

Impact of yogurt on appetite control, energy balance, and body composition

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Recent data support the idea that regular yogurt consumption promotes body weight stability. The simplest explanation is that regular consumption of healthful foods such as yogurt results in decreased intake of less healthful foods containing high amounts of fat and/or sugar. There is also evidence to suggest that the high calcium and protein contents of yogurt and other dairy foods influence appetite and energy intake. The existence of a calcium-specific appetite control mechanism has been proposed. Milk proteins differ in terms of absorption rate and post-absorptive responses, which can influence their satiating properties. Studies in humans have shown that consumption of milk and yogurt increases the circulating concentration of the anorectic peptides glucagon-like peptide (GLP)-1 and peptide YY (PYY). The food matrix can also affect appetite and satiety. Yogurt is a fermented milk that contains bacteria that enrich the microbiota of the host. It appears that lean vs obese humans differ in the composition of their gut microbiota. The available relevant literature suggests that yogurt is a food that facilitates the regulation of energy balance.

INTRODUCTION

In the context of the current obesity epidemic, the growing preoccupation with healthy eating has stimulated interest in research that documents the effects of specific foods on appetite and energy intake. Yogurt is a good candidate for a food with the potential to help manage appetite and body weight under free-living conditions. Indeed, yogurt is a nutrient-dense food that generally has a low energy density. It also offers flexibility in that it can be consumed daily at any meal or as a snack. As described here, yogurt is a satiating food that may favorably influence energy balance and body composition.

YOGURT AND BODY WEIGHT MANAGEMENT

The most consistent evidence to demonstrate that yogurt may favorably influence weight management has been

reported by Zemel et al.¹ In a 1-year intervention, during which 1 portion of yogurt was consumed daily, African-American participants displayed a mean body fat loss of 4.9 kg.¹ In a subsequent clinical trial, yogurt supplementation was found to increase total and abdominal fat loss in obese individuals.² This research team reported on additional clinical trials that demonstrated that dairy^{3,4} increased body weight loss in obese, low-calcium consumers.

Recent population data add evidence to support the idea that regular yogurt consumption promotes body weight stability. A study of large cohorts of participants revealed that yogurt and nuts were the food groups for which consumption was associated with the greatest weight loss over a 4-year follow-up period.⁵ This is in agreement with another cohort analysis that highlighted the ability of regular yogurt consumers to maintain their body weight over time.⁶ The ability of dairy foods such as yogurt to influence body weight can be

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explained by a variety of biological and circumstantial factors.

USE OF YOGURT TO REPLACE LESS HEALTHFUL FOODS

The simplest explanation of the proposed effect of dairy consumption on energy intake is that regular consumption of healthful foods such as yogurt results in a decreased intake of less healthful foods, which contain large amounts of fat and/or sugar. This concept is supported by the observation that a high intake of calcium, most of which is provided by dairy foods, was found to be negatively related to the consumption of carbonated and other sweetened beverages.⁷ This study also demonstrated the existence of a significant association between calcium intake and variations in body fat, i.e., higher calcium intakes were associated with lower body fat. More recently, Chapelot and Payen⁸ examined the effects of isocaloric portions of liquid yogurt and chocolate bars on appetite sensations. Their results showed that yogurt consumption resulted in a more pronounced effect on hunger, the desire to eat, and feelings of fullness. However, these beneficial effects of yogurt on appetite sensations were not accompanied by significant delays in requesting the next meal or a reduction in *ad libitum* energy intake at the subsequent meal.

SPECIFIC EFFECTS OF NUTRIENTS

Variations in the need for and in the metabolism, stores, and/or intakes of some nutrients are known to affect appetite control. These effects are related to carbohydrate, lipid, protein, and energy metabolism and have led to the formulation of classic theories of appetite control. More recently, Tordoff⁹ proposed the existence of a calcium-specific appetite control mechanism by referring to the numerous physiological functions of calcium in vertebrates and to the fact that calcium deficiency promotes a preferential calcium intake in animals when the opportunity is given. This is in agreement with clinical experience in obese, female, very-low-calcium consumers who were tested in the context of a 15-week, diet-based, weight-reduction program with or without calcium and vitamin D supplementation.¹⁰ Indeed, as shown in Table 1, mean body weight and fat loss were approximately 4 times greater in the supplement-receiving participants than in the nonsupplement-receiving controls, even when each group received the same dietary guidance. The table also shows that calcium (600 mg) + vitamin D (5 µg) supplementation twice daily induced a decrease in fat intake in a buffet-type meal test that was significantly different from the increased intake in the control group. Accordingly, a highly significant correlation was found

Table 1 Mean change in body weight, fat mass, and *ad libitum* lipid intake (test meal) in obese very-low-calcium consumers in response to dietary restriction with or without calcium + vitamin D supplementation

Measure	Calcium + vitamin D group	Control group
Body weight (kg)	-5.8	-1.4*
Fat mass (kg)	-4.7	-1.2*
Lipid intake (g)	-18.2	7.5*

*Significant difference between groups, $P < 0.05$.
Adapted from Major et al. (2009).¹⁰

between low fat intakes associated with the supplements and reductions in body weight and body fat during the program.

Beyond the potential impact of low calcium intake on appetite control, other biological mechanisms may explain the influence of calcium on energy balance. According to Zemel et al.,¹ low calcium intake is related to an increase in intra-adipocyte calcium content, which promotes a switch from fat cell lipolysis toward lipogenesis. The resulting decrease in fat mobilization reduces fat utilization, which is concordant with the findings of Melanson et al.,^{11,12} who showed that a low calcium intake favors a decrease in daily fat oxidation. Furthermore, calcium, particularly of dairy origin, promotes the formation of insoluble calcium soaps with fatty acids, thereby accentuating fecal fat loss by about 50–75 kcal/day.^{13,14} To date, no link has been established between this gut-related effect of calcium and a calcium-specific appetite control.

Although the role of calcium in the regulation of energy and fat balance has been demonstrated consistently, it is relevant to emphasize that many clinical trials have not shown a body weight-reducing effect of dairy or calcium intake.¹⁵ In one cohort of obese females participating in a weight-reduction program, the group receiving calcium–vitamin D supplementation displayed the same weight loss as the placebo-receiving controls¹⁶; however, when results were further analyzed to compare very-low-calcium consumers to those consuming a borderline or adequate amount of calcium, differences in body weight/fat loss were observed.¹⁰ These differences, shown in Table 1, indicate that the impact of calcium–vitamin D supplementation on energy balance in very-low-calcium consumers was quantitatively important; the energy equivalent of the 3.5-kg between-group difference in fat loss was about 300 kcal/day. Taken together, these observations suggest that calcium supplementation is effective for augmenting weight loss in obese individuals whose consumption of the mineral is inadequate. This is concordant with the clinical trials of Zemel et al.,^{2–4} who reported significant effects of calcium on weight/fat loss in obese, low- to very-low-calcium consumers.

Vitamin D is another dairy nutrient that has been considered for its potential independent effects on body weight. However, Soares et al.¹⁷ recently reported a detailed literature survey that led to the observation that “the data on vitamin D supplementation during weight loss were too few to make firm conclusions.”

Proteins are another nutrient in dairy foods that can induce a satiating effect. In milk, casein and whey protein represent the main protein components. They differ in terms of absorption rates and post-absorptive responses, which can influence their satiating properties. Whey protein is known to be more readily absorbed than casein,¹⁸ which may explain its short-term effect on reducing appetite sensations and energy intake. For instance, in the study by Akhavan et al.,¹⁹ 10–40 g of whey protein with water as a preload 30 minutes before a meal significantly reduced subsequent energy intake. Casein forms a clot via gastric acid action^{20,21} that slows gastric emptying and mediates a sustained release of amino acids.¹⁸ Thus, the rapid and sustained effect of dairy products on satiety and energy intake is likely attributable, in part, to the combined effects of its 2 main protein fractions.

Douglas et al.²² recently investigated the effects of several yogurts on appetite and energy intake using the preload paradigm that is commonly used to measure the satiating effects of nutrients and different food vehicles. Specifically, they evaluated the impact of yogurts that contained different levels of protein on appetite markers and energy intake. They found that in healthy women, an afternoon snack of Greek yogurt with a high protein content (24g) reduced hunger, increased fullness, and delayed subsequent eating compared with lower protein snacks or no snacks. Although the energy consumed at dinner was lower following the 160-kcal energy content of the yogurt snack vs no snack, energy intake was not fully compensated. This can be explained, in part, by the fact that the request for a dinner test meal was presented to participants who were served a high-protein snack almost 1 hour later than it was presented to those in a “no snack” control condition.

To summarize, evidence suggests that the high calcium and protein contents of yogurt and other dairy foods may explain, at least in part, the ability of yogurt to influence appetite and energy intake. This is corroborated by results of a recent clinical trial that demonstrated that milk supplementation facilitates appetite control during weight loss compared with an isocaloric, calcium-free, reduced-protein soy milk supplementation.²³

IMPACT OF HORMONES

Dairy intake influences gastrointestinal hormones in a manner that is compatible with a hunger-reducing effect.

Human studies have shown that milk and yogurt intake increase the circulating concentration of the anorectic peptides Glucagon-like peptide (GLP)-1 and Peptide YY (PYY).²⁴ This effect has also been demonstrated in obese individuals on a weight-loss regimen. Jones et al.²⁵ studied overweight and obese individuals on a calorie-restricted diet for 2 weeks, during which they received either a small amount of dairy (1 serving per day) or a large amount of dairy (3–4 servings per day). The use of a meal test before and after each condition demonstrated that a high dairy intake resulted in greater levels of PYY for several hours after the meal was ingested.

Plasma ghrelin concentrations also have been measured in obese, low-calcium consumers exposed to a diet-based, weight-reducing program that was supplemented with milk or an isoenergetic placebo.²³ Changes in ghrelin concentration predicted the desire to eat. In agreement with the above evidence, those in the supplemented group experienced decreases in the orexigenic hormone and a smaller increase in hunger and the desire to eat compared with those in the placebo groups.

EFFECTS OF FOOD STRUCTURE

The concept of the food matrix refers to differences in food structure that can modify properties of a food, independent of its nutrient content. The structure of yogurt lends itself to accommodate changes that affect appetite and food intake, such as the addition of fiber. Recently, Lluch et al.²⁶ reported on a study in which protein supplementation was tested along with a change in the food structure. Specifically, a control yogurt was supplemented with protein and the food matrix was modified to accommodate a fiber supplement. These modifications in the food matrix resulted in significant decreases in both subjective appetite and subsequent energy intake. Interestingly, these modifications did not affect palatability. The study was then expanded to test the effects of variations in the protein structure of yogurt and the addition of fibers to the food matrix. Variations in protein structure were tested based on the findings of preliminary laboratory work that allowed the comparison of isocaloric-, isovolumetric-, and iso-proteinemic yogurts in which the whey protein-to-casein ratios were doubled. The main hypothesis was that the increase in the relative content of whey protein in a yogurt served at snack time would exert a more pronounced effect on the reduction of *ad libitum* energy intake at lunchtime. Preliminary results showed that mean energy intake at lunch was significantly decreased following consumption of yogurt high in whey and protein, which may be explained by the fact that this protein is more rapidly digested than casein.²⁷ Also of

interest is the fact that subsequent compensation in energy intake was substantially greater than the energy content of the yogurt preload.

A food's viscosity can also influence satiety. Tsuchiya et al.²⁸ compared the effects of 2 yogurts (semi-solid and liquid) on hunger and fullness and found that both resulted in lower hunger and higher fullness ratings compared with a fruit drink or a dairy-fruit drink.

YOGURT AS A VEHICLE FOR MICROORGANISMS

Yogurt contains bacteria that enrich the host's microbiota. This is relevant in the study of obesity, as it appears there are differences between lean and obese humans in the composition of their gut microbiota.²⁹ A decrease in *Bacteroidetes* and an increase in the *Firmicutes-to-Bacteroidetes* ratio in obese participants compared with lean participants have been observed.³⁰ Furthermore, the gut microbiota has been proposed to modulate energy intake and appetite in humans through its fermentation activity and the regulation of gut peptide secretion.³¹

Recent research offers unique perspectives regarding the use of probiotics in the management of obesity. Yogurt represents an ideal food vehicle for the incorporation of probiotics that can reinforce the microbiota and favorably modify its composition. For instance, Kadooka et al.³² showed that supplementation of fermented milk with *Lactobacillus gasseri* SBT2055 over 12 weeks induced significant weight loss and a decrease in abdominal fat in overweight men and women. Recently, a placebo-controlled, double-blind, crossover clinical study reported that consumption of 2 servings per day of yogurt supplemented with *Lactobacillus amylovorus* (10^9 colony-forming units per serving of yogurt during 43 days) led to a decrease in total body fat mass.³³ Furthermore, Ilmonen et al.³⁴ showed that nutritional counseling combined with probiotic supplementation (*Lactobacillus rhamnosus* GG and *Bifidobacterium lactis* Bb12) in pregnant women reduced the risk of central adiposity and improved control of glycemia at 6 months postpartum.³⁴

A clinical trial was recently completed in which obese men and women adhered to a diet-based, 12-week weight loss program followed by 12 weeks of weight maintenance.³⁵ In both groups (men and women), participants were randomly assigned to supplementation of *L. rhamnosus* CGMCC1.3724 (3.24×10^8 colony-forming units) or a placebo during the 2 phases of the program. In men, changes in body weight and fat were comparable in the weight-loss and the weight-maintenance phases of the program. This contrasts with results obtained in women in whom the probiotic supplementation accentuated body weight

Table 2 Mean reductions in body weight, fat, and energy in obese women subjected to 12-week dietary restriction with or without probiotic supplementation with *Lactobacillus rhamnosus* CGMCC1.3724

Measure	Supplementation group	Placebo group
Body weight (kg)	-4.4*	-2.6
Fat mass (kg)	-3.75*	-2.55
Body energy (kcal/d)	-421*	-283

*Significant difference between groups, $P < 0.05$.

Adapted from Sanchez et al. (2014).³⁵

and fat loss in the 2 phases. Accordingly, the data indicated that energy intake tended to be reduced more in women given the probiotic supplements.³⁵ As shown in Table 2, the between-group difference in body composition suggests that the estimated global energy deficit over 24 weeks was about 50% greater in the supplemented participants. Furthermore, results demonstrated that the abundance of *Lachnospiraceae*, a strain of the Firmicutes family, was significantly decreased in the women who were supplemented compared with the women in the control group.

CONCLUSION

The available relevant literature suggests that yogurt facilitates the regulation of energy balance. This can be explained by the fact that yogurt consumption may reduce the intake of energy-dense foods that favor hyperphagia. Some studies have also emphasized the potential of yogurt nutrients such as calcium and proteins to favorably influence appetite control. In addition, the flexibility of yogurt's structure enables it to accommodate supplementation of ingredients, e.g., fibers and bacteria that also have the potential to promote negative energy balance. These effects are likely the main determinants of the observed weight loss of several kilograms documented in yogurt consumers tested in clinical interventions and observational studies.

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