Review

Nuts and healthy body weight maintenance mechanisms

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Nuts are rich sources of multiple nutrients and phytochemicals associated with health benefits, including reduced cardiovascular disease risk. This has prompted recommendations to increase their consumption. However, they are also high in fat and are energy dense. The associations between these properties, positive energy balance and body weight raise questions about such recommendations. Numerous epidemiological and clinical studies show that nuts are not associated with weight gain. Mechanistic studies indicate this is largely attributable to the high satiety and low metabolizable energy (poor bioaccessibility leading to inefficient energy absorption) properties of nuts. Compensatory dietary responses account for 55-75% of the energy provided by nuts. Limited data suggest that routine nut consumption is associated with elevated resting energy expenditure and the thermogenic effect of feeding, resulting in dissipation of another portion of the energy they provide. Additionally, trials contrasting weight loss through regimens that include or exclude nuts indicate improved compliance and greater weight loss when nuts are permitted. Nuts may be included in the diet, in moderation, to enhance palatability, nutrient quality, and chronic disease risk reduction without compromising weight loss or maintenance.

Key Words: nuts, body weight, satiation, metabolizable energy, energy expenditure

INTRODUCTION

As interest in incorporating nuts into the diet for heart health grows, it is important that consumers understand the effect of nut consumption on body weight.[1] One of the most prevalent approaches for weight loss or maintenance has entailed moderation of dietary energy through restriction of fat. Because nuts are a rich source of fat, they have been viewed as potential contributors to positive energy balance, so may be restricted or avoided. However, accumulating evidence challenges current recommendations to restrict nut use for weight loss and maintenance. Based on the evidence from epidemiological and controlled clinical studies, nut consumption is not associated with higher body weight.[2-7] In fact, the epidemiological evidence indicates that nut consumers have a lower BMI than non-consumers. Findings from clinical studies consistently indicate their inclusion in the diet leads to no weight gain or less weight gain than predicted from the labeled energy content.[2, 6, 8-12] Moreover, some data indicate that in free-living individuals, compliance with a moderate-fat, weight loss diet and its nutrient profile are better compared to a low-fat weight loss approach.[13] Moderate-fat diets that contain nuts may also promote a favorable lipoprotein profile.[14] An overview of the mechanisms that may account for the limited impact of nut consumption on body weight is the focus of this review.

MECHANISMS FOR WEIGHT CONTROL BENEFITS

The primary factors contributing to the less-than-predicted effects of nut consumption on body weight gain are their strong satiety effects, incomplete energy bioaccessability and possible augmentation of resting energy

expenditure.[15] These properties stem from synergies between nut components.

Satiation/satiety effects

Satiation reflects processes that influence the size of an eating event and satiety is defined by the processes that influence eating frequency. Their interaction is one determinant of energy intake and this is a result of their modulation of dietary compensation; the degree to which the energy of a food is offset by modifications of energy intake at other times. It is estimated that between 55-75% of the energy contributed by nuts is compensated by lower subsequent energy intake.[15]

A wide array of environmental and physiological factors contribute to the appetitive properties of foods. Nuts contain fiber, protein, unsaturated fats, various phytochemicals, require substantial oral processing before swallowing, have distinct flavor profiles and are widely believed to be energy-rich, all of which have been associated with satiety responses. To-date, no single attribute has been identified as uniquely influential in any nut variety.[16]

Physical properties

One of the lesser studied properties of nuts that may cont-

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ribute to their satiety effects is their physical structure. They are crunchy and must be mechanically reduced to particles small enough for swallowing. Mastication activates mechanical, nutrient, and sensory signaling systems that may modify appetitive sensations.

Studies in rats indicate chewing stimulates histaminergic neuron activity in the paraventricular nucleus and ventromedial nucleus, both purported satiety centers, in the hypothalamus.[17] Mechanical disruption of the parenchymal cell walls of nuts liberates the lipid and protein they encase. These macronutrients promote the release of intestinal peptide hormones such as cholecystokinin (CCK) and glucagon-like protein 1 (GLP-1) with reported satiety effects.[18-20] The sensory properties of nuts may also activate cephalic phase responses, defined as neurally-mediated, physiological responses to sensory stimulation. They mimic the processes that normally occur during food ingestion, but are rapid (typically peaking in about 4 minutes) and transient (typically diminishing within about 10 minutes). They modify processes including salivation, gastric motility and emptying rate, intestinal and pancreatic hormone secretion with effects on nutrient absorption, metabolism and clearance, as well as thermogenesis.[21] Their primary function is likely to serve as an early signaling system to optimize processing of nutrients from the diet. Controlled studies indicate that chewing almonds 25 times (typical mean for almond consumption) elicits the strongest reduction in hunger and increase in fullness two hours later compared to chewing 10 or 40 times.[22] The form in which nuts are available is also an appetitive factor. For example, in-shell pistachios slow the rate of consumption because of increased preparation time, and this may permit greater metabolic feedback during the ingestive event that augments satiety with the potential to reduce the energy content of the eating event.[23] One researcher has posited that people who eat more difficult to chew foods have smaller waist circumferences than those who eat softer foods[24].

Glycemic load

The importance of the glycemic load of a food or diet with respect to appetite, energy intake and body weight remains controversial. A large randomized one-year trial comparing high glycemic index (GI), low-GI and low carbohydrate diets in type 2 diabetes mellitus participants managed on diet alone failed to observe differences in energy intake or weight outcomes.[25] However, a Cochrane Collaboration review concluded that weight loss was greater in overweight people given low glycemic load diets than in people given comparison diets, including higher glycemic load diets and conventional weight loss diets.[26] Similarly, loss of total fat mass and decrease in body mass index (BMI) were significantly greater in the group receiving a low glycemic load diet. Of the six studies included in the review (202 participants), two included obese people and compared low glycemic load diets with conventional weight reducing low fat diets. Four studies included people with borderline normal weight (BMI = 25 kg/m^2) or overweight (BMI greater than 25 to 30 kg/m^2) and compared a low glycemic load diet with a higher glycemic load diet. In the two studies in which all the participants were obese, the effects of the low glyce-

mic load diets were more apparent. Hence low glycemic diets may be effective even in obese people who may benefit most from weight loss. Although a causal link between changes of blood glucose or insulin and appetitive sensations is unlikely,[27] features of lower GI diets may promote satiety.[7] One recent pre-load study noted greater fullness following a high GI breakfast containing almonds compared to one without almonds.[28]

Metabolizable energy

One of the most common and straight forward messages to consumers is that maintaining a healthy weight is simply a matter of balancing energy intake with energy output. However, using the information on food labels to estimate energy intake could be misleading because they may not accurately reflect the true biologically available energy content.[29] Food labels may over or underestimate this figure by up to 25%. Calorie values on food labels are based on a system developed in the late 19th century by American chemist, Wilbur Olin Atwater. He estimated (based, in part, on controlled combustion of foods) that carbohydrates and protein provide an average of 4 kcal per gram, while fat provides 9 kcal per gram to help approximate total food energy. However, these are only estimates of mean values. The Atwater system assumes that the proportion of food that passes through the gut undigested is more or less constant, at around 10 per cent, but this varies with the nature of the food ingested. The absorption of energy from nuts is less complete than most other foods. Studies reveal consistently elevated fecal fat loss with nut consumption. In a trial where the fat content of the diet of 6 individuals was increased from 30% of energy to 43% of energy by the addition of pecans for 4 weeks, the percentage of fecal fat increased from 2.9 to 8.3%.[30] Several trials have been conducted with almonds. In the most recent research, participants chewing almonds 10-25 times before swallowing had significantly higher fecal energy loses compared to when they chewed almonds 40 times.[22] One short term study progressively provided 3 individuals 100, 150, and 200 g/day of almonds over 3 days and observed an increase in fecal fat content from 3.5±0.9% in the control diet to 9.9%±1.1% in the combined supplemented samples.[31] A 10-week trial providing 1255 kJ/day resulted in an increased fecal loss of 6.7% of the almond energy.[12] One trial provided a 1770-kJ supplement to 27 hyperlipidemic adults for three 1-month periods. It contained 50-100 g of almonds, one half that amount of almonds, or no almonds. An increase in fecal energy excretion of 247±63 kJ/day and 113±46 kJ/day above baseline was noted.[32] In another trial, fecal fat content following diets containing 0, 10, and 20% of total energy from almonds was 1.7, 3.2, and 4.1%, respectively.[33] Although the data do not permit accurate calculation of the energy loss due to limited bioaccessibility, a working estimate may be 10-15% of the energy from the nuts.[15] Thus, direct metabolizable energy is a more accurate representation of actual energy value for nuts than package label or table values.

This inefficiency stems from resistance of the parenchymal cell walls of nuts to microbial and enzymatic degradation. Thus, cells that are not ruptured during mastication may pass through the gastrointestinal tract without

releasing the lipid they contain.[32,33] This is supported by data demonstrating greater energy loss from whole nuts compared with nut butter[34,35]; a higher energy requirement to maintain body weight during nut consumption[31]; as well as microstructural analyses of fecal samples.[32] Because lipid is the primary energy source in nuts, work on bioaccessibility has focused on this nutrient. However, the resistance of the cell walls of nuts to degradation in the gastrointestinal tract would also limit the bioaccessibility of other nutrients they contain, including protein, vitamins, minerals, and phytochemicals.[36,37]

Energy expenditure

Although not definitively documented, routine consumption of nuts may augment energy expenditure. Chronic (19 weeks) consumption of peanuts was associated with an 11% elevation of resting energy expenditure (REE).[9] In another peanut study,[9] an 11% increase was noted only among males and a 5% increment was measured among the obese. A similar effect is expected for tree nuts. One almond study reported a 209-kJ/day increment in REE that was not statistically significant, but was corroborated by doubly-labeled water measurement.[12] An explanation for the rise of REE is not obvious, but because the diets of nut consumers tend to reflect the nutrient contribution of the nuts, their high unsaturated fatty acid composition and protein concentration may be involved. Unsaturated fats are oxidized more readily than saturated fats and protein has a high thermogenic effect.[38,39] Slow absorption of the energy from this high fat food may also contribute. One recent trial with walnuts noted a significant increase in the thermogenic effect of feeding compared to a meal supplemented with saturated fats from dairy products,[40,41] but this has not been observed in several other studies with peanuts or almonds.[35,36] This aspect of the metabolism of nuts requires further exploration.

PALATABLE DIET PLANS

Weight loss is achievable with diets emphasizing different nutrient compositions as long as they are adhered to and restricted in energy.[42,43] Often, dietary advice is targeted for acute weight loss without adequate consideration of the effect of diet palatability or acceptability on long-term compliance. The inclusion of nuts in energy restricted diets has reduced attrition and augmented weight loss.[13,37] The emphasis on diet planning is now shifting towards consideration of the most healthful approach to energy restriction. Incorporation of pistachios in a reduced-energy diet plan promoted significantly lower triacylglycerol and BMI compared to pretzels (low fat control).[44] A recent study revealed beneficial effects on cardiovascular disease risk factors among individuals with high resting LDL-cholesterol and triacylglycerol concentrations when consuming peanuts of various flavors[45] This supports the allowance of nuts with varied sensory properties in diets as a means to enhance palatability and compliance without compromising health benefits.

CONCLUSION

Current dogma holds that energy-dense foods must be carefully controlled for weight loss and maintenance.

Nuts are among the most energy-dense foods consumed, yet the literature consistently documents little impact of their ingestion on body weight. These data suggest that each food must be evaluated objectively for its impact on body weight and total diet quality to ensure that recommendations about its use are sound and empirically based. The current best estimates are that 55-75% of the energy contributed by nuts is offset by dietary compensation, another 10-15% by fecal loss, and an additional, less well-established, estimate of potentially 10% via increased energy expenditure.

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核果類與維持健康體重的機制

核果類是多種有益健康的營養素和植化素的良好來源，包括降低心血管疾病的風險。因此倡議增加核果類的攝取。但是核果類亦含高脂肪及高熱量，這些性質與正向能量平衡、體重之間的可能相關性引起對上述建議的疑慮。許多流行病學及臨床研究顯示核果類與體重的增加沒有相關。機制研究指出這主要是由於核果類的高度飽足感以及低代謝能量(低生物可獲性而致熱量吸收效率低)的特性所致。代償性的飲食反應約佔 55%-75% 由核果類所提供的能量。有限的數據建議，日常攝取核果類與增加靜息能量消耗(REE)、進食產熱效應有關，這些可消耗另一部分核果所提供的能量。此外，減重對比試驗，比較包含或排除核果類的飲食方案，結果顯示在允許攝取核果類的情況下，有助改善遵從性及提昇減重效果。飲食中包含適量的核果類，可增加適口性、營養品質，以及在不影響減重或維持體重的情形下，可減少慢性疾病的風險。

關鍵字：核果、體重、飽足感、代謝能量、熱量消耗