DN Forum
Dairy Nutrition Forum
A PUBLICATION FOR INDUSTRY AND HEALTH PROFESSIONALS
Volume 10 Issue 2 2018

THIS ISSUE PAGES

Satiety: can dairy play a role?

EDITORIAL

Satiety is embedded in a myriad of biological, emotional and environmental factors that impact how much food we eat and our propensity for weight gain. The satiating effect of different foods varies and is intricately linked to energy intake.

In this edition of *DN Forum*, Food for Health Ireland (FHI) researchers explore the impact of dairy on satiety and body weight. Novel research is presented, which examines the mechanisms of appetite regulation, including the role of the dairy matrix and specific dairy peptides.

On page 4, we feature a new resource: Dairy Allergy and Intolerance.

We hope you enjoy this edition of *DN Forum* and look forward to any feedback or comments you wish to share: nutrition@ndc.ie

Dr Marianne Walsh
Nutrition Manager
The National Dairy Council (NDC)

Summary points

- Satiety is among the multitude of factors that can mediate individual susceptibility to an obesogenic food environment. Foods that can enhance satiety may be valuable for the prevention of weight gain as they promote feelings of fullness.
- A wealth of research indicates a positive relationship between dairy intake, satiety and a healthy body composition. Irish national data indicates that those with higher dairy intakes have lower BMI, % body fat and central adiposity.
- Several mechanisms have been identified that may explain the role of dairy in enhancing satiety. These include the impact of the dairy matrix and of individual dairy peptides, which have been demonstrated to stimulate satiety hormone secretion in the gut.
- Food for Health Ireland (FHI) researchers are exploring the potential of dairy proteins and have identified a casein hydrolysate known as LFC25, which has been shown to increase the secretion of satiety hormone, GLP-1 by up to five-fold. In addition, individual whey proteins have demonstrated a 94% inhibition of the hunger related enzyme, DPP-IV.
- FHI researchers are also exploring the potential of cheese as a healthy, satiating snack in both *in vitro* and human intervention studies. Preliminary results indicate that casein peptides produced during cheese ripening can stimulate the secretion of satiety hormone, GLP-1.

The role of dairy in satiety and appetite suppression

Dr Aifric O'Sullivan, UCD Institute of Food and Health, University College Dublin; Dr Alina Kondrashina and Dr Linda Giblin, Teagasc Food Research Centre, Moorepark, Co. Cork


Dr Aifric O'Sullivan


Dr Alina Kondrashina


Dr Linda Giblin

Introduction

The science of eating is complex with many factors influencing food intake, including: hunger, satiety, taste, palatability, habits, knowledge, self-control and social interaction. In a society that faces the simultaneous challenges of obesity and malnutrition, it becomes increasingly important to understand the factors that impact appetite and motivation to eat. The aetiology of obesity goes far beyond energy intake and, therefore, the solutions are both diverse and multifactorial. However, it is well accepted that the restriction of energy intake is a significant factor that can assist in weight loss and the prevention of weight gain.

Low satiety responsiveness has been proposed as a mechanism that can lead to surplus energy intake and weight gain[1]. Therefore, nutrient-dense foods that increase satiety could help to reduce appetite for subsequent eating occasions and this may help to decrease energy intake or propensity to overeat for some individuals. Dairy foods such as milk, yogurt and cheese form part of the population dietary guidelines for healthy eating as they are an important source of essential nutrients[2]. They contain carbohydrate, fat and protein in varying proportions along with key micronutrients, such as calcium, phosphorus, potassium, iodine, zinc, vitamin A and a range of B vitamins. A wealth of research supports the intake of dairy for good health, with evidence indicating that it can play positive roles in the prevention of a range of chronic non-communicable diseases[3,4].

The calorific value of dairy foods varies widely, mainly due to the fat content, which ranges from approximately 0.3% in skimmed milk to 80% in butter. Due to their lower nutrient density, higher fat dairy products, such as butter and cream, are separated from the nutrient-dense 'milk, yogurt and cheese' food group in the dietary guidelines[2]. It is this variation in fat content that contributes to confusion about the role of dairy in body weight management, with some individuals restricting all dairy intake in an effort to lose weight. In a survey of Irish adults, 16% of the population sampled strongly agreed that dairy is fattening and this was a key driver for those with negative perceptions about dairy[5].

In contrast to this common belief that dairy is fattening, a growing body of research suggests that dairy foods can be a valuable inclusion to weight-reducing diets and may have a positive role in weight control[6-8]. This article will explore the impact of dairy intake on body weight, with a specific focus on the role of dairy in satiety and appetite suppression.

Dairy and body weight

Over the past four decades, observational and experimental research has indicated a role for dairy in weight loss and body weight maintenance. The early studies identified a relationship between body weight and dietary calcium intake[9], but later studies reported weight change benefits specific to dairy intake[10-12], including an inverse relationship with central adiposity[13]. Randomised controlled trials suggest that the effects of calcium are mediated through reduced fat absorption and an increase in fat oxidation[14,15]. More recently, analysis of data collected as part of the National Adult Nutrition Survey in Ireland showed that those in the highest tertile of dairy intake had a more favourable body composition; including lower BMI, % body fat and central fat accumulation[16].

Dairy is a rich source of medium-chain fatty acids, which may also play a role as they have been shown to down-regulate genes and transcription factors responsible for fat-cell accumulation[17]. Substituting long-chain fatty acids for medium-chain fatty acids during energy restriction has shown greater weight loss and fat loss in both men and women[18]. In addition, dairy protein may play a role in fat storage with protein bioactives shown to inhibit the production of angiotensin II, a hormone that controls blood pressure and regulates both lipid synthesis and fat storage[19,20].

Dairy and satiety

Evidence from epidemiological and intervention studies indicates that consumption of dairy foods can increase feelings of fullness[7,21]. Initially, a 'feeling of fullness' leads to meal termination or satiation and, longer term, it leads to satiety, delaying subsequent food intake. A recent meta-analysis reviewed 13 randomised controlled trials, which assessed the impact of dairy consumption on subsequent energy intake in a second meal and subjective feelings of satiety[21]. In brief, consuming more than 500ml of dairy products increased feelings of fullness and decreased the amount of food the person thinks they could eat. Energy intake in a second meal was lower when dairy was consumed as a preload meal, but with large variation between studies. A subgroup analysis showed that other preloads also decreased energy intake with the exception of fruit drink, cola or chocolate bar preloads.

There are relatively few studies that have examined the effect of whole-dairy foods on subjective satiety and satiety hormone concentrations. One study compared the satiating effects of a fibre-enriched drinking yogurt, a regular drinking yogurt, plain crackers, fresh banana; or an isovolumetric serving of water[22]. Although there were no significant differences between the satiating capacity of the foods, the trend indicated that the fibre-enriched yogurt was highest, followed by regular yogurt, banana, crackers and, lastly, water.

Another study reported that yogurt had the greatest effect on subjective appetite ratings when compared to isoenergetic milk and cheese snacks versus a water control[23]. The hormone response to all three dairy snacks was different to water, but there were no significant differences between snacks[23]. While these well-designed, isoenergetic studies provided important information with respect to the satiating effects of different foods, the macronutrient composition of each differed and there was no macronutrient matched control.

Mechanisms

There are several internal mechanisms that regulate how much food we consume. Gastric distension is the first satiation signal, which is followed by production of gut-satiety hormones and slowing of gastric emptying to maintain a feeling of fullness[24]. The endocrine system plays a central role in signalling hunger and satiety by interacting with the GI tract, the brain and other body tissues (Fig 1). Ghrelin is a hormone that increases appetite, whereas leptin and insulin act to reduce appetite. Cholecystokinin (CCK), peptide YY (PYY) and the incretin hormone, glucagon-like peptide-1 (GLP-1), also act to reduce food intake and increase feelings of satiety. Satiety hormones are secreted by specialised endocrine cells sparsely populated throughout the gastrointestinal tract, from the stomach to the rectum[25]. These cells face directly into the gut lumen and respond to the presence of food components coming in contact with them.

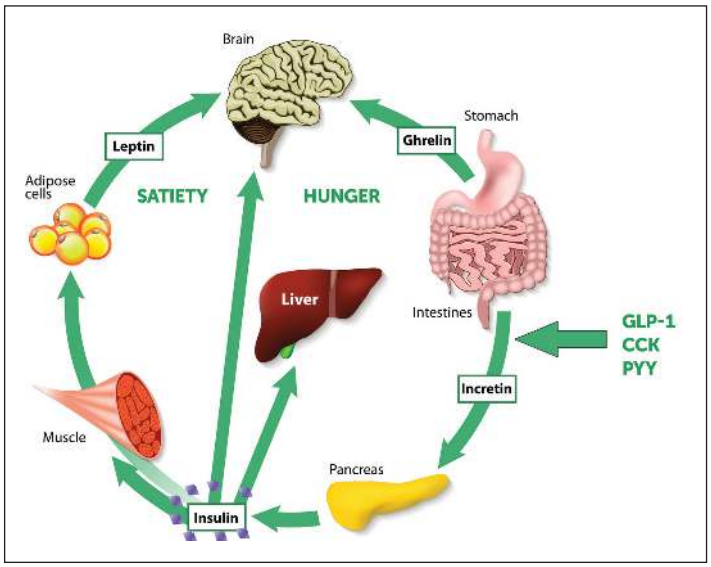

Figure 1: The endocrine system plays a central role in regulating food intake by stimulating hunger and satiety signals.

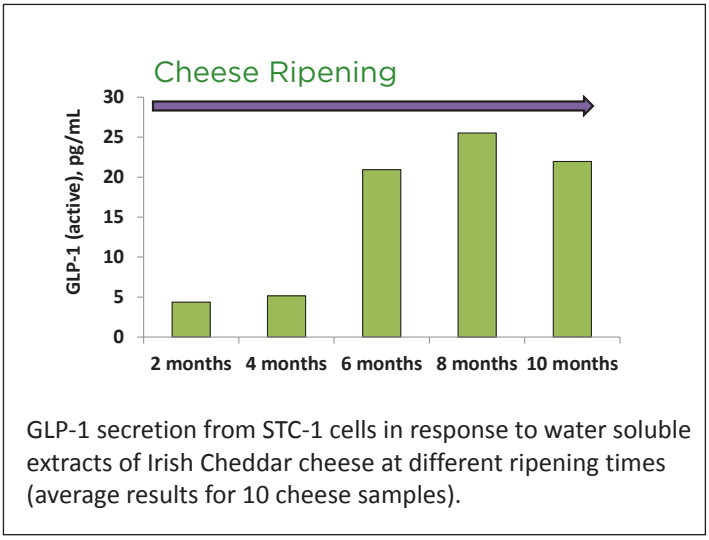

Figure 2: Secretion of satiety hormone GLP-1 from intestinal cells in response to cheddar cheese peptides.

Diets high in protein are well recognised for their satiating effects and mechanistic research suggests that the dairy proteins whey and casein have specific effects on gut hormones that regulate appetite and satiety[7]. When whole casein transits the gut, it is broken down or hydrolysed into peptides which have been shown to increase the satiety hormones GLP-1[26, 27] and CCK[28]. Schellekens *et al*. reported that a casein hydrolysate modulates the serotonin pathway, which is not only responsible for mood, but also plays a major role in appetite suppression[29].
Whey differs to casein in that it is rapidly digested in the upper gut[30]. It is best known for the ability to promote satiety by inhibiting the enzyme DPP-IV[31]. Free fatty acids found in dairy have also been shown to stimulate satiety hormones such as CCK[32].

Novel research: The role of the dairy matrix

Researchers now realise that the health effects of foods are not just due to the individual nutrients and have shifted focus to the whole dairy matrix rather than its individual components. For example, a recent study from Food for Health Ireland (FHI) showed that 120g of full-fat cheese per day, reduced cholesterol levels more than when the same amount of nutrients were consumed separately (as butter, calcium caseinate powder and a calcium supplement)[33].
In relation to satiety, a new FHI study is underway, which aims to elucidate the potential matrix effects of cheese on satiety by comparing it to both isoenergetic and macronutrient matched control snacks. The study is a randomised cross-over trial that will compare subjective satiety, gut hormone concentrations and second meal food intake following a cheese snack, a macronutrient and energy-matched egg snack and an energy-matched scone, considered a typical snack in Ireland. Results from this food matrix study could have implications for snack recommendations when following an energy-restricted weight-loss diet.

Novel Research: Identifying dairy ingredients to enhance satiety

In vitro research by FHI has identified a novel dairy ingredient with the potential to enhance satiety. It is a casein hydrolysate, LFC25, which increases GLP-1 secretion by five fold[34]. LFC25 has been produced at pilot plant scale and proven to reduce food intake in mice over eight hours[35]. In humans, consumption of 15g of LFC25 (60 kcal) resulted in an increase in GLP-1 secretion, which cannot be further increased by the consumption of a substantial *ad libitum* lunch 30 minutes later (459 kcal)[36].
Other FHI research has shown that individual whey proteins (β-lactoglobulin, α-lactalbumin, bovine serum albumin or lactoferrin) subjected to the harsh conditions of the upper gut can inhibit the hunger related enzyme, DPP-IV, by 94%. Whether individual dairy peptides survive long enough in the gut to have an effect on satiety is debatable and they may require some enteric protection to be incorporated in foods for satiety.
FHI are also investigating the satiating potential of the water soluble (fat free) component of cheddar cheese. Ripening up to 10 months increased the ability of cheese to stimulate GLP-1 secretion *in vitro*, although there was variation between different cheeses (Fig 2)[37]. Stimulation of GLP-1 secretion was not a function of amino acid content but most likely the presence of unique casein peptides produced during the cheese ripening. This indicates the potential of cheese and other fermented dairy products to stimulate satiety and interact with feelings of fullness.

References

1. Llewellyn CH *et al*. Satiety mechanisms in genetic risk of obesity. *JAMA Pediatr* 2014; 168: 338-344.
2. Department of Health. (2016) Healthy Food for Life [Online]. Available at: http://www.healthyireland.ie/wp-content/uploads/2016/12/M9738-DEPARTMENT-OF-HEALTH_Food-Pyramid_Milk-yogurt-cheese.pdf (Accessed July, 13, 2018).
3. Thorning TK *et al*. Milk and dairy products: good or bad for human health? An assessment of the totality of scientific evidence. *Food Nutr Res* 2016; 60: 32527.
4. O'Keefe JH *et al*. Nutritional strategies for skeletal and cardiovascular health: hard bones, soft arteries, rather than vice versa. *Open Heart* 2016; 3: e000325.
5. Ryan, L and Butler-Rees E. Dairy sentiment 'benchmark study'. Behavious & Attitudes 2017; J.8106 unpublished
6. Mozaffarian D. Foods, obesity, and diabetes—are all calories created equal? *Nutr Rev* 2016; 75: 19–31.
7. Dougkas A *et al*. Associations between dairy consumption and body weight: a review of the evidence and underlying mechanisms. *Nutr Res Rev* 2011; 24: 72-95.
8. Wang W *et al*. Association of dairy products consumption with risk of obesity in children and adults: a meta-analysis of mainly cross-sectional studies. *Ann Epidemiol* 2016; 22: S1047-2797.
9. McCarron DA. Calcium and magnesium nutrition in human hypertension. *Ann Intern Med* 1983; 98: 800-805.
10. Lin YC *et al*. Dairy calcium is related to changes in body composition during a two-year exercise intervention in young women. *J Am Coll Nutr* 2000; 19: 754-760.
11. Van Loan M. The role of dairy foods and dietary calcium in weight management. *J Am Coll Nutr* 2009; 28: 120S-129S.
12. Astrup A *et al*. Dairy beverages and energy balance. *Physiol Behav* 2010; 100: 67-75.
13. Azadbakht L *et al*. Dairy consumption is inversely associated with the prevalence of metabolic syndrome in Tehranian adults. *Am J Clin Nutr* 2005; 82: 523-530.
14. Vaskonen T. Dietary minerals and modification of cardiovascular risk factors. *J Nutr Biochem* 2003; 14: 492-506.
15. Soares MJ *et al*. Mechanistic roles for calcium and vitamin D in the regulation of body weight. *Obes Rev* 2012; 13: 592-605.
16. Feeney *et al*. Patterns of dairy food intake, body composition and markers of metabolic health in Ireland: results from the National Adult Nutrition Survey. *Nutr Diabetes* 2017; 7: e243.
17. Aoyama T, Nosaka N, Kasai M. Research on the nutritional characteristics of medium-chain fatty acids. *J Med Invest* 2007; 54: 385-388.
18. Tsuji H *et al*. Dietary medium-chain triacylglycerols suppress accumulation of body fat in a double-blind, controlled trial in healthy men and women. *J Nutr* 2001; 131: 2853-2859.
19. Yamamoto N, Takano T. Antihypertensive peptides derived from milk proteins. *Biopolymers* 1999; 43: 159-164.
20. Jones BH, Standridge MK, Moustaid N. Angiotensin II increases lipogenesis

in 3T3-L1 and human adipose cells. *Endocrinol* 1997; 138: 1512-1519.
21. Onvani S *et al*. Dairy products, satiety and food intake: A meta-analysis of clinical trials. *Clin Nutr* 2017; 36: 389-398.
22. Almiron-Roig E *et al*. Impact of some isoenergetic snacks on satiety and next meal intake in healthy adults. *J Hum Nutr* Diet 2009; 22: 469-474.
23. Dougkas A *et al*. Differential effects of dairy snacks on appetite, but not overall energy intake. *Br J Nutr* 2012; 108: 2274-2285.
24. De Graaf C *et al*. Biomarkers of satiation and satiety. *Am J Clin Nutr* 2004; 79: 946-961.
25. Gribble FM, Reimann F. Signalling in the gut endocrine axis. *Physiol Behav* 2017: 176: 183-188.
26. Kondrashina A, Papkovsky D, Giblin L. Physiological gut oxygenation alters GLP-1 secretion from the enteroendocrine cell line STC-1. *Mol Nutr Food Res* 2018; 62: 1700568.
27. Hall W *et al*. Casein and whey exert different effects on plasma amino acid profiles, gastrointestinal hormone secretion and appetite. *Br J Nutr* 2003; 89: 239-248.
28. Osborne S *et al*. *In vitro* transport and satiety of a beta-lactoglobulin dipeptide and beta-casomorphin-7 and its metabolites. *Food Func* 2014; 5: 2706-2718.
29. Schellekens H *et al*. Milk protein-derived peptides induce 5-HT2C-mediated satiety in vivo. *Int Dairy J* 2014; 38: 55-64
30. Greco E *et al*. The role of source of protein in regulation of food intake, satiety, body weight and body composition. *J Nutr Health Food Eng* 2017; 6: 00223.
31. Power-Grant O *et al*. *In vitro* bioactive properties of intact and enzymatically hydrolysed whey protein: targeting the enteroinsular axis. *Food Func* 2015; 6: 972-980.
32. Hand KV *et al*. Acute and chronic effects of dietary fatty acids on cholecystokinin expression, storage and secretion in enteroendocrine STC-1 cells. *Mol Nutr Food Res* 2010, 54: S93-S103.
33. Feeney *et al*. Dairy matrix effects: Response to consumption of dairy fat differs when eaten within the cheese matrix - a randomized controlled trial. *Am J Clin Nutr* 2018; In Press
34. O'Halloran F *et al*. A casein hydrolysate increases GLP-1 secretion and reduces food intake. *Food Chem* 2018; 252: 303-310.
35. Giblin L *et al*. Letter to the editor regarding equivalent increases in circulating GLP-1 following jejunal delivery of intact and hydrolysed casein: relevance to satiety induction following bariatric surgery. *Obesity Sur* 2017; 27: 816.
36. Le Roux C *et al*. Equivalent increases in circulating GLP-1 following jejunal delivery of intact and hydrolysed casein: relevance to satiety induction following bariatric surgery. *Obesity Sur* 2016; 26: 1851-1858.
37. Kondrashina A *et al*. Irish Cheddar cheese increases glucagon-like peptide-1 secretion *in vitro* but bioactivity is lost during gut transit. *Food Chem* 2018; 265: 9-17.

New Resource

In collaboration with the Irish Nutrition and Dietetic Institute, the National Dairy Council has produced a new patient leaflet on 'Dairy Allergy and Intolerance'. The leaflet covers an overview of both conditions with a focus on common symptoms, diagnosis, prevalence and management.
Leaflets may be downloaded from http://www.ndc.ie/health-professionals/our-publications or a limited number of copies may be ordered by contacting **nutrition@ndc.ie**

Upcoming Event

Keeping nutrition at the core of sustainable diets

The National Dairy Council and the Irish Nutrition and Dietetic Institute would like to invite you their CPD symposium on sustainable diets. Guest speakers will review the science in this area with a focus on the upcoming challenges facing dietitians.

5.45 pm – 8.30 pm, 15th November 2018
Royal College of Physicians Ireland, Dublin 2

To register, email **info@indi.ie**

Contact us....

THE NATIONAL DAIRY COUNCIL (NDC)

The National Dairy Council
The Studio, Maple Avenue,
Stillorgan, Co. Dublin, Ireland
Tel: +353 (0)1 290 2451
Email: info@ndc.ie
Web: www.ndc.ie

NDCIreland @NDC_ie

Mission: To deliver real and unique value to Irish dairy farmers by protecting and promoting the image, quality, taste and nutritional credentials of Irish dairy produce to a wide variety of audiences in a clearly defined, focused and effective manner.

FOOD FOR HEALTH IRELAND (FHI)

Food for Health Ireland
Science Centre South
University College Dublin
Tel: + 353 (0)1 716 2391
Email: fhi@ucd.ie
Web: www.fhi.ie

@fhi_phase2 Food for Health Ireland

Mission: To leverage the world-class capabilities of the Irish academic partners, with the market expertise of the industry partners, into a pipeline of innovative, nutritional functional ingredients/products for the global food industry.

While the NDC and FHI have made all reasonable efforts to ensure the accuracy of the information presented in this document, no responsibility is taken by the NDC or FHI for any errors or omissions. The individual views expressed in this publication do not necessarily constitute the views or policies of the NDC or FHI.