observed high RSC value of about 75% in cookies containing 9 - 11% of Fibrex. The results obtained by statistical regression analysis are consistent with the results for IC_{50} presented in Figure 2.

4. CONCLUSION

Based on the results of analyzing the influence dietary fibers on the antioxidant properties and prolongation of shelf life the following can be concluded:

- In the initial week of storage the IC_{50} values of cookies with fibers range from 0.59 to 0.70 g/ml. Increasing the quantity of dietary fibers in cookies for 4% leads to a decrease of IC_{50} for 0.11 g/ml. The lower IC_{50} values compared to the control sample (0.9 g/ml) verify a positive antioxidant effect of dietary fibers.
- The cookies with 11% dietary fibers in the third week of storage have the highest antioxidant activity - RSC about 55%.
- The cookies containing 9% of Fibrex have the best antioxidant properties (IC_{50} 0.58 g/ml), or shelf life in the sixth week of storage.

- The highest value of RSC is noticed in cookies with 9 - 11% Fibrex in initial and sixth week of storage, about 90% and 75%, respectively
- IC_{50} values of cookies with Fibrex were higher in comparison to those obtained for cookies with similar quantity of dietary fibers by about three times.
- Control cookies during all six weeks of storage have a higher IC_{50} value than cookies with Fibrex, which confirms the assumption of better shelf life of fibers enriched cookies.

ACKNOWLEDGMENT
The authors thank to the Ministry of Education and Science, Republic of Serbia, for the support (Project: TR 31014).

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