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Original Research

White bread enriched with polyphenol extracts shows no effect on glycemic response or satiety, yet may increase postprandial insulin economy in healthy participants☆

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ABSTRACT

Extracts from different plant sources have been shown to modify starch digestion from carbohydrate-rich foods and lower resulting glycemia. It was hypothesized that extracts rich in polyphenols, added to white bread, would improve the glycemic response and insulin response and increase satiety in healthy participants. An in vitro dose-response analysis was performed to determine the optimal dose of a variety of extracts (baobab fruit extract, green tea extract, grape seed extract, and resveratrol) for reducing rapidly digestible starch in white bread. The 2 extracts with the greatest sugar reducing potential were then used for the human study in which 13 volunteers (9 female and 4 male) were recruited for a crossover trial of 3 different meals. On separate days, participants consumed a control white bread, white bread with green tea extract (0.4%), and white bread with baobab fruit extract (1.88%). Glycemic response, insulin response, and satiety were measured 3 hours postprandially. Although enriched breads did not reduce glycemic response or hunger, white bread with added baobab fruit extract significantly ($P < .05$) reduced the total (0-180 minutes) and segmental insulin area under the curve at 0 to 90, 0 to 120, and 0 to 150 minutes, and therefore reduced the amount of insulin needed for a given blood glucose response. This preliminary research suggests that there is potential for baobab fruit extract added into white bread to improve insulin economy in healthy adults.

Abbreviations: AUC, area under the curve; ANOVA, analysis of variance; BAO, baobab fruit extract; CON, control; GI, glycemic index; GR, glycemic response; GTE, green tea extract; GSE, grape seed extract; IR, insulin response; RDS, rapidly digestible starch; RES, resveratrol; VAS, visual analog scale.

☆ There are no conflicts of interest for any of the authors.

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1. Introduction

An elevated glycemic response (GR) to food has been associated with increased weight gain, and therefore, managing postprandial glucose excursions could be seen as a potential target for reducing the prevalence of obesity and associated comorbidities. Previous research has shown that extracts from plant foods may influence glucose metabolism by several mechanisms such as inhibition of carbohydrate digestion and/or glucose absorption and transport, improved fasting blood glucose levels, enhanced insulin secretion, and improved insulin sensitivity [1]. This has generated much interest into the role of certain extracts as potential functional food ingredients for improving health [2].

Plant extracts contain a wide range of health compounds including polyphenols, which can be absorbed into the blood and exert their effects at the cellular level, yet can also reduce postprandial glycemia by inhibiting and/or prolonging digestion in the intestinal tract [3,4]. According to the glucostatic theory proposed by Mayer [5] in 1953, postprandial blood glucose levels may influence feelings of satiety through glucoreceptors. Insulin response (IR) is also thought to be highly associated with GR and satiety [6]. Thus, extracts from plants rich in secondary metabolites may not only exert glucose-lowering effects by reducing starch digestion but also reduce postprandial IR and increase satiety.

It was therefore hypothesized that the addition various plant extracts to white bread, a high glycemic index (GI) food, would decrease starch breakdown and improve glucose metabolism. This would therefore reduce the postprandial GR and IR and increase satiety in healthy humans. The specific aims of this study were (1) to perform a dose-response analysis to determine the optimal concentration of polyphenol-rich extracts (green tea extract [GTE], grape seed extract [GSE], resveratrol [RES], and baobab fruit extract [BAO]) for reducing in vitro starch digestion and sugar release from white bread to identify the 2 extracts with the greatest sugar reducing potential; (2) to characterize the effect of the identified extracts on GR, IR, and satiety in vivo; and (3) to determine if a correlation exists between the in vitro and in vivo methods of measuring GR.

2. Methods and materials

2.1. Study protocol: in vitro

The effect of polyphenols on the inhibition of starch breakdown was determined. This was achieved by subjecting samples of white bread with added polyphenol extracts to an in vitro digestion procedure, and measuring the resultant reducing sugars released at various phases throughout duodenal digestion.

2.2. Materials

All chemicals and reagents were of analytical grade and were purchased from Sigma-Aldrich (Poole, UK). The extracts included GTE, GSE, and BAO (Holland & Barrett, Oxford, UK) and RES (Biotivia, UK). All bread ingredients were purchased from Tesco Supermarket, UK. Extract compositions are given in Table 1.

2.3. Folin-Ciocalteu method

The total phenolic content was determined using the Folin-Ciocalteu method protocol from Sharma and Gujral [7] and reproduced by Coe et al [8]. The results were expressed as mg gallic acid equivalents per gram of sample.

2.4. Bread preparation

White bread was made in a Russell Hobbs bread maker (model no. 18036; Manchester, UK) with ingredients added in the following order: 190 g warm water, 1 tablespoon (tbsp) virgin olive oil, 1 tsp salt, 1 tbsp sugar, 1 tbsp dried milk powder, 350 g strong white flour, 1½ tsp yeast. Green tea extract, GSE, and RES were added immediately before the baking process was initiated. A dose-response was performed using a range of extract concentrations to determine the lowest concentration of each extract that could significantly reduce rapidly digestible starch (RDS) from white bread with percentages given based on a 500-g loaf (Table 2). The optimal dose of BAO was previously determined in our laboratory [9]. When adding extracts to the breads, the flour content was altered in order to keep the overall weight of each bread the same as the control bread. This was achieved by subtracting the extract weight in grams from the flour weight in grams, to determine the new flour weight with added extract. All bread samples were baked the night before, sealed at room temperature in plastic containers overnight, and tested the following morning.

2.5. In vitro digestion

The in vitro digestion procedure consisted of a simulated gastric digestion phase followed by an ileal digestion phase

Table 1 – Contents, ingredients, and bioactives in each extract tested

Extract	Contents
GTE (Holland & Barrett)	315 mg GTE (*Camellia sinensis*, standardized to contain 15% polyphenols), maltodextrin, bulking agent (dicalcium phosphate), anticaking agents (silicon dioxide, magnesium stearate)
GSE (Holland & Barrett)	50 mg GSE (standardized to contain 50% proanthocyanidins, 25 mg), citrus bioflavonoids 500 mg (from 250 mg of 2:1 concentrate), rice powder, lactose, maltodextrin, anticaking agents (silicon dioxide, magnesium stearate, stearic acid)
Trans-RES (Biotivia)	Japanese knotweed (*Polygonum cuspidatum*), dried rhizome extract (Biotivia) containing 50% trans-RES, 2% emodin, hydroxypropyl methylcellulose, color copper complex of chlorophyll and chlorophyllins
BAO (Holland & Barrett)	100% natural baobab powder

Contents based on per capsule amount.