Appetite 116 (2017) 544–551

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Consumption of dark chocolate attenuates subsequent food intake compared with milk and white chocolate in postmenopausal women

Channa E. Marsh [a, *], Daniel J. Green [a, b, c], Louise H. Naylor [a], Kym J. Guelfi [a]

[a] School of Human Sciences, The University of Western Australia, Perth, Western Australia, Australia
[b] Research Institute for Sport and Exercise Science, Liverpool John Moores University, Liverpool, United Kingdom
[c] Principal Research Fellow, National Health and Medical Research Council, Australia

ARTICLE INFO

Article history:
Received 19 December 2016
Received in revised form
3 May 2017
Accepted 27 May 2017
Available online 29 May 2017

Keywords:
Appetite
Ad libitum energy intake
Cocoa
Polyphenols
Mood
Ghrelin

ABSTRACT

Background: Chocolate has a reputation for contributing to weight gain due to its high fat, sugar and calorie content. However, the effect of varying concentrations of cocoa in chocolate on energy intake and appetite is not clear.
Objective: To compare the acute effect of consuming an isocaloric dose of dark, milk and white chocolate on subsequent energy intake, appetite and mood in postmenopausal women.
Methods: Fourteen healthy postmenopausal women (57.6 ± 4.8yr) attended an introductory session followed by three experimental trials performed in a counterbalanced order at a standardised time of day, each separated by one week. *Ad libitum* energy intake, perceived appetite, mood and appetite-related peptides were assessed in response to consumption of 80% cocoa [dark chocolate], 35% cocoa [milk chocolate] and cocoa butter [white chocolate] (2099 kJ), prepared from a single-origin cacao bean.
Results: Ad libitum energy intake was significantly lower following dark (1355 ± 750 kJ) compared with both milk (1693 ± 969 kJ; $P = 0.008$) and white (1842 ± 756 kJ; $P = 0.001$) chocolate consumption. Blood glucose and insulin concentrations were transiently elevated in response to white and milk chocolate consumption compared with the dark chocolate ($P < 0.05$), while pancreatic polypeptide was elevated in response to higher cocoa content chocolate (dark and milk) compared with white chocolate ($P < 0.05$). No differences in active ghrelin or leptin were observed between conditions, nor was mood altered between conditions ($P > 0.05$).
Conclusions: Dark chocolate attenuates subsequent food intake in postmenopausal women, compared to the impact of milk and white chocolate consumption.

1. Introduction

Chocolate is a highly palatable and indulgent confection, with American's consuming 5–6 kg per capita in 2010 (Caobisco, 2013). Notwithstanding this high rate of consumption, chocolate is generally considered 'unhealthy'; however, growing evidence suggests that some types of chocolate may provide benefits to consumers ranging from protection against biomarkers of cardiovascular disease risk (Ellam & Williamson, 2013; Grassi et al., 2005; McFarlin et al., 2015), to enhanced cognition (Francis et al., 2006) and reduced overall mortality rate (Buijsse et al., 2006). Such benefits have been attributed to the high polyphenol content (particularly flavanols) contained within the component of cocoa liquor termed non-fat cocoa solids (Kay et al., 2006; Lazarus et al., 1999). Dark chocolate contains a greater proportion of this cocoa liquor, and therefore non-fat cocoa solids (~5-fold greater) compared with milk chocolate (Miller et al., 2009), with the remainder comprising mainly sugar and a small amount of other constituents, as well as the addition of milk in milk chocolate (Scholey & Owen, 2013). In comparison, white chocolate is comprised of cocoa butter extracted from cocoa liquor and is therefore devoid of the non-fat cocoa solids that contain flavanols, with the remainder comprised of sugar and sweeteners (Ellam & Williamson, 2013). Accordingly, dark chocolate is generally promoted over milk and white chocolate.

Despite these potential benefits of dark chocolate consumption,

Abbreviations: UWA, The University of Western Australia; POMS-A, Profile of Mood States – Adolescents; VAS, Visual analogue scale; PP, Pancreatic polypeptide.

* Corresponding author. M408 The University of Western Australia, 35 Stirling Highway, Crawley, WA, 6009, Australia.
E-mail address: channa.marsh@research.uwa.edu.au (C.E. Marsh).

http://dx.doi.org/10.1016/j.appet.2017.05.050
0195-6663/

it is important to note that most commercially available chocolate is high in fat, simple sugar and calories (Greenberg et al., 2015). This may contribute to excess energy intake and subsequent weight gain in the long-term, which in turn may increase the risk of cardiovascular disease and type 2 diabetes (Salmeron et al., 2001). However, there is some preliminary evidence to suggest that dark chocolate may also have beneficial effects on appetite. More specifically, Sørensen and Astrup (2011) found that consumption of 100 g of dark chocolate (70% cocoa) promoted satiety, reduced hunger and *ad libitum* energy intake at the next meal, compared with an equivalent volume of milk chocolate (30% cocoa) in young healthy men (Sørensen & Astrup, 2011). It is important to note that this study compared two commercially available chocolate bars that were not matched for energy content (217 kJ difference between conditions) and were unlikely to be from a cacao bean of similar origin, which would influence the biochemical composition of the cocoa liquor and mixture of polyphenols present. More recently, Akyol and colleagues (2014) demonstrated that substituting milk chocolate for dark chocolate in a traditional Turkish recipe reduced subsequent *ad libitum* energy intake at a lunch meal; however, the specific origin of the chocolate used in this study was unclear (Akyol et al., 2014). Furthermore, no previous studies have included a white chocolate comparison in order to assess the dose-response to chocolate containing distinct concentrations of cocoa, and the mechanisms for the proposed effect of dark chocolate on appetite are yet to be studied. Accordingly, the present study aimed to assess the acute effect of consuming an isocaloric dose of chocolate with varying cocoa concentrations (80% cocoa dark chocolate, 35% cocoa milk chocolate and a cocoa butter white chocolate devoid of non-fat cocoa solids) produced from the same batch of single-origin cacao beans (to ensure a consistent biochemical profile of the cocoa liquor portion) on appetite, subsequent energy intake and the circulating concentration of a number of appetite-related peptides and metabolites (active ghrelin, insulin, leptin, pancreatic polypeptide, glucose). These issues were examined in postmenopausal women, as the hormonal changes accompanying menopause are associated with an increased risk of weight gain (Rebuffe-Scrive et al., 1989; Toth et al., 2000). It was hypothesised that acute consumption of dark chocolate would reduce subsequent food intake to a greater extent than both milk and white chocolate.

2. Materials and methods

2.1. Participants

Healthy, postmenopausal (defined as absence of menstruation for at least 12 months) women aged 50–65 yr were recruited from The University of Western Australia (UWA) and the local community via email announcements and flyers. Postmenopausal women were studied due to their increased risk of weight gain resulting from the reduced production of endogenous oestrogen during the menopausal transition (Rebuffe-Scrive et al., 1989; Toth et al., 2000). Exclusion criteria included taking any prescribed medication, diabetes, a current eating disorder or weight loss diet, smoking, or not enjoying regular consumption of all types of chocolate (white, milk and dark). Of those who responded, fourteen women were eligible for inclusion in the study and consented to participate. It was estimated that a sample size of 12 participants would provide 80% power to detect a difference of approximately 300 kJ in *ad libitum* dietary intake from our laboratory test meal with an alpha value of 0.05. This study was approved by the UWA Human Research Ethics Committee (Perth, WA, Australia) and each woman provided written informed consent.

2.2. Experimental design

Using a within-subjects counterbalanced design, each participant was required to attend four separate laboratory sessions at the School of Sport Science, Exercise and Health, UWA. The first visit, an introductory session, was followed by three 2 h experimental trials administered in a counterbalanced order involving the consumption of three energy-matched (2099 kJ) chocolate conditions; (a) 84 g of a high concentration cocoa (80%) 'dark' chocolate, (b) 87 g of a lower concentration cocoa (35%) 'milk' chocolate and (c) 85 g of a cocoa butter 'white' chocolate (0% cocoa solids). This amount was based on previous studies examining the effect of an acute dose of chocolate on appetite and cardiovascular outcomes (90–100 g; 1735–2500 kJ; Akyol et al., 2014; Francis et al., 2006; Grassi et al., 2008; Sørensen & Astrup, 2011). All chocolate was specifically manufactured in a single batch using a single-origin cacao bean from The Sambirano Valley, Madagascar, in the desired concentrations of 35% and 80%, with the white chocolate condition containing the cocoa butter extracted from the same bean (Gabriel Chocolate Factory, Yallingup, WA, Australia). The nutritional composition of each chocolate was analysed by an independent agency (Australian National Nutritional Measurement Institute, Melbourne, Australia; Table 1). Of note, the precise macronutrient content of the chocolate could not be matched as it is the proportion of cocoa liquor, cocoa butter and sugar that distinguishes dark, milk and white chocolate.

2.3. Introductory session

Participants were instructed to complete a food diary and abstain from caffeine, alcohol, chocolate and vigorous physical activity in the 24 h prior to the introductory session and to replicate this in the 24 h prior to each experimental session. The replication of energy intake was confirmed verbally upon arrival at each session and later via quantitative analysis of their individual 24 h food diary (Foodworks 7; Xyris Software, Queensland, Australia). The abstinence from caffeine and chocolate was intended to amplify any potential effect of chocolate administration in the experimental trials. Body mass and height were recorded before participants were familiarised with the questionnaires to be used in the subsequent experimental sessions, with explanation, demonstration and opportunity to complete each questionnaire. In addition, the laboratory test meal to assess energy intake was explained.

2.4. Experimental trials

The three experimental testing sessions were conducted approximately one week apart at a standardised time in the morning, after an overnight fast. Upon arrival at the laboratory,

Table 1
Nutritional composition of white, milk and dark chocolate.

Nutritional component	White chocolate	Milk chocolate (35% cocoa)	Dark chocolate (80% cocoa)
Energy (kJ/100 g)	2470	2420	2490
Amount consumed (g)	85	87	84
Energy consumed (kJ)	2099	2099	2099
Carbohydrate (g)	44.2	42.6	36.1
Sugar (g)	42.5	35.7	19.3
Fat (g)	34.1	34.0	36.3
Saturated fat (g)	21.3	21.1	22.1
Mono-unsaturated fat (g)	9.9	10.2	11.4
Poly-unsaturated fat (g)	1.1	1.0	1.0
Protein (g)	4.9	7.1	7.8
Total polyphenols (mg)	35	200	395