Food Research International 44 (2011) 127–132

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Antidiabetic effects of three Korean sorghum phenolic extracts in normal and streptozotocin-induced diabetic rats

Ill-Min Chung [a], Eun-Hye Kim [a], Min-A Yeo [a], Sun-Jin Kim [a], Myong–Cheol Seo [b], Hyung-In Moon [c,d,*]

[a] Department of Applied Life science, Kon Kuk University, Seoul 143-701, South Korea
[b] Functional Cereal Crop Research Division, National Institute of Crop Science, RDA, Suwon 441–857, Korea
[c] Cardiovascular Medical Research Center, College of Korean Medicine, Dongguk University, Gyeong–Ju 780–714, South Korea
[d] Inam Neuroscience Research Center, Wonkwang University Sanbon Medical Center, Kyunggi–Do 435–040, South Korea

ARTICLE INFO

Article history:
Received 22 September 2010
Accepted 31 October 2010

Keywords:
Sorghum bicolor
Korean sorghum
Antidiabetic
Phenolic components

ABSTRACT

The present study evaluated the antidiabetic effects from phenolic extracts of three varieties (Hwanggeumchal sorghum, Chal sorghum, and Heuin sorghum) from Korean sorghum (*Sorghum bicolor* L. Monech) in normal and streptozotocin-induced diabetic rats. Hwanggeumchal sorghum phenolic extracts in the streptozotocin-induced diabetic rats showed significant hypoglycemic activity for 14 days and significantly decreased the serum glucose, total cholesterol, triglycerides, urea, uric acid, creatinine, aspartate amino transferase and alanine amino transferase while it increased the serum insulin in diabetic rats but not in normal rats ($p<0.05$) (at doses of 100 and 250 mg/kg for 14 days). A comparison was made between the action of Hwanggeumchal sorghum phenolic extracts and glibenclamide (600 μg/kg), a known antidiabetic drug. Twenty-four of the 29 phenolic components monitored were detected by high performance liquid chromatography. The antidiabetic effect of the Hwanggeumchal sorghum phenolic extracts was similarly effective with that observed with glibenclamide. Phenolic components were analyzed using high performance liquid chromatography, and a total of 29 phenolic components were detected in the Korean sorghum studied. The relationships of antidiabetic effects and phenolic components of Hwanggeumchal sorghum phenolic extracts were significantly higher than that of Chal sorghum and Heuin sorghum phenolic extracts.

1. Introduction

Diabetes mellitus is a serious, complex chronic condition that is a major source of ill health all over the world. The total number of people with diabetes is projected to rise from 4% of the population worldwide and is expected to increase to 5.4% in 2025. Hyperglycemia and hyperlipidemia are involved in the development of microvascular and macrovascular complications of diabetes, which are the major causes of morbidity and mortality of diabetes (Holman & Turner, 1991; Taskinen, 2002). There is an increasing demand by patients to use natural products with antidiabetic activity, due to the side effects associated with the use of insulin and oral hypoglycemic agents. On the other hand, plant products are generally considered to be less toxic with fewer side effects than synthetic products. Consequently, plant-derived materials have received increased attention as biochemical active agents in antihyperglycemia and antihyperlipidemia therapies. The study of such medicines might offer a natural key to unlock the diabetologists pharmacy for the future. So, some herbal (and/or supplements) drugs are a good source of natural antidiabetic agents (Ozsoy-Sacan, Karabulut-Bulan, Bolkent, Yanardag, & Ozgey, 2004). Phenolic compounds can be classified as simple phenols and phenolic acids such as gallic acid, benzoic acid, syringic acid, chlorogenic acid, and other associates, and polyphenols, which are classified into many groups such as flavonoids, tannins, stilbenes, and so on. Flavonoids are a group of polyphenolic compounds with known health-beneficial properties, which include free radical scavenging, inhibition of hydrolytic and oxidative enzymes, and anti-inflammatory action (Yildiz, Karakaplan, & Aydin, 1998). Grain polyphenols are abundant in the human diet, particularly in fruit, vegetables and pulses which have been consistently associated with a decreased risk of nutritional disease. They constitute one of the most abundant groups of natural metabolites and are now recognized for their important contribution to both human and animal diet and health (Spencer, Abd El Mohsen, Minihane, & Mathers, 2008). *Sorghum bicolor* L. Monech (Gramineae) is a drought resistant low input cereal crop grown throughout the world, and can be an alternative source of oil having clinical advantages. Genus sorghum includes many species and subspecies, including grain sorghum, grass sorghum, sweet sorghum and broomcorn. It is used as food, animal feed, fibers as in

* Corresponding author. Cardiovascular Medical Research Center, College of Korean Medicine, Dongguk University, Gyeong-Ju 780-714 and, Inam Neuroscience Research Center, Wonkwang University Sanbon Medical Center, Kyunggi-Do 435-040, South Korea. Fax: +82 54 770 2654.
E-mail address: himun68@gmail.com (H.-I. Moon).

0963-9969/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodres.2010.10.051

wall board, fences, biodegradable packing material and for ethanol production (Rooney & Waniska, 2000). Sorghum is an important food for people living in the semi-arid tropical areas of Africa and Asia (Murthy & Kumar, 1995). Sorghum flour is rich in phytochemical components with a potential to impact human health in a beneficial manner (Kamath, Chandrashekar, & Rajini, 2004). The storage proteins of sorghum constitute 50–60% of the total protein of the grain and have been classified into three main groups, according to their molecular weight, extractability and structure. Phenolic compounds in sorghum occur as phenolic acids, flavonoids and condensed tannins (Paulis & Wall, 1979; Serna-Saldivar & Rooney, 1995). Condensed tannins (proanthocyanidins) occur in sorghums with pigmented test which have dominant B1B2 genes. The tannins in sorghums have the highest levels of antioxidants of any cereal analyzed (Gu et al., 2004). Sorghum tannins are 15–30 times more effective at quenching peroxyl radicals than simple phenolics, thus they are potential biological antioxidants. Despite their possible beneficial effects as antioxidants, tannins have been linked to reduced protein digestibility of sorghum because they bind with proteins and inhibit enzymes (Duodu et al., 2002).

The objective of the present study was to determine contents of phenolic components in three varieties phenolic extracts (Hwanggeumchal sorghum (HGS), Chal sorghum (CS), and Heuin sorghum (HS)) from Korean sorghum commonly cultivated in Korea as well as to give animal experiments about their antidiabetic effect. The relationship between phenolic components content and antidiabetic effect in three varieties sorghum phenolic extracts was also investigated. To the best of our knowledge, this is the first report on the antidiabetic effect of Korean sorghum phenolic extracts.

2. Materials and methods

2.1. Grain materials and sample extracts for animal experiments

Three Korean sorghum cultivars were provided by the Department of Functional Crop, National Institute of Crop Science, Rural Development Administration, South Korea. The botanical identification was made by one of the authors, Dr. Ill-Min Chung on Kon Kuk University (Seoul, South Korea). Voucher herbarium specimens were deposited with the reference number (KNICS-579) in the Herbarium of the Department of Functional Crop. The seeds were stored at 4 °C. Sorghum cultivars used in this study were Hwanggeumchal sorghum (HGS), Chal sorghum (CS), and Heuin sorghum (HS) (Fig. 1). The three varieties of sorghum (each 300 g) were ground and refluxed three times (12 h, 24 h, 48 h) with 10 mL of acetonitrile and 2 mL of 0.1 N hydrochloric acid and stirred for 2 h at room temperature. The suspension was filtered through No. 42 Whatman filter paper. The extracts were gathered and the acetonitrile and hydrochloric acid were evaporated under reduced pressure at 45 °C in a rotary vacuum evaporator (Buchi RII, Buchi, Switzerland), followed by lyophilization. The stock solutions were kept at 4 °C in the dark until further analysis. Prior to analysis, the solution was filtered through a 1.0 μm syringe filter.

2.2. Chemical composition of Korean sorghum

Methods for analyses of crude protein, lipid, and ash were AOAC 990.03, 920.39, and 942.05, respectively. Crude fiber was analyzed by the filter bag technique using the ANKOM A200 (http://www.ankom.com/media/documents/CrudeFiber_1108_A200.pdf).

2.3. Analysis of phenolic components

Twenty-nine phenolic compound standards, flavonoids as catechin, naringin, naringenin, myricetin, quercetin, biochanin A, formononetin, hesperetin, kaempferol, rutin, gallic acid, pyrogallol, homogentisic acid, protocatechuic acid, gentisic acid, *p*-hydroxybenzoic acid, chlorogenic acid, vanillic acid, caffeic acid, syringic acid, vanillin, cinnamic acid, *p*-coumaric acid, ferulic acid, veratric acid, salicylic acid, benzoic acid, *o*-coumaric acid, and resveratrol were purchased from Sigma Aldrich (MO, USA) and Extrasynthese (Gernay, France) and used for calibration curves. The standard stock solutions (50, 100, 250, and 500 ppm) were made with dimethylsulfoxide (DMSO). All standard calibration curves showed high degrees of linearity (r^2>0.99) (data not shown). Sample compounds were identified on the basis of the retention times of standard materials and were quantified by comparing their peak areas with those of standard curves. Sample preparation for analysis of phenolic compounds followed Kim et al. (2006).Two grams of freeze-dried three sorghum powder was mixed with 10 mL of acetonitrile and 2 mL of 0.1 N hydrochloric acid and stirred for 2 h at room temperature. The suspension was filtered through No. 42 Whatman filter paper. The phenolic extracts were freeze-dried below −40 °C, and the residues were redissolved in 10 mL of 80% aqueous methanol (HPLC grade) (J. T. Baker, NJ, USA), filtered through a 0.45 μm nylon membrane filter (TITAN, TN, USA). The 20 μL filtrate was loaded on the HPLC system, a Shimadzu SPD-M10A HPLC system with a photodiode array detector (Tokyo, Japan) equipped with a Midas autoinjector. Separation was achieved on a 250 mm×4.6 mm i.d., 5 μm, YMC-Pack ODS AM-303 (YMC, Kyoto, Japan) column. The absorbance of each sample solution was measured at 280 nm. The mobile phase was distilled water with 0.1% glacial acetic acid (solvent A) and acetonitrile with 0.1% glacial acetic acid (solvent B). The gradient was 0 min, 92% A; 0–2 min, 90% A;2–27 min, 70% A; 27–50 min, 10% A; 50–51 min, 0% A; 51–60 min, 0% A; 60–63 min, 92% A. Run time was 60 min using a flow rate of 1 mL/

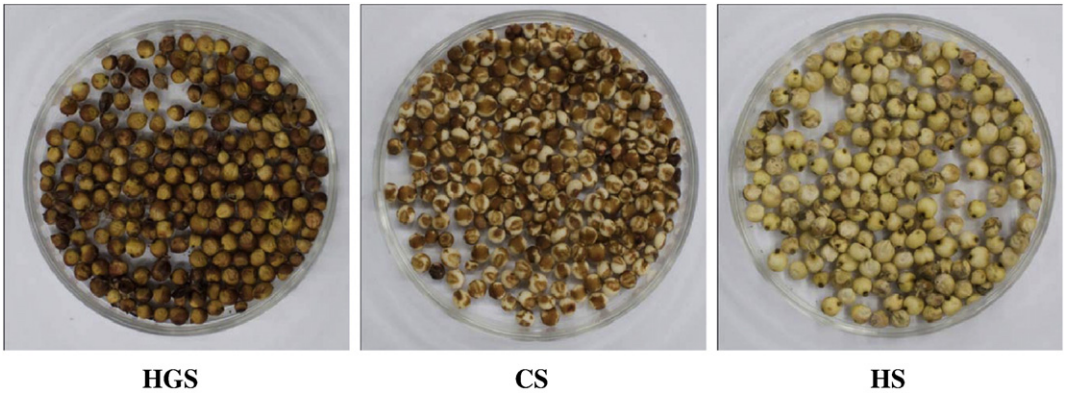

Fig. 1. Photograph of three Korean sorghum cultivars. Hwanggeumchal sorghum (HGS), Chal sorghum (CS), Heuin sorghum (HS).