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Effects of a viscous-fibre supplemented evening meal and the following un-supplemented breakfast on post-prandial satiety responses in healthy women

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HIGHLIGHTS

- We examine the satiety effect of viscous fibre on initial and subsequent meals.
- We examined the fullness score at post prandial time points.
- The "second-meal effect" was investigated.

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ABSTRACT

The post-prandial satiety response and "second-meal effect" of a viscous fibre supplement PolyGlycopleX® (PGX®) was evaluated in a single-blind, randomised controlled crossover study of 14 healthy adult women. The two hour post-prandial satiety response, expressed as the area under the curve (AUC) of perceived hunger/fullness score *versus* post-prandial time, of a standardised evening meal with concurrent intake of either PGX softgel or rice flour softgel (control) was determined. On the following morning, after an overnight fast, the four hour satiety response to a standardised breakfast with no softgel supplementation was assessed. A significantly higher satiety response (AUC) to the standard dinner for the PGX-supplemented dinner compared with the control dinner ($p = 0.001$) was found. No significant difference ($p = 0.09$) was observed in the satiety response (AUC) of the breakfast regardless of which supplemented-dinner had been consumed prior, however the p value indicated a trend towards a higher response to the breakfast following the PGX-supplemented dinner. The fullness scores of the breakfast following the PGX-supplemented dinner at 15, 30, 90, 120, 150, 180, 210 and 240 min post-prandial were significantly higher than those for the breakfast following the control dinner ($p = <0.001, 0.007, 0.009, 0.009, 0.049, 0.03, 0.003$ and <0.001 respectively). PGX supplementation at dinner increased the satiety effects of both the dinner itself and the subsequent un-supplemented breakfast; a "second meal effect" indicting the potential for this fibre supplement to induce extended satiety.

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Abbreviations: PGX, PolyGlycopleX; AUC, area under the curve; LMS, labelled magnitude scale; MCT, medium chain triglycerides; VAS, visual analogue scale.

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1. Introduction

The consumption of meals high in dietary fibre, especially soluble viscous fibres such as alginate and guar has been demonstrated to induce long lasting perceptions of post-prandial fullness known as satiety [1,2,3]. This post-prandial effect of viscous fibres may be one reason why increased dietary fibre intake in the diet can increase satiety levels over a longer term and reduce hunger and energy intake, effects that may ultimately reduce risk of obesity [4].

Intake of food containing viscous dietary fibres can result in gel formation in the stomach and increased viscosity of the upper gastrointestinal tract contents [5,6]. These physicochemical changes may delay gastric emptying and slow the rate of absorption of nutrients from the small intestine resulting in lowered but sustained postprandial blood glucose levels [7,8,9,10,11] lowering the glycaemic index (GI) of available carbohydrate-containing foods to which the fibre has been added [12,13]. The release of gut hormones such as cholecystokinin (CCK) in the duodenum and peptide YY (PYY) and glucagon-like-peptide (GLP-1) in the ileum/colon are involved in suppressing food intake [14]. In contrast, the release of ghrelin in the stomach stimulates appetite and food intake [15]. These changes to the gastrointestinal processing of food, as a consequence of the inclusion of viscous fibres in the diet, can promote satiety through modulating the release of these gastrointestinal hormones [7,16,17,18,19].

Increased intake of dietary fibre through increased consumption of wholegrains, vegetables and fruit is recommended in the Australian Dietary Guidelines [20]. Fibre intake by American adults is approximately half the recommended level [21]. Australian adults eat 24 g of dietary fibre, 6 g less than the 30 g recommended level [22]. The use of fibre supplements may be an effective way to boost fibre consumption to the recommended levels [23]. Combinations of viscous fibres have been used in the development of fibre supplements with elevated viscosity, specifically aimed at providing high satiety effects when taken in conjunction with a meal. One such supplement is PolyGlycopleX® (PGX®) which is a commercially manufactured soluble viscous polysaccharide complex of konjac glucomannan, sodium alginate and xanthan gum with a higher viscosity than currently known single dietary fibre sources and with gel-forming properties [16,10].

Solah et al. [10,24] reported that PGX significantly improved post-prandial fullness and satiety when compared to an inulin control, with 7.5 g supplementation of the breakfast bread meal having the greatest effects. Brand-Miller et al. [25] demonstrated that PGX supplementation also reduces post-prandial glycaemia, when a 7.5 g supplementation to a white bread meal containing 50 g available carbohydrate reduced the incremental area under the 120 min post-prandial blood glucose curve by 50% compared to that of the un-supplemented bread meal.

The satiety response to a meal is commonly determined for a post-prandial period of several hours, during which time no food and beverages (except limited amounts of water) are consumed. However the post-prandial physiological response to one meal (*e.g.* dinner) may delay the absorption rate of nutrients, resulting in changes in hormonal signals in the gut and effects on colonic fermentation [26,27,28,29] and thus affect the satiety response to the following meal (*e.g.* breakfast the following morning). This phenomenon is known as the "second-meal effect". Brand-Miller et al. [25] found that softgels containing PGX gave a second-meal effect on post-prandial glycaemia as a dose related response by improving glucose tolerance at breakfast time when consumed with the previous evening meal. Chen et al. [30] found a second-meal effect where postprandial glucose was reduced in people with type 2 diabetes as a result of soy yoghurt consumption with the previous meal. In a study by Isaksson et al. [31] a rye breakfast resulted in higher satiety ratings in the morning and afternoon, compared with the isocaloric control breakfast of wheat bread, and reduced *ad libitum* energy intake at lunch on the subsequent day. Despite the lack of overall effect on appetite sensation, Ibrügger et al. [32] observed an effect of wholegrain rye consumption on *ad libitum* energy intake at a third meal. Reichert et al. [33] found fullness scores increased over a 10 week period with PGX supplementation of meals, indicating a carry-over effect, but found no effect on fullness in the three hours after PGX supplementation with a meal or a second meal effect. There is limited published research investigating second meal effects on post-prandial satiety. Further research is important since fibre supplements demonstrating a second-meal effect on satiety, compared to those providing only short term effects, may through inducing a longer lasting reduction in appetite be more effective in reducing overall dietary energy intake.

The objective of this study was to determine the effect of:

a) a standardised dinner with concurrent intake of either a PGX softgel supplement or a rice flour softgel (control) supplement by healthy women on the post-prandial satiety response.
b) the PGX softgel supplement or control supplemented dinner on the post-prandial satiety response an un-supplemented standardised breakfast the following morning.

2. Materials and methods

2.1. Participants

Healthy adult female participants were recruited from the population of students at Curtin University (Bentley, WA, Australia) through approved flyers and emails. All participants attended a short interview session prior to the study to explain the procedures. Volunteers were assessed for eligibility to ensure recruitment of regular breakfast eaters. Exclusion criteria were those with food allergies, smoking, pregnancy, more than three alcoholic drinks per day, type 2 diabetes, cardiovascular diseases or being on a weight loss diet. A written informed consent was signed by each participant prior to commencing the study and participants had the option to withdraw at any point in time.

Curtin University approved this research and ethical approval was obtained for this study from the Human Research Ethics Committee of Curtin University (HR03/2014). Seventeen participants were recruited for the study and 14 completed the entire study. Two participants withdrew due to personal reasons and one due to time constraints.

2.2. Test meals and supplements

Dinner consisted of a pre-packed frozen meal (Lean Cuisine, Simplot Australia, Mentone, Victoria, Australia) which was supplied to the participants who prepared the meal according to manufacturer's instructions at home. These dinners provided a standardised energy intake (1520 kJ) and food volume (380 g) for each participant. Bottled water (600 mL) was also provided for consumption as part of the dinner (see Table 1 for detailed nutritional composition). As part of the total dinner meal, six softgel supplements were provided. Each softgel contained either 0.75 g of the PGX® (Inovobiologic Inc., Calgary, Canada) or 0.75 g raw rice flour (supplied by Inovobiologic Inc., Calgary, Canada). An evening snack was also provided to participants in the form of a 32 g muesli bar (Uncle Tobys®, Nestle Australia, Rutherglen, Victoria, Australia). The total dinner meal design met the needs of the participant as a typical/healthy "dinner" containing cooked rice, water, vegetables, cooked marinated chicken and differed only in flavour. A standard breakfast of 1261 kJ was previously determined to provide a meal that would induce immediate post-meal satiety of at least "Moderately full" using the LMS in a previously fasted panellists [24]. The standard breakfast (total weight 220 g) (see Table 1 for composition) used in this research was similar to the previous breakfast [24] and contained cereal flakes (45 g) (Cornflakes and Special K®, Kellogg's, Ferntree Gulley, Vic, Australia), whole cow's milk (175 g) and water (200 mL).

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