Raw Materials in Fibre Enriched Biscuits Production as Source of Total Phenols

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Summary

Due to scientifically well documented health beneficial effects of dietary fibres and recommendations for an every day intake on an average of 30 g by food (DRI 2005), the confectionery industry has been increasingly engaged in the production of fibre enriched biscuits with the aim to offer such a product as a valuable constituent of proper nutrition and dietetic functional food intended for risky populations. Thereby, commercially available pure fibres or fibre-rich raw materials have been used for the enrichment of biscuits, prevalently pure fibres. To evaluate such products as functional food it is of interest to know how the choice of raw material for biscuit fibre enrichment influences the content of other health protecting compounds which commonly accompany fibres in plant material. With the aim of evaluating fibre rich biscuits as a source of total phenols depending on the origin of fibres, total phenols were determined spectrophotometrically by a modified Folin-Ciocalteau method (Gao et al. 2002) in ten experimentally baked biscuits based on wheat flour type 500 and type 1700 with or without different dietary fibres or fibre rich raw materials added instead of definite amount of white flour. Results show that shares of total phenols and fibres in biscuits based on the wheat flour depend on the type of the flour. Biscuits with pure wheat and oats fibres added were the lowest in phenol content regardless on the highest amount of fibres (0.96 g kg^{-1} and 1.09 g kg^{-1}, respectively); inulin and amaranth do not change essentially phenol content; apple fibres, soya flour, and carob flour enhance phenol content thereby carob flour being the most effective giving biscuits 5.53 g total phenols kg^{-1}.

Key words

fibre enriched biscuits, raw materials, total phenols

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Introduction

Cereals and cereal-based products, especially whole grain based once, are considered as a functional food due to their well-documented beneficial effects in prevention of some chronically diseases such as cardiovascular diseases, some kinds of cancer, diabetes, constipation, obesity etc. (Jacobs et al. 1995, Fuchs et al. 1999, Brown et al. 1999, Erkkila et al. 2005, Slavin et al. 1997, Liu et al. 1999). The effects are attributed in a great part to dietary fibers as well as to accompanying bioactive phytochemicals such as phenol compounds, phytic acid, phytoestrogens etc.

However, cereal-based confectionery products having a high content of carbohydrates, sugars in particular, are considered by nutritionists and consumers as a source of so called "empty energy" and one of the factors affecting obesity throughout all populations, especially children. Therefore, these for many people favorite cereal products are on the list of food recommended to be avoided in nutrition.

On the other hand, considering the fact that biscuits are widely consumed by all populations, they are an appropriate „carrier" for different protecting compounds becoming in this way the functional food.

Since last decades modern nutritional science has been lay stress on important role of dietary fiber in health protection and prevention of modern diseases and on necessity of every day intake of dietary fibres by food (Flammang et al. 2006, Periera and Ludwig 2001, Periera et al. 2004), confectionery industry has been increasingly engaged in production of fibre enriched biscuits with the aim to offer such product as a valuable constituent of proper nutrition and dietetic functional food intended for risky populations. Thereby, commercially available pure fibres or fibre-rich raw materials have been used for the enrichment of biscuits, prevalently pure fibres.

Recent scientific investigations point out that the intake of dietary fibers from whole grain or whole grain products are more effective in health protection when compared to refined grain fibers because of the possibility of loosing potent protective phytochemicals in refined grain fibers (Jacobs et al. 2000), such as phytic acid and phenol compounds for example.

Total phenols or "polyphenols" are a heterogeneous group of structurally different compounds ranging from simple phenol molecules to high molecular mass complex polymers.

The most important phenol compounds in nutrition are phenol acids, flavonoids and tannins. The main sources of phenols in nutrition are fruits and different beverages (fruit juices, tea, vine, coffee etc.), and to a lesser extent vegetables and grains. However, cereals are considered to be very important source of phenol compounds due to their high intake in everyday diet. Scalbert and Williamson (2000) found that the average intake of total phenols through food consumption is 1g per day.

The main phenol compound in wheat is ferulic acid and it makes 90% of its total phenol content. Since it is mostly found in outer parts of the grain, its richest source is wheat bran (Beta 2005).

Some other raw materials used in our research have a significantly different phenol composition. For example soy flour mostly contains phytoestrogenic isoflavons like genistein and daidzein, while in carob the most represented compounds are different gallic acid derivatives as well as free gallic acid (Fontaine et al. 2003, Owen et al. 2003). Differences in phenol composition of raw materials can result in dissimilar types of their biological activity. Namely, foods rich in phenol compounds show various health protecting effects such as cardiovascular disease prevention (Watanabe et al. 2002) and carcinoma prevention. Some of them also show neuroprotective effects in Parkinson disease (Mandel and Youdim 2004) as well as antimicrobial activity (Cushine and Lamb 2005).

Therefore, the aim of our work was to investigate how the choice of raw materials in fibre rich biscuit production influences the total phenol content as an important contributor to antioxidative capacity of cereals and cereal-based products, and to evaluate the fibre rich biscuits as a source of total phenols.

Material and methods

To evaluate raw material in the production of fiber rich biscuits as a contributor of total phenols in baked products, cereal-based biscuits were prepared with wheat flour of different milling extraction (flour T 500 and T 1700) without or with different pure fibres or fibre rich raw materials added. Wheat fibres, oats fibres, apple fibres, and inulin were chosen as often-used fibres in production of enriched food products while soya full fat flour, milled amaranth and carob were chosen due to their fibre content, specific composition and/or known beneficial health effects. Experimental biscuits were laboratory prepared using a recipe of the standard tea biscuit as far as the amount of flour, fat, added sugar, powder milk, salt and flavour was concerned and having a definite proportion of white wheat flour T 500 (35 %) and whole grain wheat flour T 1700 (65 %). Enriched biscuits were prepared by substitution of the part of white flour by pure fibres (17 %) or fibre rich raw material (25 %). For the sake of comparison, biscuits based only on white wheat flour and wheat whole grain flour were prepared, as well. The maximal amounts of pure fibres or raw materials were chosen respecting dough properties

Table 1. Total phenols in raw materials

Sample		Total phenols (g kg^{-1} of sample)			RSD	Total phenols (g kg^{-1} dry matter of sample)			RSD
Number	Type	1*	2*	Mean value	%	1*	2*	Mean value	%
I	Wheat flour T 500	0.88	0.89	0.885	0.56	1.00	1.01	1.005	0.70
II	Wheat flour T 1700	1.46	1.44	1.450	0.69	1.66	1.63	1.650	1.29
III	Apple fibre	9.77	9.93	9.850	0.81	10.76	10.95	10.860	0.87
IV	Oats fibre	0.17	0.17	0.170	0.00	0.18	0.18	0.180	0.00
V	Wheat fibre	0.05	0.06	0.055	12.86	0.06	0.07	0.065	7.69
VI	Inulin	0.13	0.14	0.135	5.24	0.13	0.14	0.135	3.70
VII	Amaranth meal	1.49	1.42	1.460	3.39	1.68	1.60	1.640	2.44
VIII	Soya full fat flour	4.94	4.58	4.760	5.35	5.28	4.89	5.090	3.83
IX	Carob meal	41.07	38.38	39.730	4.79	46.48	43.44	44.960	3.38

SD = standard deviation; RSD = relative standard deviation; * = parallel determinations

and sensory quality of biscuits. The biscuits were as follows: three cereal based biscuits: 1) white wheat flour biscuit (T 500), 2) wheat whole grain flour biscuit (T 1700), 3) standard tea biscuit (T 1700 flour + T 500 wheat flour); four biscuits enriched with pure fibres: 4) apple fibre biscuit, 5) oats fibre biscuit, 6) wheat fibre biscuit, 7) inulin biscuit, and three biscuits enriched with fibre rich raw materials: 8) amaranth meal biscuit, 9) full fat soy flour biscuit, and 10) carob meal biscuit.

Prepared doughs were rolled, formed and baked at 175^{0}C for 15 min, cooled and milled to particle size < 1 mm, and stored in dry containers at 4 °C. Total phenols were determined in defatted samples by modified Folin-Ciocalteau method (Gao et al. 2002) spectrophotometrically at 725 nm (ATI Unicam UV/VIS Spectrometer UV4).

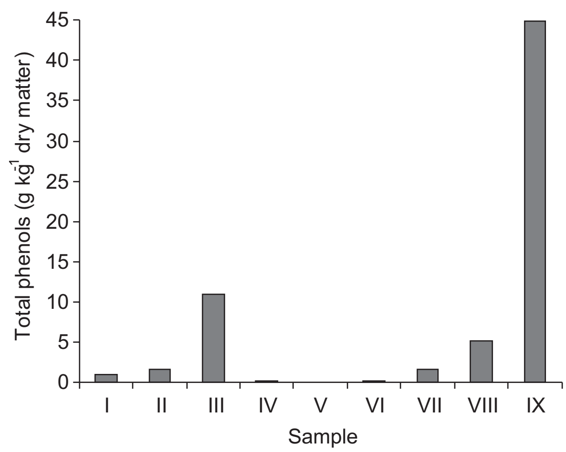

Figure 1. Total phenols in raw materials

Results

Total phenols in the raw materials used in the preparation of investigated biscuits, together with moisture content, are presented in Table 1. Differences in total phenol content in examined fibre rich raw materials are evident from Figure 1 showing total phenols in dry matter of samples.

Shares of total phenols determined in three series of ten experimentally baked biscuits and the share of total dietary fibres (TDF) determined in the same samples by an enzymatic-gravimetric AOAC 991.43 method published previously (Vujić et al. 2005) are presented in Table 2.

Figure 2 shows differences in total phenol content in biscuits depending on the raw materials used.

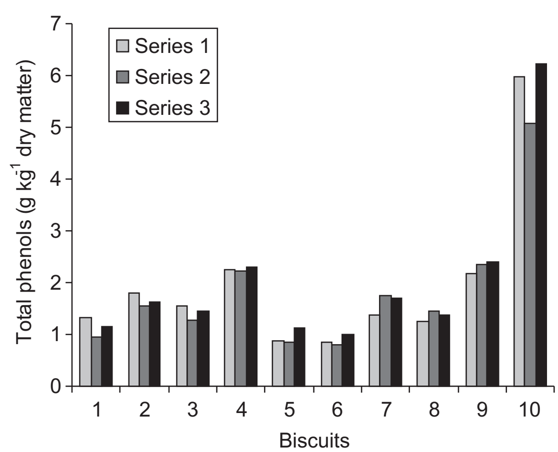

Figure 2.
Range of total phenols contents in dry matter of biscuits

Discussion

Total phenol content in the raw materials used range from 0.055 g kg^{-1} in wheat fibre up to 39.730 g kg^{-1} in carob meal (moisture content ranged from 6.40 % up to 12.04 %), or expressed in dry matter of the samples ranged from 0.065 g kg^{-1} up to 44.960 g kg^{-1}, respectively. In general, the lowest total phenol content was found in pure fibres (wheat, inulin and oats fibres, 0.055, 0.130 and 0.170 g kg^{-1}, respectively) produced by different isolation or purification techniques. The total phenol content of wheat flour as basic

Table 2. Total phenols and total dietary fibres in biscuits

Sample	Total phenols ($g\ kg^{-1}$ of biscuit)					RSD (%)	TDF* (%)	Moisture** (%)		
	Series 1	Series 2	Series 3	mean value	SD			Series 1	Series 2	Series 3
1.	1.28	0.89	1.12	1.10	0.16	14.55	7.60	3.72	4.69	3.74
2.	1.73	1.50	1.56	1.60	0.19	6.09	11.52	4.00	3.69	3.74
3.	1.51	1.22	1.37	1.37	0.18	8.64	9.72	3.72	3.48	4.34
4.	2.11	2.12	2.18	2.14	0.03	1.44	16.21	6.07	4.38	4.79
5.	0.82	0.81	1.09	0.91	0.13	14.25	19.20	6.47	4.58	3.21
6.	0.80	0.76	0.96	0.84	0.09	10.29	20.78	6.40	5.08	3.42
7.	1.33	1.69	1.64	1.55	0.16	10.27	-	3.57	3.27	3.72
8.	1.19	1.41	1.32	1.31	0.09	6.89	11.97	4.42	2.31	4.44
9.	2.05	2.27	2.32	2.21	0.12	5.30	14.64	5.65	3.81	3.53
10.	5.73	4.86	5.99	5.53	0.48	8.74	16.41	4.17	4.25	3.72

Samples: 1) white wheat flour biscuit (T 500); 2) wheat whole grain flour biscuit (T 1700); 3) standard tea biscuit (T 1700 + T 500); 4) biscuit enriched with apple fibre; 5) biscuit enriched with oats fibre; 6) biscuit enriched with wheat fibre; 7) biscuit enriched with inulin; 8) biscuit enriched with amaranth meal; 9) biscuit enriched with full fat soya flour; 10) biscuit enriched with carob meal
TDF* = total dietary fibres, mean values of two parallel determinations (Vujić et al. 2005);
** mean value of three parallel determinations; SD = standard deviation; RSD = relative standard deviation

raw material depending on the milling extraction rate was 65 % higher in flour T 1700 (1.45 $g\ kg^{-1}$) compared to flour T 500 (0.88 $g\ kg^{-1}$). Pseudo cereal amaranth is as rich in total phenols as wheat whole grain flour (1.46 $g\ kg^{-1}$).

Full fat soya flour containing 4.76 $g\ kg^{-1}$ of total phenol is 230 % richer than whole grain flour and even 440 % richer in total phenols in comparison with white flour. The highest total phenol content has been found in apple fibres and carob meal, 9.85 $g\ kg^{-1}$ and 39.73 $g\ kg^{-1}$, respectively. The real relation of examined raw materials as a total phenol source is expressed as total phenol content in dry matter is shown in Figure 1.

Total phenols in experimentally baked biscuits range depending on the type and series of biscuit from 0.76 g kg^{-1} up to 5.99 $g\ kg^{-1}$, on an average from 0.84 $g\ kg^{-1}$ up to 5.53 $g\ kg^{-1}$, which shows essential differences in content of these very potent antioxidant compounds in cereal based biscuits depending on fibre rich ingredients. Such differences point to essential differences in functionality of biscuits enriched with different fibre rich raw materials, too. Comparing the range of total phenol contents in baked products (Figure 2) it is evident that the richest are biscuits with carob meal added, followed by biscuits enriched with soya flour and apple fibres, respectively.

Total dietary fibres content ranges from 7.60 up to 20.78 %, the highest being in biscuits enriched with pure wheat and oats fibres (Table 2).

An analysis of the relation of shares of total phenols and total dietary fibres in biscuits shows that the shares of total phenols and TDF in biscuits based on wheat flour depend on the type of flour, which means the higher the fibre content the higher the total phenol content. Biscuits with pure wheat and added oats fibres, although the highest in fibres (20.78 % and 19.20 %, respectively) were the lowest in total phenol content (0.84 $g\ kg^{-1}$ and 0.91 $g\ kg^{-1}$, respectively).

Taking into account the total phenol content and TDF content in the standard tea biscuit as a basic one in this analysis (produced predominantly from wheat whole grain flour), it is evident that enrichment of cereal based biscuits with pure cereal fibres results in lowering of antioxidative capacity of such fibre rich products (38.69 % and 33.58 % with wheat and oats fibres, respectively). Inulin and amaranth do not change essentially total phenol content in enriched biscuits, additionally amaranth did not enhanced fibres content in biscuit as well. Soya full fat flour and apple fibres enhanced total phenol approximately 58 % enhancing in the same time total fibres content for 27, 08 % and 40.71 %, respectively. The richest source of total phenols was biscuit prepared with milled carob having 304 % higher total phenol content in comparison to standard tea biscuit. In the same time, carob biscuit was 42.45 % higher in total dietary fibres content.

Considering total dietary fibres shares in enriched biscuits, it is evident that 100 g of enriched biscuits can cover approximately 40 % to 70 % of daily-recommended intake of fibres pointing to their functionality and confirming justification of development of new types of biscuits, too. The intake of antioxidant or total phenols has been not recommended.

However, considering that Scalbert and Williamson (2000) found that the average daily intake of total phenols by the general population was 1g, some of examined biscuits can be considered as a good source of health beneficial constituents accompanying fibres in plant material. Thus, biscuits enriched with soya flour and apple fibres cover about 22 % while biscuits prepared with carob meal cover 55 % of the average daily total phenol intake, confirming once again carob as a valuable food and raw material in production of such types of functional food.

Conclusion

The performed analyses of influence of raw materials choice in production of fibre rich biscuits on total phenol content show that the incorporation of pure cereal fibres lowered the share of potent antioxidants although the highest content of fibres in biscuits was achieved. Results approved wheat whole grain products as a good source of protective compounds showing dietary fibres and total phenol shares depend on the flour extraction rate. Effective enhancers of dietary fibres and total phenol contents in biscuits are apple fibres, full fat soya flour, and carob meal, thereby carob meal was the richest source enhancing by 304 % total phenols and by 42 % total dietary fibres in enriched biscuit compared to the standard tea biscuit prepared with wheat whole grain flour (65 %) and wheat flour T 500 (35 %). Compared to biscuits produces from wheat flour T 500 the carob biscuit was a 403 % richer source of total phenols. Although better fibre enrichment was achieved by pure wheat and oats fibres (114 % and 97 %) compared to soya flour (51 %), apple fibres (67 %), and carob meal (69 %), presented results show that priority should be given to not refined, natural raw materials to produce multiple functional fibre rich biscuits. Such biscuits are a good source of total dietary fibres and total phenols; 100 g of biscuits covering from 49 % up to 55 % of DRI for fibres and from 22 % to 55 % assessed average intake of total phenols.

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