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Effect of milk protein intake and casein-to-whey ratio in breakfast meals on postprandial glucose, satiety ratings, and subsequent meal intake

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ABSTRACT

Whey and casein proteins differentially affect postprandial blood glucose and satiety mechanisms, with relevance for type 2 diabetes and obesity. Therefore, the purpose of this work was to investigate the effect of the casein-to-whey protein ratio and total protein concentration of milks consumed with cereal on postprandial blood glucose, appetite ratings, and subsequent food intake in a randomized, controlled, double-blinded study with healthy young adults (n = 32, 23.4 ± 3.1 yr, body mass index = 22.2 ± 2.5 kg/m^2). Fasted participants consumed milk (250 mL) with either 80:20 or 40:60 (modified) casein-to-whey protein ratios at commercially normal (3.1%, wt) or high protein (9.3%, wt) concentration, or control (water with whey permeate), each along with 2 servings of oat-based breakfast cereal. Blood glucose concentrations were determined from finger prick blood samples and appetite was assessed using visual analog scales. Participants consumed a measured ad libitum pizza lunch at 120 min and blood glucose determination and appetite assessment continued following the lunch meal (140–200 min) to observe the second meal effect. Pre-lunch (0–120 min) incremental area under the curve (iAUC) and mean change from baseline blood glucose were reduced with consumption of all milk treatments relative to control. However, we found no differences between all treatments on pre-lunch appetite change from baseline and total area under the curve (tAUC) or lunch meal food intake. In terms of protein concentration results, high protein (9.3%, wt) treatments contrasted to normal protein (3.1%, wt) treatments lowered blood glucose change from baseline and iAUC, and post-lunch appetite change from baseline and tAUC. Protein ratio showed a modest effect in that modified (40:60) protein ratio lowered pre-lunch blood glucose change from baseline but not iAUC, and normal (80:20) protein ratio lowered pre-lunch appetite change from baseline but not tAUC. Therefore, high-carbohydrate breakfast meals with increased protein concentration (9.3%, wt) could be a dietary strategy for the attenuation of blood glucose and improved satiety ratings after the second meal.
Key words: dairy protein, whey, casein, glycemia, appetite

INTRODUCTION

Metabolic diseases are on the rise globally, with type 2 diabetes and obesity as leading concerns in human health. Obesity is now recognized as a risk factor for type 2 diabetes and can occur concurrently (Eckel et al., 2005). Thus, there is impetus to develop dietary strategies for the risk reduction and management of obesity and diabetes to empower consumers to improve their personal health. The role of the breakfast meal and composition has received relatively little attention beyond the high glycemic index attributed to many high-carbohydrate foods consumed at breakfast. However, these foods are often consumed with a source of protein, including dairy and eggs, which modify the postprandial glycemic response. Frequent consumption of cow milk and dairy products has been associated with lower risk of obesity and type 2 diabetes (Anderson et al., 2011). Meal studies have specifically shown that milk consumed with a high-glycemic, ready-to-eat breakfast cereal consumed by young adults (Law et al., 2017a) or cheese and yogurt consumed with toast and jam by older adults (Law et al., 2017b) markedly lower postprandial glycemia compared with the carbohydrate alone.

The lower postprandial glycemia occurring when dairy is consumed with carbohydrates may be explained by dairy casein and whey proteins, which are present in an 80:20 ratio and have different AA compositions, physical structures, and physiological properties. Casein is higher in methionine, phenylalanine, proline, and histidine; whey proteins have higher amounts of

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lysine, threonine, tryptophan, leucine, and isoleucine. Based on the rise of their plasma AA concentrations postingestion, whey proteins have been referred to as rapidly digested proteins and found to pass relatively quickly through the stomach. In contrast, caseins are considered to be slowly digested (Dangin et al., 2002; Hall et al., 2003) due to forming cross-linked aggregates that delay gastric emptying (Boirie et al., 1997). Consumption of whey protein increases early feelings of satiety and reduces food intake, whereas the effect of casein occurs later (Anderson et al., 2004). For example, consumption of 45 to 50 g of whey protein decreased food intake more than casein at a meal interval of 30 to 90 min (Anderson and Moore, 2004), but casein consumption reduced food intake more than whey protein at 180 min (Anderson et al., 2011). Differences in the digestion kinetics of whey and casein proteins facilitate the stimulation of gastric hormones that delay gastric emptying, thus increasing feelings of fullness and attenuation of food particle breakdown and release in the small intestine. Relative to whey, casein digests and releases AA slowly, leading to a delayed stimulation of gastric hormones (Benelam, 2009).

Although the physiological characteristics of whey and casein are well described, the physiological significance of their ratio and concentration in milk are not. Of note, human milk has a ratio of casein to whey approximating 40:60 and a protein content of 1% (wt; Fox and McSweeney, 1998). Current infant milk formulas often approximate this ratio (Klein, C., 2002), but are higher in protein (2–2.5%; Martin et al., 2016). Although not recommended in the first year for infants, both the ratio and protein concentration change to 80:20 and 3.1% (wt), respectively, with the introduction of cow milk.

In addition to the potential for dairy proteins to affect postprandial metabolism, evidence has shown that daily protein intake should be spread equally over 3 main meals, indicating a need to include more protein with the breakfast meal (Mamerow et al., 2014). Therefore, the purpose of our work was to test the effect of novel milk formulations with altered amounts and proportions of whey and casein proteins on postprandial blood glucose (**BG**), feelings of satiety, and subsequent food intake when consumed with a high-glycemic carbohydrate breakfast cereal in healthy young adults. Milk products containing similar protein content as commercial milk (3.1%, wt, protein) or increased to 9.3% (wt), both formulated to contain either a 80:20 or 40:60 casein-to-whey ratio, were consumed with breakfast cereal containing a total of 76.7 g of available carbohydrates. We hypothesized that the milk products containing modified 40:60 casein-to-whey protein ratios or enhanced protein concentrations or both, when compared with the control and commercial milk (3.1%, wt, concentration and 80:20 ratio), would be associated with reductions in post-lunch BG, enhanced feelings of satiety, reductions in food intake at a subsequent meal, and reductions in BG following the subsequent meal.

MATERIALS AND METHODS

Treatment Preparation

Breakfast drinks (250 mL) based on skim milk (Neilson Dairy–Saputo Dairy Products Canada G.P., St-Laurent, Quebec) or control (water with whey permeate) were formulated and cold-mixed together using whey permeate (DariSweet 200, #215503), skim milk powder (Low Temp, #202001), and whey protein concentrate (Prodel 35, #33703; all from Parmalat Canada, London, ON, Canada) to increase the concentration of commercial milk protein (3.1%, wt) 3-fold (9.3%, wt) and modify the casein-to-whey protein ratio from (normal) 80:20 to high whey (i.e., 40:60) while holding the lactose (34.7 g) contents constant (Table 1). Treatments and the water and permeate control were combined with 58 g of oat-based cereal (Honey

Table 1. Composition of breakfast drinks served with Cheerios (General Mills, Mississauga, Canada) to participants

Treatment (250 mL)	Water (mL)	Skim milk liquid (mL)	Permeate powder (g)	Skim milk powder (g)	Whey protein concentrate powder (g)
Control[1]	250	—	47.3	—	—
3.1% MKP (80:20)[2]	—	250	31.9	—	—
3.1% MKP (40:60)[3]	125	125	31.6	—	12.5
9.3% MKP (80:20)[4]	—	250	—	46.8	—
9.3% MKP (40:60)[5]	—	250	—	11.8	37.7

[1]Control (water with whey permeate).

[2]Commercial skim milk 3.1% (wt) milk protein (MKP; 80 casein:20 whey).

[3]Normal 3.1% (wt) MKP (40 casein:60 whey protein).

[4]High 9.3% (wt) MKP (80 casein:20 whey protein).

[5]High 9.3% (wt) MKP (40 casein:60 whey protein).