

Dietary Saturated/Unsaturated Ratio as a Determinant of Adiposity

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Abstract

The characteristic leanness of vegans and adherents to “Mediterranean” diet patterns may reflect the fact that the high saturated-to-unsaturated ratio of Western omnivore diets tends to impair muscle insulin sensitivity, leading to a compensatory up-regulation of insulin secretion. Since insulin signals adipocytes to take up and retain fatty acids, a high dietary saturated-to-unsaturated ratio would be expected to promote obesity. It is proposed that, at any given level of total fat intake, the dietary saturated/unsaturated ratio will correlate positively with BMI and propensity for weight gain – a readily testable prediction. The relatively low ratios of saturates to unsaturates and of essential to non-essential amino acids in plant-based diets may be primarily responsible for the low rates of obesity, diabetes, coronary disease, and “Western” cancers observed in quasi-vegan societies.

Plant-based Diets Promote Leanness

Cross-sectional studies which have compared the average BMIs of vegans with those of age-matched ovo-lactovegetarians and omnivores have invariably found lower BMI s in vegans, those of ovo-lactovegetarians tend to higher than those of vegans, but lower than those of omnivores.¹⁻⁷ Somewhat less consistently,⁸ the BMIs of adherents to a “Mediterranean” diet pattern – in which intakes of meats and dairy products are relatively low, whereas intakes of olive oil, fish, fruits and vegetables are high – have been found to lower than those of people who eat a more typical “Western” omnivore diet.⁹⁻¹¹ Those who follow these diets have also been found to be at reduced risk for weight gain in longitudinal studies.¹²⁻¹⁴

These findings may be viewed as corollaries of the following proposition: at any given level of dietary fat intake (percentage fat calories), those whose diets have a relatively low ratio of saturates to unsaturates will be leaner than those whose diets have a higher saturated/unsaturated ratio.

How Long-Chain Saturated Fats Preferentially Promote Obesity

This can be predicted from the following considerations: long-chain saturated fatty acids, in excess, have a more negative impact on muscle insulin sensitivity than do unsaturated fats – a finding that has been established in rodent studies, in cultured myotubes, in clinical trials, and in human studies which correlate dietary fat or tissue fatty acid profiles with insulin sensitivity.¹⁵⁻²⁵ This reflects the fact that excess amounts of these saturated fats in skeletal muscle fibers are prone to give rise to increased amounts of ceramide and diacylglycerol, which work in various ways to compromise muscle insulin sensitivity. In contrast, unsaturates cannot serve as precursors for ceramide, and, because diacylglycerol acyltransferase has a higher affinity for unsaturated fatty acyl-coAs than saturated fatty

acyl-coAs, they tend to yield a higher amount of (metabolically inert) triglycerides and a lesser amount of diacylglycerol.^{18, 21, 22, 26, 27} This provides a satisfying explanation for the many studies demonstrating superior insulin sensitivity in those whose dietary saturate/unsaturate ratio is relatively low. In addition, there is limited evidence that a relatively high fraction of oleic acid in tissue lipids may be associated with higher glucose effectiveness.^{28, 29} (The seemingly discordant finding that tissues levels or intakes of palmitoleic acid correlate with poorer insulin sensitivity, may simply reflect the fact that this fatty acid is serving as a marker for its precursor palmitic acid, arguably the most noxious fatty acid from the standpoint of its impact on insulin function.^{29, 30})

The poorer muscle insulin sensitivity and glucose effectiveness associated with saturate-rich diets can be expected to lead to a compensatory up-regulation of pancreatic secretion and blood levels of insulin. As is well known, insulin acts to promote the storage and retention of fatty acids in adipocytes. The steady weight gain observed in diabetics following commencement of treatment with injectible insulin or insulin-releasing sulfonylurea drugs illustrates the long-term impact of chronically elevated insulin levels on adiposity; in contrast, metformin therapy, which tends to decrease diurnal insulin secretion by suppressing hepatic glucose output, is often associated with modest weight loss in diabetics.^{31, 32} It is reasonable to predict that a chronic up-regulation of insulin levels stemming from the muscle insulin resistance associated with saturate-rich diets will have a comparable anabolic impact on adipose mass. Eventually, as adipocytes hypertrophy and become more insulin resistant, an increase in free fatty acid flux will lead to an increase in free fatty acid oxidation, such that weight gain ceases and a new equilibrium is established at a higher adipose mass.

These considerations do not predict that adding more unsaturated fats to a diet will promote leanness; a high intake of any type of fat seems unlikely to favor leanness, and societies which are traditionally quite lean tend to consume diets quite high in carbohydrates. Rather, what is predicted here is that *substituting* unsaturated fat for saturated fat will promote a leaner physique.³³ In other words, if total dietary fat intake is held stable, a transition to a more plant-based or Mediterranean diet pattern will tend to be associated with weight loss. The particular merit of low-fat vegan diets for weight control is that they tend to offer a low ratio of saturates to unsaturates in the context of a low total fat content. Physicians who recommend ad libitum consumption of such diets for patients with vascular disease or diabetes, with or without concurrent walking exercise, have often reported significant “spontaneous” weight loss.³⁴⁻³⁹

This proposition could readily be tested using data from on-going prospective cohort studies. It is predicted that, at any given level of total fat intake (percentage dietary fat calories), a higher saturate/unsaturate ratio will predict a higher BMI and a greater risk for weight gain.

It should be noted that modulation of insulin levels is not likely to be the only mechanism by which the nature (as opposed to the quantity) of dietary fat can influence adiposity. For example, several clinical studies suggest that oleic acid may be oxidized more rapidly than palmitic acid following acute oral administration.⁴⁰⁻⁴² If this phenomenon persists in

the longer term, it presumably would amplify the magnitude of the relationship predicted here. Additional studies pertaining to differential metabolism of dietary fatty acids have recently been reviewed.²⁶

Finally, to the extent that adherents to vegan or Mediterranean diets are more prone to consuming ample amounts of whole fruits and vegetables, the relatively low caloric density and high fiber content of these foods would seem likely to make an independent contribution to their relative leanness.⁴³⁻⁴⁶

Fatty Acid And Amino Acid Ratios Mediate the Protection Afforded by Vegan Diets

The low saturate-unsaturate ratio of most plant-based diets (that exclude tropical oils) is also evidently a key determinant of the low LDL cholesterol levels observed in vegans⁴⁷⁻⁴⁹ – albeit absence of dietary cholesterol and a poorly understood impact of plant proteins also play a role in this regard.⁵⁰⁻⁵³ In conjunction with the relative leanness and good insulin sensitivity associated with such diets, low LDL presumably explains why coronary disease has been very rare in Third World societies following quasi-vegan diets.

Vegan diets are characterized by relatively low intakes of certain essential amino acids – most notably methionine and lysine – either on an absolute basis, or relative to total protein content.⁵⁴ Since a relatively low intake of one or more essential amino acids can decrease hepatic production of IGF-I, this may explain why plasma IGF-I levels tend to be lower in vegans than in ovo-lacto-vegetarians or omnivores.⁵⁵⁻⁵⁸ Intriguingly, attempts to correlate IGF-I levels with habitual dietary intakes have revealed that increased intakes of non-soy plant protein (which tend to be of “lower quality” than soy or animal protein) correlate with reduced IGF-I levels⁵⁸ – which seems counterintuitive inasmuch as increased intakes of any protein will increase the absolute intake of essential amino acids. Perhaps this reflects the fact that non-essential amino acids, by provoking increased glucagon activity, promote increased catabolism of essential amino acids, such that their hepatic levels are decreased.^{53, 59} Thus, the dietary *ratio* of essential to non-essential amino acids may be an important determinant of IGF-I levels.

The good insulin sensitivity and relatively low diurnal insulin levels of vegans would be expected to boost hepatic production of IGFBP-1, a functional antagonist of IGF-I bioactivity;⁶⁰⁻⁶² a relative dietary deficit of essential amino acids may amplify this effect.⁶³ Hence, systemic bioactivity of IGF-I in vegans may be even lower than that suggested by their decreased IGF-I levels. Low diurnal insulin also leads to increased hepatic production of sex-hormone-binding globulin (SHBG), such that the free fraction of circulating sex hormones is diminished.^{64, 65} Hypothalamic feedback mechanisms will tend to blunt this effect by a compensatory increase in sex hormone production – but no such mechanism will be operative in post-menopausal women. Thus, high SHBG levels and lower adiposity (associated with decreased aromatase-mediated estrogen production⁶⁵) will tend to decrease estrogen bioactivity in post-menopausal vegans. Since IGF-I, insulin, and free sex hormones have important cancer-promoting activity in many tissues⁶⁶⁻⁶⁸ – and since they also may collaborate to induce early menarche^{69, 70} (a key determinant of breast cancer risk) – a satisfying explanation may be at hand for the

anomalously low risks for “Western” cancers enjoyed by rural Third World societies throughout the twentieth century.⁷¹⁻⁷⁴

Thus, the fact that plant-based diets tend to be associated with relatively low ratios of saturated fats to unsaturated fats and of essential amino acids to non-essential amino acids, may be primarily responsible for the relative paucity of obesity, diabetes, coronary disease, and Western cancers observed in societies whose traditional diets are low in animal products.

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