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Research report

Effect of whey protein and glycomacropeptide on measures of satiety in normal-weight adult women☆

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ABSTRACT

Protein is the most satiating macronutrient and dairy whey protein is thought to be more satiating than other protein sources. The purported satiating effect of whey protein may be attributable to the presence of glycomacropeptide (GMP). The objective of this study was to investigate the role of GMP in the satiating effect of whey protein. Isoenergetic (~1600 kJ) preload drinks contained GMP isolate (86% GMP, "GMP"), whey protein isolate (WPI) with 21% naturally occurring GMP, WPI with 2% naturally present GMP, or maltodextrin carbohydrate ("carbohydrate"). Satiety was assessed in 22 normal-weight adult women by determining the consumption of a test meal provided *ad libitum* 120 min following ingestion of a preload drink, and also by using visual analogue scales (VAS) for rating feelings of hunger, desire to eat, prospective consumption and fullness (appetite). The *ad libitum* test meal intake was significantly different between the preload drinks ($p = 0.0003$), with food intake following ingestion of both WPI preload drinks (regardless of the amount of GMP) being ~18% lower compared with the beverages enriched with carbohydrate or GMP alone. There were no significant differences ($p > 0.05$) in the VAS-rated feelings of appetite among the four preload drinks. GMP alone did not reduce subsequent food intake compared with a drink enriched with carbohydrate, but whey protein had a greater satiating effect than carbohydrate. The presence of GMP in whey does not appear to be the cause of the observed effect of whey protein on satiety.

Introduction

The role of dietary protein in enhancing satiety and reducing food intake to a greater extent compared with other macronutrients has been the subject of several scientific reviews (Anderson & Moore, 2004; Eisenstein, Roberts, Dallal, & Saltzman, 2002; Halton & Hu, 2004; Westerterp-Plantenga, Nieuwenhuizen, Tome, Soenen, & Westerterp, 2009). The source of protein may influence the satiating effect and dairy whey protein appears to be more satiating than other protein sources (Luhovyy, Akhavan, & Anderson, 2007; Veldhorst et al., 2008).

During cheese making, whey is the soluble protein component of milk that is separated from the casein curd. This whey also contains glycomacropeptide (GMP), a 64 amino acid soluble peptide cleaved from the action of rennet (chymosin) on κ-casein proteins. GMP refers to the glycosylated form of caseinomacropeptide (CMP) and contains varying amounts of oligosaccharides, mostly sialic acid (*N*-acetylneuraminic acid), galactosamine, and galactose (Walstra, Wouters, & Geurts, 2006). Human studies investigating the effect of GMP on food intake and satiety have resulted in mixed findings. Veldhorst et al. (2009a) showed a decrease in food energy intake at a subsequent meal 180 min after consumption of a test breakfast containing whey protein with GMP compared with whey protein without GMP. However, in studies where isolated GMP or CMP was tested, no difference in food energy intake at a subsequent test meal was found relative to a control preload (water, basal mixture, carbohydrate or whey protein) (Burton-Freeman, 2008; Clifton et al., 2009; Gustafson, McMahon, Morrey, & Nan, 2001; Keogh et al., 2010; Poppitt, Strik, McArdle, McGill, & Hall, 2013). With respect to subjective measures of satiety, Clifton et al. (2009), Gustafson et al. (2001), Keogh et al. (2010) and Poppitt et al. (2013) reported no effects, while Burton-Freeman (2008) found that ratings of satiety were greater after consumption of whey-containing drinks (whey protein with and without GMP) compared with a milk-based mixture and a GMP (0.8 g) drink in 10 women, although such a change in satiety ratings was not observed in men.

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Previous studies from our own group showed that the ingestion of preload drinks enriched with whey protein containing naturally present GMP resulted in subjects consuming a lower energy intake at a subsequent meal and reporting a greater feeling of fullness compared with a maltodextrin carbohydrate-enriched control beverage (Chungchunlam, Moughan, Henare, & Ganesh, 2012; Lam, Moughan, Awati, & Morton, 2009). The natural presence of GMP in whey confounds investigation of the satiating effect of whey protein, and the influence of GMP alone on satiety and food intake remains to be elucidated. We hypothesise that the greater satiety observed (Chungchunlam et al., 2012) when whey protein including naturally occurring GMP was consumed is related to GMP content. The aim of the presently reported study was to compare the effects of preload drinks enriched with WPI with a high (21%) and minimal (2%) level of naturally present GMP relative to GMP (86% GMP) alone on measures of satiety in normal-weight adult women. Maltodextrin carbohydrate was used as a comparator. Possible mechanisms underlying the effects on subsequent food intake and rated feelings of appetite were not studied.

Subjects and methods

Subjects

Healthy women aged 18 to 40 years were recruited by public advertisement. Smokers, trained athletes, pregnant or lactating women and women not consuming breakfast everyday were excluded from the study. Subjects were also excluded if their body weight had changed over the past 6 months (weight gain or loss > 3 kg), if they had a history of menstrual irregularities, a gastrointestinal disorder or were taking any medication known to affect gastrointestinal motility or appetite. All subjects attended an information session about the study procedure, signed a consent form, had their height and weight measured to ensure that they met the body mass index (BMI) criteria (BMI range: 20–25 kg/m^2), completed the Three Factor Eating Questionnaire (Stunkard & Messick, 1985) and tasted the preload drinks and test meal. The Massey University Human Ethics Committee (Application no. 11/47) approved the study. Twenty-two women completed the study, with 14 subjects being white Caucasian and eight subjects of Asian descent. The participants had a mean age of 23.8 ± 0.9 years, mean weight of 62.9 ± 1.3 kg and mean BMI of 23.1 ± 0.4 kg/m^2. According to the Three Factor Eating Questionnaire, subjects scored low in restraint (8.9 ± 1.0), disinhibition (5.9 ± 0.4) and perceived hunger (4.5 ± 0.7).

Preload drinks and test meal

Preloads (Table 1) were approximately isovolumetric (~280 ml) and isoenergetic (~1600 kJ) drinks that comprised a basal mixture of skim milk powder, sucrose, natural sweetener, vanilla flavour, yellow colouring and water, and either GMP isolate containing 86% GMP (“GMP”), whey protein isolate (WPI) containing 21% naturally occurring GMP (“WPI-high GMP”), WPI containing minimal 2% GMP (“WPI-low GMP”), or maltodextrin carbohydrate (“carbohydrate”). The skim milk powder contained a minimal amount of whey protein (6.7%) and GMP (0.2%), contributing 1.005 g of whey protein and 0.03 g of GMP per 300 g serve of preload drink. The remaining 14% of the fully glycosylated GMP isolate (86% GMP) comprised 0.4% fat, 6.2% ash, 5.9% moisture and 1.5% undetermined material. Although the WPI-low GMP powder was anticipated to contain no GMP, protein analysis using reverse-phase high performance liquid chromatography showed that the GMP content in the WPI was 2%, likely arising from contamination during processing. The “protein” preload drinks were high in protein (66–76% of metabolisable energy) but also contained some carbohydrate (22–31% of metabolisable energy) while the “carbohydrate” preload drink mainly comprised of carbohydrate (89.5% of metabolisable energy) but also contained some protein (7.2% of metabolisable energy). The preload beverages of mixed macronutrient composition were deemed more acceptable to an independent group of sensory panellists than preload drinks

Table 1
Composition of the preload drinks containing either glycomacropeptide isolate (GMP), whey protein isolate containing 21% glycomacropeptide (WPI-high GMP), whey protein isolate with 2% glycomacropeptide (WPI-low GMP) or maltodextrin carbohydrate (carbohydrate).

	GMP[a]	WPI-high GMP[b]	WPI-low GMP[c]	Carbohydrate[d]
Ingredient (g per 300 g serve)				
Skim milk powder	15	15	15	15
Sucrose	9	9	9	9
Natural sweetener (Stevia)	0.06	0.06	0.06	0.06
Vanilla flavour	1.5	1.5	1.5	1.5
Yellow colour	0.09	0.09	0.09	0.09
Glycomacropeptide isolate[a]	60	–	–	–
Whey protein isolate-high glycomacropeptide[b]	–	60	–	–
Whey protein isolate-low glycomacropeptide[c]	–	–	60	–
Maltodextrin carbohydrate[d]	–	–	–	60
Water	214.35	214.35	214.35	214.35
Nutrient (per 300 g serve)				
Metabolisable energy (ME)[e] (kJ)	1599	1623	1558	1650
Fat				
(g)	1.3	1.2	1.0	1.4
(% of ME)	3	3	2	3
Carbohydrate				
(g)	29.3	22.8	20.4	88.4
(% of ME)	31	23	22	90
Protein				
(g)	63.5	71.6	70.6	7.2
(% of ME)	66	74	76	7
GMP (g)	51.4	12.8	1.5	0

[a] Glycomacropeptide isolate containing 86% glycomacropeptide (BioPURE-GMP™, Davisco Foods International Inc., Le Sueur, MN, USA).
[b] Whey protein isolate containing 21% glycomacropeptide (WPI 894, Fonterra Co-operative Group Ltd, Palmerston North, New Zealand).
[c] Whey protein isolate containing 2% glycomacropeptide (WPI 895, Fonterra Co-operative Group Ltd).
[d] Maltodextrin carbohydrate (Avondex 10, New Zealand Starch Ltd, Auckland, New Zealand).
[e] Metabolisable energy (ME) calculated from the energy-containing food components using the energy conversion factors of 16.7 kJ/g for protein and available carbohydrate and 37.7 kJ/g for fat.