Macronutrients Content and Energy Value of Fiber Rich Biscuits

Lovorka VUJIĆ (✉)
Blaženka ŠEBEČIĆ
Koraljka GALI
Marija BABIĆ
Dubravka VITALI

Summary

Cereals and cereal based products are an important source of energy, fibers and a range of macro- and micronutrients such as carbohydrates, proteins, minerals etc. Most of the evidences for health benefits of cereal foods are related to the fiber rich wholegrain foods and its role in reducing risk of degenerative chronic diseases, so-called Western diseases (constipation, diabetes, cardiovascular diseases, diverticulosis, obesity, and colon cancer). To evaluate fiber-rich cereal products as a functional food, nine types of biscuits based on whole grain wheat flour with enlarged share of dietary fibers were experimentally prepared. The goal of this study was to present the contents of main macronutrients, such as total proteins, carbohydrates and total fat in mentioned biscuits and to estimate contributions of each individual component to biscuit's energy value in relation to new reference values. Our results show that regarding Dietary Reference Intakes (DRI) given by the Food and Nutrition Board, USA (FNB 2005), examined biscuits can be considered as a good source of macronutrients and dietary fibers in nutrition. Consumption of those biscuits ensure relatively balanced intake of energy originated from main macronutrients. Being high in total dietary fibers (16.50 up to 46.77 g/1000 kcal) that is considerably higher than recommended by Adequate Intake (AI) for total dietary fibers based on 14 g/1000 kcal of required energy (DRI 2005), investigated biscuits can significantly contribute to the intake of those health enhancing components.

Key words

biscuit, dietary fibers, macronutrients, dietary guidelines, energy value

University of Zagreb, Faculty of Pharmacy and Biochemistry,
Department of Food Chemistry, A. Kovačića 1, 10000 Zagreb, Croatia
✉ e-mail: lovorka_vujic@yahoo.com

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Introduction

Cereals are the most important staple food and therefore cereal products play a central role in human nutrition. These products represent a good source of energy, carbohydrates, proteins, and fibers in nutrition, as well as a range of micronutrients such as vitamin E, some of the B vitamins, magnesium, and zinc (McKevith 2004). Cereal grains also contain a large variety of substances, especially those that are biologically active, such as phytoestrogens, lignans, and antioxidants, which exhibit anticarcenogenic, antimutagenic, antibacterial, antiviral, and antitrombotic effect (Zíelinski et al. 2001). The food intake pattern of the population in the developed countries is related to the risk of developing some of the more frequent chronic diseases such as cardiovascular diseases, diabetes and some types of cancer (Pi-Sunyer 1993). In regard to the evidence that regular intake of cereals, especially products based on whole grains, have a protective role in prevention of those degenerative chronic diseases, dietary guidelines recommend an increase in the consumption of whole grain cereal products (Ragaee and Abdel-Aal 2006). Those beneficial physiological and metabolic effects are related to a high intake of dietary fibers, which are a heterogeneous mix and can be categorized (Burkhalter et al. 2001) into two major subclasses, i.e. soluble (viscous, fermentable) fibers and insoluble (nonviscous, nonfermentable) fibers. Insoluble fraction of dietary fibers, which represents hemicellulose, cellulose, and lignin, is related to water absorption and intestinal regulation (Grigelmo-Miguel et al. 1999). Soluble fraction of dietary fibers (gums, mucilages, and pectins), seem to have more positive actions, like lipid lowering effect, possibly the best recognized effect of this kind of fiber what results in reducing the risk of heart disease, dampening of the response of insulin and the hormones of the enteroinsular axis, altering postprandial lipoprotein synthesis and clearance and enhanced short chain fatty acid production (Jenkins et al. 2004). Unrefined food high in dietary fibre have a low glycaemic index (GI of a particular food describes how quickly the glucose from that food enters the bloodstream), what might benefit those with type 2 diabetes because it will help to maintain an adequate balance between blood glucose and insulin levels (Ryan-Harshman 2006). Taking into consideration that cereal products are recognized as a good source of dietary fibers and other ingredients which have beneficial effects on human health, the intention of our research has been to develop a fiber rich biscuit based on a high share of whole grain wheat flour and different pure fibers or fiber rich raw materials added to provide higher incorporation in nutrition of those health enhancing components by biscuits as a food widely consumed by all populations.

Regarding the fact that carbohydrates, fats and proteins contribute to the energy required to sustain the body's various function, including respiration, circulation, physical work, and maintenance of core body temperature, the aim of our work was to determine energy derived from available and total carbohydrates, proteins, fats, and dietary fibers of biscuits experimentally prepared with the goal to be a functional food.

Materials and methods

To achieve the optimal recipe for fiber rich biscuits in regard to technological possibilities, i. e. without significant interrupt of the quality properties of each product, the experimental biscuits were laboratory prepared by a modification of the original recipe for tea biscuit (standard tea biscuit).

Investigated samples were as follows:

1) Standard tea biscuit prepared with 35% of white wheat flour (T-500) and 65% whole grain wheat flour (T-1700)
2) Biscuit prepared with white wheat flour (T-500) only
3) Biscuit prepared with whole grain wheat flour (T-1700) only

Other six investigated types of biscuits were prepared with replacement a definite amount of T-500 wheat flour with different fiber rich raw materials (soya full fat flour, carob, or amaranth flour) or different pure fibers (wheat, oat, or apple fiber) as follows:

4) Biscuit with soya full fat flour
5) Biscuit with carob flour
6) Biscuit with amaranth flour
7) Biscuit with wheat fiber (type WF 600-30)
8) Biscuit with oat fiber (type HF-600)
9) Biscuit with apple fiber (type AF 400-30).

The samples were prepared with exactly the same amounts of other compounds (vegetable fat, sugar, powder milk, salt, and flavour) to prevent their influence on the results. Biscuits were baked at 175°C for 15 min, cooled, and ground to pass through a 50-mesh. Samples were kept in air-tight containers at 4°C until analysis.

Total dietary fiber (TDF) values were estimated previously by enzymatic – gravimetric AOAC 991.43 method (Southgate 1995) in fat extracted samples. The samples were sequentially digested with enzymes: heat-stable amylase (Sigma Chemical Co, No. A-3306) at 95 °C, protease (Sigma Chemical Co, No. A-9913), and amyloglucosidase (Sigma Chemical Co, No. A-9913) at 60 °C. Undigested components were precipitated with 225 mL 95% ethanol preheated to 60 °C, then filtered, washed, dried, and weighted.

Total nitrogen was determined by the semi-automatic Kjeldahl (AOAC 984.13 2000) apparature, and the protein content was calculated by using a factor of 6.25.

Available carbohydrate contents were determined as a sum of water soluble carbohydrates and starch. Water soluble carbohydrates were determined according to Luff-Schorl method (Acker et al. 1967) and starch was determined by the Ewers polarimetric method (Arbeitsgemeinschaft Getreideforschung 1978). Total fat content was determined by the Soxhlet method (AOAC 963.15 1990) using petroleum ether as a solvent.

Results and discussion

The contents of different fractions of sugars (i.e. glucose + fructose and saccharose) and starch content in investigated biscuits are presented in Table 1, where the available carbohydrates are reported as a sum of each individual fraction of sugar and starch. Differences in shares of total dietary fibers, total carbohydrates, proteins, and fat are presented in Table 2, where total carbohydrate content was defined as a sum of total dietary fibers and available carbohydrates (FAO 2003). Values are expressed as mean value of two series of examined biscuits. Depending on investigated biscuit, the protein content ranged from 75.6 g kg^{-1} to 129.9 g kg^{-1} with the lowest share in the biscuit enriched with pure wheat fibers, while the highest content was in the biscuit prepared with full fat soya flour, as we expected. Total dietary fiber (TDF) content ranged from 76.0 g kg^{-1} to 207.8 g kg^{-1}, with the lowest and the highest share being in biscuit based on white wheat flour and biscuit enriched with pure wheat fibers, respectively. The shares of available carbohydrates ranged from 505.9 g kg^{-1} to 625.8 g kg^{-1}, while total fat content ranged from 179.4 g kg^{-1} to 217.8 g kg^{-1}, respectively.

The results show that regarding Dietary Reference Intakes (DRI) given by Food and Nutrition Board, USA (FNB 2005) for proteins (average 50 g per day), carbohydrates (average 130 g per day) and fiber (average 30 g per day), 100 g of examined biscuits can cover approximately 17% up to 26% of daily needs of proteins, approximately 39% up to 47% of daily needs of available carbohydrates and approximately 25% up to 70% of daily needs of dietary fibers. All values relate to adult persons. Dietary reference intakes for total fats are not determined.

Table 1. The contents of different fractions of sugars in biscuits

Sample	Glucose + fructose (g kg^{-1})				Saccharose (g kg^{-1})				Starch (g kg^{-1})				Available carbohydrates (g kg^{-1})
	S1	S2	mean value	RSD (%)	S1	S2	mean value	RSD (%)	S1	S2	mean value	RSD (%)	
1	6.6	6.0	6.3	6.73	216.1	218.0	217.1	0.62	389.4	386.0	387.7	0.61	611.1
2	6.6	6.0	6.3	6.73	201.9	210.5	206.2	2.95	401.2	425.5	413.3	4.15	625.8
3	6.6	6.2	6.4	4.42	227.1	235.8	231.5	2.66	336.7	367.2	351.9	6.12	589.8
4	6.4	6.0	6.2	4.56	232.5	225.7	229.1	2.10	283.9	257.3	270.6	6.96	505.9
5	15.4	14.6	15.0	3.77	270.2	260.6	265.4	2.56	264.6	266.0	265.3	0.35	545.7
6	9.6	10.0	9.8	2.89	208.1	217.0	212.6	2.96	355.5	338.0	346.8	3.56	569.1
7	7.0	6.6	6.8	4.16	219.0	205.4	212.2	4.53	317.7	283.4	300.6	8.07	520.0
8	6.6	6.4	6.5	2.18	217.7	217.6	217.7	0.03	273.6	304.2	289.0	7.50	513.1
9	30.3	32.2	31.3	4.30	220.7	227.2	224.0	2.05	333.4	315.8	324.6	3.82	579.8

S1 = series 1; S2 = series 2; RSD = relative standard deviation; Available carbohydrates were estimated as a sum of glucose + fructose, saccharose, and starch

Table 2. The contents of total dietary fibers, total carbohydrates, proteins, and fat in biscuits

Sample	Total dietary fibers (g kg^{-1})				Total carbohydrates (g kg^{-1})	Proteins (g kg^{-1})				Fats (g kg^{-1})			
	S1	S2	mean value	RSD (%)		S1	S2	mean value	RSD (%)	S1	S2	mean value	RSD (%)
1	100.7	93.8	97.2	5.02	708.3	84.3	89.0	86.7	3.88	189.7	187.3	188.5	9.51
2	74.3	77.7	76.0	3.16	701.8	84.7	83.3	84.0	1.21	177.2	181.5	179.4	9.12
3	116.7	115.1	115.9	0.98	705.7	87.4	90.7	89.0	2.63	188.8	187.7	188.3	9.45
4	142.4	150.4	146.4	3.86	652.3	131.1	128.8	129.9	1.26	215.9	219.7	217.8	11.02
5	168.2	160.0	164.1	3.53	709.8	82.4	88.5	85.4	4.98	191.2	182.9	187.1	9.65
6	116.3	123.1	119.7	4.02	688.8	97.4	92.1	94.7	3.99	193.1	195.8	194.5	9.82
7	202.2	213.4	207.8	3.81	727.4	74.3	76.8	75.6	2.39	181.5	184.6	183.1	9.26
8	195.8	188.2	192.0	2.80	705.1	76.1	76.6	76.3	0.50	186.1	186.5	186.3	9.33
9	159.4	164.8	162.1	2.36	741.9	73.4	80.6	77.0	6.61	187.3	190.3	188.8	9.55

S1 = series 1; S2 = series 2; RSD = relative standard deviation; Total dietary fibers = TDF (Vujić et al. 2005); total carbohydrates were estimated as a sum of TDF and available carbohydrates

Table 3. The energy contribution of total dietary fibers, available and total carbohydrates, proteins, and fats (kcal/100 g of biscuit)

Sample	Total dietary fibers	Available carbo-hydrates	Total carbo-hydrates	Proteins	Fats	Total energy
1	19.4	244.4	263.8	34.7	169.7	468.2
2	15.2	250.3	265.5	33.6	161.4	460.5
3	23.2	235.9	259.1	35.6	169.4	464.1
4	29.3	202.4	231.7	52.0	196.0	479.7
5	32.8	218.3	251.1	34.2	168.3	453.6
6	23.9	227.6	251.5	37.9	175.0	464.4
7	41.6	207.8	249.4	30.2	164.7	444.3
8	38.4	205.2	243.6	30.5	167.7	441.8
9	32.4	231.9	264.3	30.8	169.9	465.0

Table 4. The percent of energy value of biscuit from total dietary fibers, available and total carbohydrates, proteins, and fats (% of energy value of biscuit)

Sample	Total dietary fibers	Available carbo-hydrates	Total carbo-hydrates	Proteins	Fats
1	4.1	52.2	56.3	7.4	36.2
2	3.3	54.4	57.7	7.3	35.0
3	5.0	50.8	55.8	7.7	36.5
4	6.1	42.2	48.3	10.8	40.9
5	7.2	48.1	55.4	7.5	37.1
6	5.1	49.0	54.2	8.2	37.7
7	9.4	46.8	56.1	6.8	37.1
8	8.7	46.4	55.1	6.9	38.0
9	7.0	49.9	56.8	6.6	36.5

The results presented in Table 3 show the energy contribution of available and total carbohydrates, proteins, fats, and total dietary fibers of each biscuit. The content of each individual component is converted to food energy according to FAO recommendations (2003), using an Atwater general factor sistem (for available carbohydrates and proteins conversion factors are 4.0 kcal g^{-1} and for fats is 9.0 kcal g^{-1}). The conversion factor for dietary fibers is 2.0 kcal g^{-1}. Total energy value of biscuits was estimated as a sum of energy values of total carbohydrates, proteins and fats and regarding that the total energy intake is quite high it is possible to decrease it exchanging added sugar with different reduced caloric value ingredients. For example, sorbitol, a sugar alcohol incompletely digested in the human small intestine, has energy value 2.7 kcal g^{-1} (Beaugerie et al. 1991).

The results given in Table 4 represent the percent of energy value of biscuit from available and total carbohydrates, proteins, fats and total dietary fibers. Regarding to acceptable macronutrient distribution ranges (AMDR - the range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients) for energy given by DRI (FNB 2005), consumption of examined biscuits ensures unbalanced inbalanced intake of energy. Regarding to recommendations the energy contribution of proteins was lower, the energy contribution of fat was higher, while the percent of energy value of biscuit from total carbohydrates was within the recommended values (45 – 65%). Implementation of soya flour, which is rich in proteins of high biological value, could be a good choice to provide an adequate level of this important macronutrient, however it should be noted that it is necessary to use soya flour with a low content of fat. Obtained distribution of macronutrient's energy demands reduction of fat content or introducing a group of reduced calorie triacylglycerides which were developed as alternative fats for bakery products and confectionery , for example, reduced-calorie fats as a novel food ingredient, like salatrims (5.2 kcal g^{-1}) (FAO 2003). Regarding that investigated biscuits are high in nutritive density of fibers (16.50 g to 46.77 g/1000 kcal of total dietary fibers), and concerning Adequate Intake (AI) for total dietary fibers based on 14 g/1000 kcal of required energy, those biscuits can be considered as a very good source of those health enhancing components in nutrition.

The proposed correction of the recipe should ensure that the biscuits become a rich source of both, dietary fibers and well balance in energy contribution of macronutrients and therefore a functional food.

Conclusion

Cereals have been a basic diet of people worldwide and they remain a fundamental part of the dietary pattern since today, providing energy, dietary fiber and a range of nutrients, such as carbohydrates, proteins and fats. Regarding to that, we estimated the shares of them in different experimentally prepared biscuits, chosen as a cereal based food favorite by great part of the populations. Also, we evaluated nutritive value of those fiber rich biscuits and considering our results, they represent an energy unbalanced food, since the fat energy contribution was in the upper limit and the protein energy contribution below of recommended one in a balanced nutrition. Concerning that, we suggest a reduction or replacement of the part of added fat with reduced-calorie fats to improve the balance of energy contributors in biscuits. With proposed modifications, consumption of those biscuits can result in both, an improved intake of dietary fibers and well balance in energy contribution of macronutrients and therefore could be considered as a functional food.

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