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Effect of white kidney bean extracts on estimated glycemic index of different kinds of porridge

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ABSTRACT

The low glycemic index (GI) foods can be particularly effective for diabetics to help keep their blood sugar levels under control. The α-amylase inhibitor from white kidney beans could inhibit the mammalian α-amylase and thus lower the estimated GI (eGI) of high-GI food. In this study, the inhibitory effect of white kidney bean extracts on α-amylase was evaluated, and low-eGI instant porridge with white kidney bean extracts was developed. By adding white kidney bean extracts to 43.2 U/g starch, the eGI of rice porridge, oat porridge, barley porridge, and lotus seed porridge were reduced from 85.18, 55.57, 65.21, and 56.21 to 45.01, 30.41, 42.23, and 20.48, respectively. Since the white kidney bean extracts was heat sensitive, ultra-high pressure (UHP) was used to replace thermal pasteurization in protecting the activity of white kidney bean extracts in instant porridge. With UHP (600 MPa) treatment, no significant change in the eGI of rice porridge (eGI = 45.01) was observed, and the microbial population remained under 1.5 $\log_{10}$ CFU/mL when the rice porridge was stored at 4 °C for 30 d. These findings may support the view that UHP treatment can be potentially used in the production of commercial low-GI porridge with white kidney bean extracts.

1. Introduction

The glycemic index (GI) characterizes the blood glucose response following the consumption of food with a certain quantity of available carbohydrates relative to a reference food (glucose or white bread) (Udani, Singh, Barrett, & Preuss, 2009). Low-GI diets can reduce the risk of type II diabetes, coronary heart disease, and certain cancers. As such, they have been introduced to patients with diabetes for dietary management (Augustin et al., 2001; Franceschi et al., 2001; Liu et al., 2000; Schulze et al., 2004). Many studies (Augustin, Franceschi, Jenkins, Kendall, & La Vecchia, 2002; Brand-Miller, 2004) have suggested that reducing the GI in the diet can benefit the general population by preventing or delaying the development of diseases linked to insulin resistance.

Glycemic response is influenced by the rate of starch digestion (Englyst, Veenstra, & Hudson, 1996; Magaletta et al., 2010; Sáyago-Ayerdi, Tovar, Osorio-Diaz, Paredes-López, & Bello-Pérez, 2005). Thus, researchers have focused on reducing the GI of certain types of food by limiting the starch digestibility. According to Udani et al. (2009), the addition of white kidney bean extract could effectively lower the GI of high-GI food. This white kidney bean extracts containing α-amylase inhibitor (α-AI) could reduce GI by limiting starch digestibility via inhibition of α-amylase (Gibbs & Alli, 1998). The α-AI from white kidney beans belongs to a family of plant defense proteins and is a potent inhibitor of mammalian α-amylases. The inhibitor molecule could fill the whole substrate-docking region of α-amylase and induce structural changes at the active site, allowing the inhibitor to prevent starch digestion by completely blocking access to the active site of the enzyme (Bompard-Gilles, Rousseau, Rougé, & Payan, 1996). The α-amylase inhibitor extracts from white kidney beans are legally acceptable on the basis of the *de minimis* concept and are considered as conventional food by the United States Food and Drug Administration. Thus, significant attention has been paid to the industry-wide application of white kidney bean extracts in the production of low-GI food. Although Phase 2® white kidney bean extracts as a commercial food supplement has been used for reducing postprandial glucose levels, there are still some problems in industry process for production of low GI foods. Thus, an efficient method for the application of white kidney bean extracts in food industry has to be developed, and the factors (pH, temperature, incubation time, etc.) that influence the inhibitory activity of white kidney bean extracts should be elucidated.

Instant porridge is one of the most popular foods worldwide because it contains healthy cereals and provides convenience. However, the relatively high GI of instant porridge is not favorable for glucose control. Therefore, this study aimed to investigate the inhibitory effects of white kidney bean extracts on α-amylase activity and to develop a

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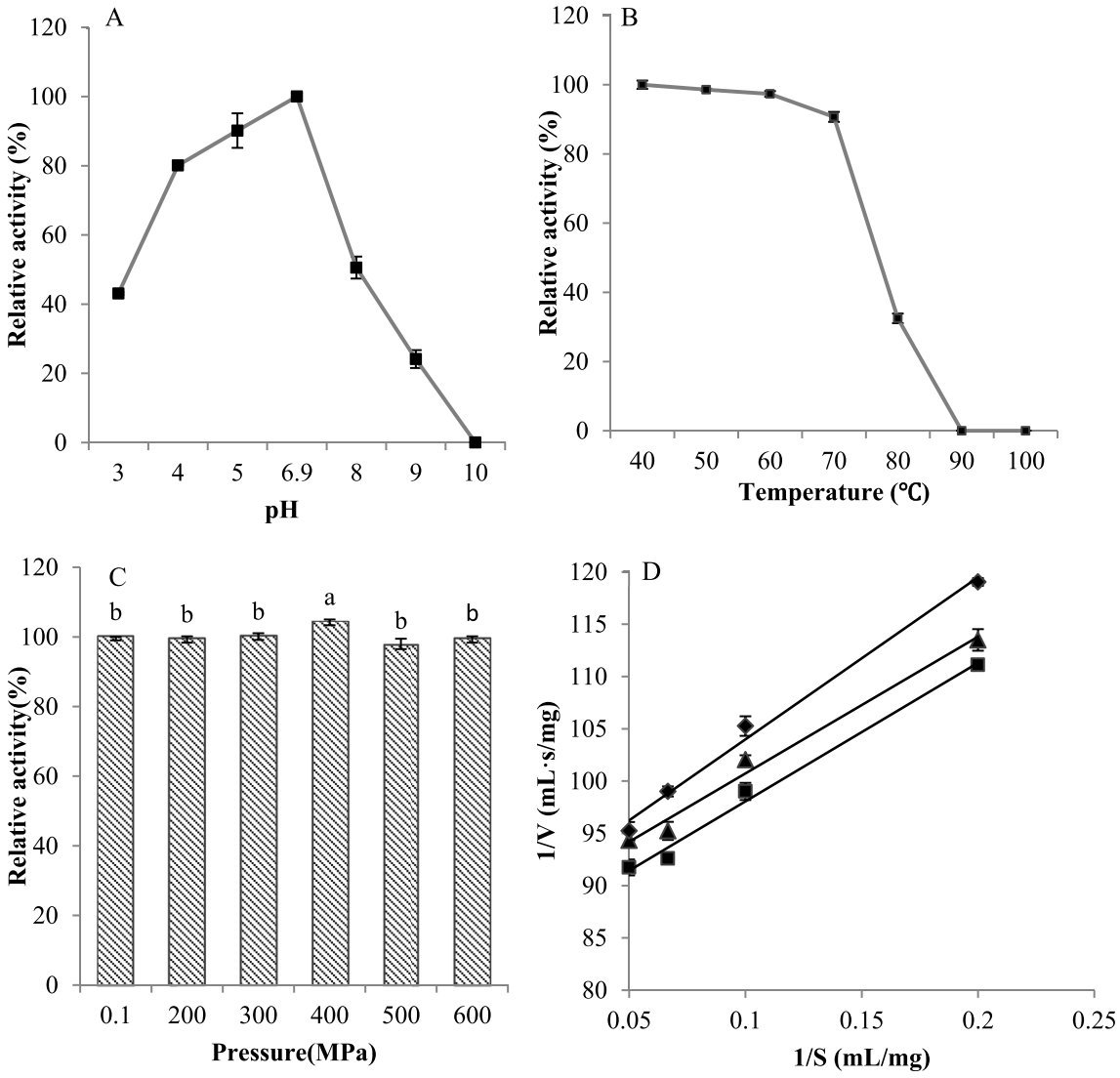

Fig. 1. Effect of pH(A), temperature(B), UHP(C) on the inhibitory activity of white kidney bean extracts and Line weaver-Burk plots(D) of PPA (without white kidney bean extracts (■) and partly inhibited by white kidney bean extracts at 2.619 U (▲) and 5.238 U (♦)). (mean ± SD, n = 3).

method for lowering the GI of different kinds of instant porridge.

2. Materials and methods

2.1. Materials

White kidney beans purchased from Lijiang (Yunnan, China) were ground and then passed through a 60-mesh sieve. The powder was then used immediately. White bread, rice porridge, oat porridge, barley porridge, and lotus seed porridge were purchased from a local store in Wuxi, Jiangsu. Decorticated white bread was homogenized with deionized water at a ratio of 1:5 (m/v) for 5 min by using a homogenizer (DS-1, Shanghai Specimen Model Factory, Shanghai, China). The total starch content of the mixture was 7.46% ± 0.90%. Rice porridge, oat porridge, barley porridge, and lotus seed porridge were directly homogenized for 5 min; total starch contents (AOAC, 2000) were 10.4% ± 0.47%, 11.19% ± 1.15%, 11.46% ± 1.48%, and 8.59% ± 1.47%.

Porcine pancreatic α-amylase (PPA) and pepsin were supplied by Sigma-Aldrich (St. Louis, MO, USA). Dinitrosalicylic acid reagent (DNS) was prepared according to Miller (1959).

2.2. Preparation of white kidney bean extracts

White kidney bean extracts were prepared as described in the study by Bowman (1945), with certain modifications. White kidney bean powder was mixed with deionized water at a ratio of 1:5 (w/v), and the white kidney bean extracts were extracted at room temperature (25 °C) for 3 h with continuous stirring at 150 rpm. The mixture was then centrifuged at 10,000 rpm for 30 min, and the supernatant was passed through a 150-mesh sieve. The filtrate was adjusted to pH 3.0 with 1 mol/L HCl and then incubated at 60 °C for 30 min. The solution was subsequently cooled in an ice water bath, and the pH was adjusted to 6.9 with 1 mol/L NaOH. The mixture was ultimately centrifuged at 10,000 rpm for 30 min. The supernatant was used to prepare the white kidney bean extracts by spray-drying, with the inlet temperature at 180 °C and the outlet temperature at 70 °C. The α-amylase inhibitory activity of the powder was determined as 3000 U/g.

2.3. α-Amylase (α-A) assays

α-Amylase activity was measured as described in the study by Bernfeld (1955), with certain modifications. About 0.25 mL of α-amylase solution (dissolved in 100 mM phosphate buffer, pH 6.9) was