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Total, soluble and insoluble oxalate content of bran and bran products

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Abstract

The total and soluble oxalate content of various wheat, oat and rice bran products available in supermarkets and health food shops were analyzed using HPLC chromatography. The total oxalate contents of the individual bran samples analyzed ranged from 37.0 mg/100 g dry matter (DM) for oat bran to 392.7 mg/100 g DM for wheat bran flakes while the soluble oxalate contents ranged from 8.9 mg/100 g DM (Oat Bran Weet-Bix) to 109.6 mg/100 g DM (wheat bran flakes), respectively. The mean data showed that oat bran products contained the lowest level of total oxalate (67.2 mg/100 g DM) and soluble oxalate (8.9 mg/100 g DM) compared to rice bran (total oxalate 139.5 mg/100 g DM, soluble oxalate 65.3 mg/100 g DM) and wheat bran (total oxalate 220.8 mg/100 g DM, soluble oxalate 60.8 mg/100 g DM). The data suggests that a daily portion of bran products, particularly wheat bran, would supply a constant intake of soluble and insoluble oxalate but this would be a relatively small intake compared to other oxalate containing foods that may be eaten in the diet. The effect of the soluble oxalate intake could be mitigated by the consumption of high calcium foods at the same time.

Key words: Total oxalate, soluble oxalate, insoluble oxalate, cereal bran, bran products.

Introduction

Approximately 75% of all kidney stones are composed of calcium oxalate [1] and the main risk factor for this disorder is hyperoxaluria[2, 3]. Because urinary oxalate originates from a combination of absorbed dietary oxalate and endogenously synthesized oxalate[1], reduction of dietary oxalate has been suggested as a way to reduce the occurrence of nephrolithiasis in some patients [4]. Plants and plant products are the main sources of dietary oxalate [5, 6]. Frequent consumption of foods containing high oxalate levels can increase the risk of kidney stone formation and inhibit calcium absorption [5, 6]. Plant tissues contain soluble oxalate sources such as sodium and potassium oxalate as well as insoluble oxalate salts such as calcium and magnesium oxalate [7]. The efficiency of oxalate absorption is an important determinant of whether a particular food can significantly increase urinary oxalate excretion[8]. The amount of soluble oxalate in a food is also important because it is more bioavailable than insoluble oxalate [9, 10]. There are many foods that are known to contain naturally high levels of oxalate including spinach, rhubarb, beets, nuts, wheat bran and kiwifruit[5-8,] and more recently spices such as cinnamon and turmeric have been shown to contain high levels of oxalate [11]. However, the most important consideration is the soluble oxalate content of these foods [12].

Bran is the hard outer layer of cereal grains and consists of the aleurone and pericarp layers. It is produced as a milling by-product in the production of refined grains. Bran can be produced from any cereal grain such as wheat, rice, maize, oats, barley and millet. Wheat and oat bran are most commonly used in human diets and are often used to enrich breads, baked products and breakfast cereals. Brans are rich in dietary fibre, omega-3- fatty acids and contain modest amounts of starch, protein, vitamins and minerals. It is often mentioned that bran contains oxalates but recent reliable data on oxalate content are hard to find.

Siener *et al.* [13] suggested that at the pH of the gastrointestinal tract, soluble oxalic acid can be totally released from bran and combine maximally with calcium at 0.010-0.024 mmol/g of bran. They showed that a total oxalate content of whole wheat flour ranged from of 67-70 mg/100 g dry matter (DM) [13]. In contrast, the total oxalate content of white flour ranged from 16.8 to 45.0 mg/100 g DM while brown rice flour contained 37 mg/100 g DM [6, 14]. Moreover, Siener *et al.* [14] compared the soluble and total oxalate contents among cereals and cereal products such as wheat, rye, oat, barley, maize, rice etc. The result showed that wheat bran had the highest concentrations (131.2 and 457.4 mg/100 g DM) for soluble and total oxalate contents, respectively, whereas whole grain rice flake contained the lowest amount compared to the other whole grain cereals (soluble oxalate 4.2 mg/100 g DM and 12.2 mg/100 g DM for total oxalates). Therefore, Siener *et al.*[14] concluded that a high amount of oxalate was contained in the outer layer of cereal grains. In addition, Judprasong *et al.*[15] found a very small amount of oxalate in whole grain rice both before or after boiling (< 3 mg/100 g DM) which confirms the observations made in the previous report [15].

In this study, soluble, insoluble and total oxalate levels of various types and brands of cereal bran available in supermarkets and health shops in New Zealand were determined to provide data to assist people who are prone to renal stone formation due to hyperoxaluria.

Materials and Methods

Samples: The raw materials for this study (Table 1) were purchased from either local health food shops or supermarkets in Christchurch and Dunedin in July 2008. Once purchased, the food materials were ground to a fine powder using a Sunbeam multi grinder (Model No. EMO 400 Sunbean Corporation Limited, NSW, Australia). The grinder was cleaned thoroughly after each sample to avoid contamination of the samples. The finely ground samples were stored at 20°C until analysis commenced. The raw materials and foods analyzed in this study are known commercially as "dry goods" and they typically contain between 4 and 6% moisture. In this study the extraction and analysis was carried out on the finely ground dry or "as is" samples and is referred to as dry matter (DM).

Chemical extraction of total and soluble oxalates: Soluble and total oxalate contents of 0.5 g of each finely ground sample of dry food were extracted and measured by HPLC, as described in detail by Savage *et al.* [8]. Insoluble oxalate content (calcium oxalate) was calculated by difference [16]. Each sample was analyzed in triplicate and all data are presented as a mean mg oxalate/100 g DM ± SD.

Preparation of standards: Standards of oxalic acid (Sigma-Aldrich Co., St Louis, USA) were made up in the following concentrations: 1.0, 5.0, 10.0, 20.0, 40.0, 50.0 and 100.0 mg/100 ml and made up in either 2 M HCl (Aristar, BDH Chemicals, Ltd., Poole, Dorset, UK) or Nanopure II water (Barnstead International, Dubuque, Iowa, USA) and then filtered through a 0.45 µm cellulose nitrate filter (Sartorius AG, Göttingen, Germany) into a 1 ml HPLC auto sample vial.

Recovery study: The recoveries of pure oxalic acid (Sigma-Aldrich Co., St Louis, USA) were studied by adding 50 mg oxalate to each of the water and acid extractions. The samples were extracted and measured using the method described by Savage *et al.* [8] and the results were compared with samples with no oxalic acid added. The analysis was carried out in quadruplicate. The mean recovery for the water and acid extractions were 94.8 ± 0.4 and 93.6 ± 0.7%, respectively.

Results and Discussion

Mean total, soluble and insoluble oxalate content of the bran products (mg/100 g DM) are shown in Table 2. The mean total oxalate content (mg/100 g DM) was highest in wheat bran (220.8 ± 130.6) followed by rice bran (139.5 ± 21.9) and oat bran (67.2 ± 28.8). The mean soluble oxalate content (mg/100 g DM) of the wheat bran was (60.8 ± 31.6) which was very similar to rice brans (65.3 ± 33.5). The soluble oxalate content could not be detected in two samples of oat bran while the levels in Oat Bran Weet-Bix were very low (8.9 mg/100 g DM). Overall, the mean soluble oxalate ranged from 29.9 ± 10.8 for wheat bran to 47.1 ± 4.3 mg/100 g DM for the rice bran samples. The mean insoluble oxalate level in wheat bran was 160.0 ± 104.9 mg/100 g DM, which was much higher than in oat bran (64.2 ± 28.8 mg/100 g DM) and rice bran (74.2 ± 38.0 mg/100 g DM). As foods of plant origin are the main source of dietary oxalate an increase in fruits and vegetables and possibly cereal consumption could be considered an increased dietary risk factor for kidney stone formation. In addition, considerable encouragement is given to the increased consumption of cereal bran in the diet to increase overall fiber intake, but no consideration of the oxalate content is ever made. One of the major problems is that modern and reliable data on the oxalate composition of bran products is not easy to find. Recently, Liebman and Okombo [17] showed that whole wheat and brown rice contained, respectively, 69.8 and 34.4 mg total oxalate/100 g DM, and mentioned that an unpublished value for wheat bran produced in the USA was approximately 84 mg/100 g DM. This value is similar to the value for All Bran wheat flakes (88.4 mg/

Table 1. Source of raw materials and stated composition by the manufacturers.

Bran type	Composition of food as stated on the packet	Manufacturer listed on the packet
Wheat bran		
Bran flakes	100% wheat bran	Fleming's Bran flakes, Bluebird Foods Ltd., Manukau City, Auckand
Elfin bakers bran	Wheat bran	Goodman Fielder Milling and Baking, East Tamaki, Auckland
Baking bran, Dunedin	Wheat bran	Health 2000, George Street, Dunedin
Processed bran, home brand	Wheat bran 64%, wheat flour, sugar and salt	Woolworths, Mangere, Auckland
Kellogg's All-Bran original	Wheat bran 84%, sugar, barley malt extract, salt, vitamins and minerals	Kellogg's Ltd., Falcon Street, Parnell, Auckland
Kelloggs's All-Bran wheat flakes	Whole wheat 67%. Wheat bran 12%, sugar, barley malt extract, salt, vitamins and minerals	Kellogg's Ltd., Falcon Street, Parnell, Auckland
Oat bran		
Oat bran, Dunedin	100% oat bran	Health 2000, George Street, Dunedin
Oat bran, Weet-Bix	Wholegrain cereals81% (wheat, rolled oats), oat bran 10%, sugar, wheaten cornflower, barley malt extract, salt, honey and vitamins	Sanitarium, Royal Oak, Auckland
Oat bran, Woolworths	100% oat bran	Home brand, Woolworths, Mangere, Auckland
Rice bran		
Rice bran, fine	Produced from brown rice	Lotus Foods Pty., Ltd., Cheltenham, Victoria, Australia
Rice bran, granules	Produced from brown rice	Lotus Foods Pty., Ltd., Cheltenham, Victoria, Australia
Rice bran, Thai	Produced from mixed long grain and glutinous rice	Grown and manufactured in Surin Province Thailand

Table 2. Total, soluble and insoluble oxalate content of bran products (mg/100 g DM ± SD).

	Total	SD	Soluble	SD	Insoluble [1]	SD
Wheat bran						
Bran flakes	392.7	6.2	109.6	13.8	283.0	14.0
Bakers bran	346.0	7.1	64.1	1.4	281.9	7.1
Baking bran, Dunedin	260.4	4.3	77.3	15.4	183.1	11.9
Processed bran	116.5	1.0	27.1	2.7	89.5	3.5
All-bran original	120.7	1.0	60.4	0.9	60.3	1.7
All-bran wheat flakes	88.4	1.8	26.3	0.9	62.1	2.0
Oat bran						
Oat bran, Dunedin	37.0	0.1	[2]-	-	37.0	0.1
Oat bran, Weet-Bix	70.2	2.0	8.9	0.7	61.3	1.6
Oat bran, Woolworths	94.4	1.0	-	-	94.4	1.0
Rice bran						
Rice bran, fine	163.7	0.6	58.4	1.9	105.4	1.5
Rice bran, granules	121.1	0.6	35.8	1.9	85.3	2.1
Rice bran, Thai	133.6	2.4	101.7	0.7	31.9	2.8

[1] Insoluble oxalate = total oxalate - soluble oxalate (Holloway *et al.* [16]), [2] not detected.

100 g DM) in this study but much lower than the value obtained for bran flakes (392.7 mg/100 g DM).

It is very difficult to define exactly what bran is except to say that it is the outer layers of cereal grains. It is also difficult to be sure whether the product is pure bran or contains an admixture of starch from the original grain. The rice bran sample imported from Thailand is reported to contain grain from long grain and glutinous rice which would reduce the content of bran and the overall oxalate content. The reverse effect occurs in processed oat bran products such as Oat Bran Weet-Bix which also contains wheat bran (Table 2).

Overall, wheat bran contained the largest amount of total oxalate, but these were predominantly insoluble (mean 70.1%). The total oxalate content of the wheat bran samples fell into two groups. The highest levels of total oxalate were found in the baking bran and bran flakes (mean 333.0 mg total oxalate/100 g DM). It is possible that wheat products with low levels of total oxalate such as All-Bran contain starch in addition to wheat bran thus lowering the total and soluble oxalate contents of this product.

Conclusions

This study suggests that oat and rice bran should be included in the medium to low oxalate food groups as defined by Noonan and Savage [5]. While the levels of total oxalate in wheat bran are reasonably high, the proportion of oxalate available for absorption from the gastrointestinal tract is reasonably low compared with other oxalate-containing foods. The standard serving size of bran and bran products ranges from 30 to 50 g and many people consuming a healthy diet would eat this amount of bran every day. The data suggests that while bran products, particularly wheat bran, would supply a constant intake of total and soluble oxalate this would be a relatively insignificant intake compared to other oxalate containing foods that may be eaten in the diet. The effect of the soluble oxalate intake could also be mitigated by the consumption of high calcium foods (such as milk) at the same time although this would reduce calcium availability.

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