



# High-carb, high satiety?

*Differing effects of high-fat or high-carbohydrate meals on food hedonics in overweight and obese individuals* 

# Introduction

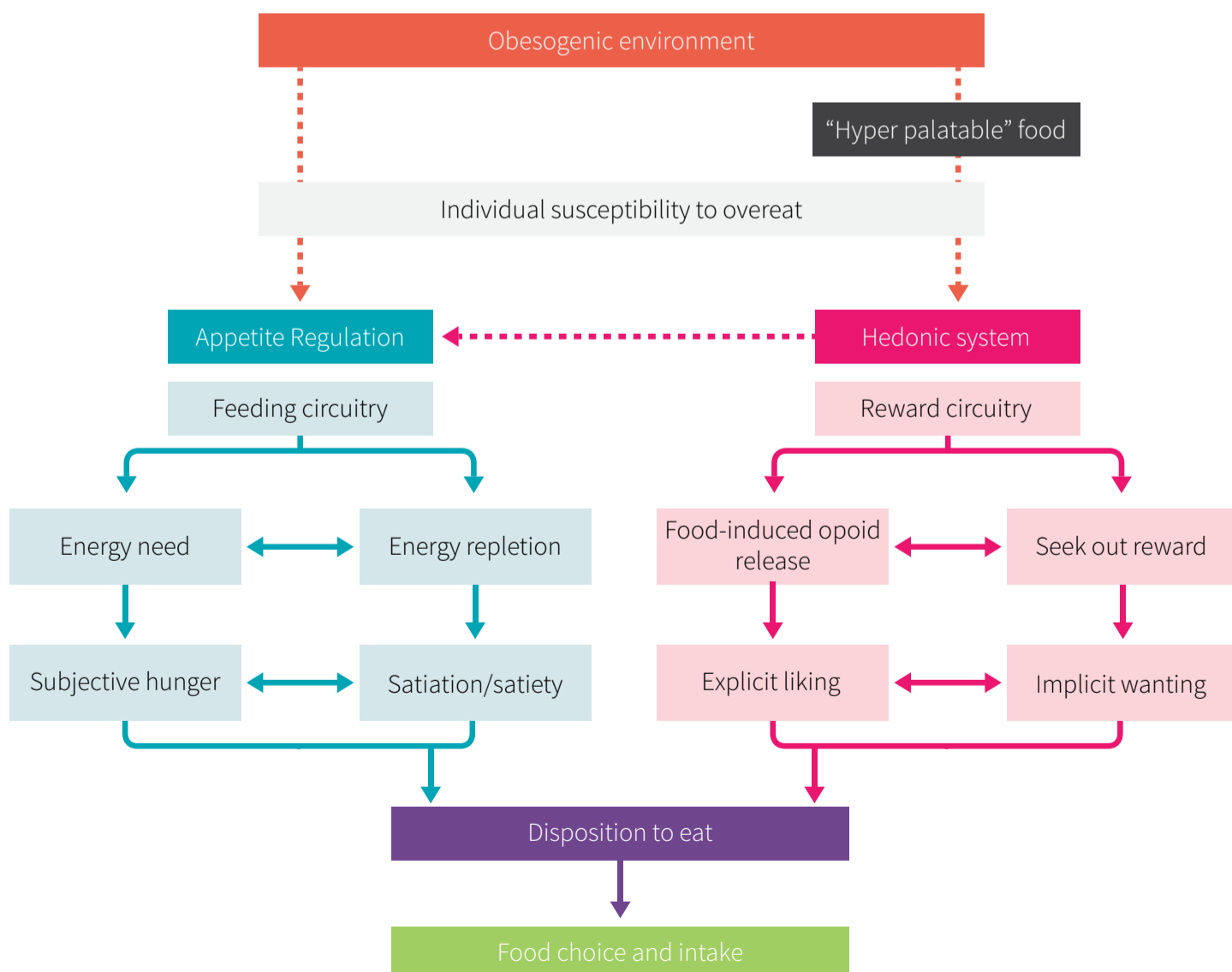
Overeating can be a much more complex phenomenon than you'd think. Figure 1 shows an extremely simplified framework of food intake regulation. Each category listed comprises many, many variables. [Fiber content](#), [palatability](#), [convenience](#), and even [eating with friends](#) can all alter our food consumption. One obvious variable that plays a major role is satiety. Satiety is the feeling of fullness experienced after having a meal. As we eat, signals from the digestive system tell the brain about the quantity and quality of what was eaten. The brain integrates these signals, and as they build over the course of a meal, the brain generates a growing feeling of satiety. However, there are other factors at play that can generate different levels of satiety.

Macronutrient composition and food hedonics are two such factors. Food hedonics is comprised of food liking and food wanting. Food liking is the “perceived pleasurable sensory properties of food” such as taste, smell, and texture. Food wanting is the “attraction towards a specific food over available alternatives”.

[It has been established](#) that protein consistently exhibits the most pronounced effect on satiety of the three macronutrients. Carbohydrates and fat deliver [the same amount of satiety per calorie](#) when caloric density and palatability are matched. High-fat foods do commonly exhibit lower satiety per calorie, but that appears to be due to calorie-density and palatability. The metabolic and behavioral mechanisms that lead to the overconsumption of calorically dense foods are not

Figure 1: Regulation of food intake in an obesogenic environment

*An obesogenic environment is one that provides little to no barriers that may prevent consistent overconsumption of palatable, high-calorie foods.*



Adapted from: Finlayson et al. Curr Obes Rep. 2012 Mar.

fully understood. It is possible that the hedonic value of foods prior to consuming a meal can influence appetite and caloric intake.

The hedonic value of food liking and food wanting was evaluated in this study. The current body of evidence examining the effects of food macronutrient composition on hedonics are somewhat mixed. There remains some debate over the contributions of dietary fat and carbohydrate in the promotion of overconsumption, and there hasn't been much research on the interaction between food hedonics and macronutrient content. Thus, the purpose of this study was to examine the effect of meals differing in dietary fat and carbohydrate on caloric intake, satiety, and food hedonics in people who are overweight or obese. Illuminating these effects could provide further tools to people attempting to lose weight.

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**Many variables affect how much food we consume. These include feelings of satiety and the hedonic value of food, food liking and food wanting. The purpose of this study was to investigate how manipulating macronutrient composition of meals throughout the day would affect satiety and the hedonic response to a subsequent food exposure in people who were overweight or obese.**

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## Who and what was studied?

Sixty-five males and females, who were either overweight or obese, were recruited into this cross-over, randomized trial. In a cross-over study, all participants are exposed to each intervention and act as their own control. Potential participants who were smokers, physically active, had experienced recent weight fluctuations, or were taking medications that affect metabolism or appetite were excluded from the trial.

All participants completed two separate meal test days. On one test day they consumed only high-fat/low-carbohydrate (HFLC) meals and on the other test day, only low-fat/high-carbohydrate (LFHC) meals. Macronutrient composition for HFLC was 56% fat, 13.9% protein, and 30.1% carbohydrate. The LFHC condition was 23% fat, 13.5% protein, and 63.5% carbohydrate. Note that the protein content was kept equal between groups to help eliminate it as a potential confounding variable due to its satiating nature.

Testing between meal conditions was separated by at least 2 days. Meals were matched for sensory properties and taste to help mask the meal types from the participants. For example, both groups received milk as part of their breakfast, but the HFLC group received full-fat milk while the LFHC group got reduced-fat milk.

## Diet Composition

Breakfast (*ad libitum*)

High-fat/Low-carb	Low-fat/High-carb
Cereal (Kellogg's Corn Flakes)	Cereal (Kellogg's Corn Flakes)
Full fat milk	Semi skimmed milk
White bread- toasted (medium sliced)	White bread- toasted (thick sliced)
Scrambled egg and 70% fat Sunflower margarine	Scrambled egg
Butter (Lurpak spread)	Margarine- Low fat (Flora Light margarine)
Granulated sugar	Granulated sugar

### Lunch (*fixed calories*)

High-fat/Low-carb	Low-fat/High-carb
Cheese Sandwich- white bread (medium sliced), butter, medium cheddar cheese, and lettuce	Cheese Sandwich- white bread (thick sliced), margarine, low fat white cheese, and lettuce
Crisps (Pringles Original)	Crisps (Pringles Light)
Caramel shortcake	Choc Chip Slice (Sainsbury's)

### Dinner (*ad libitum*)

High Fat Pizza	Low Fat Pizza
Garlic bread	French bread and margarine
Coleslaw	Lettuce, Tomato and cucumber
Chocolate biscuits	Malt loaf
Shortbread fingers	Swiss roll cake
Crisps	Apple

### Snack Boxes (*ad libitum*)

Jacobs TUC biscuits	McVities jaffa cakes
Chocolate chunk and hazelnut cookies	Garibaldi biscuits
Flapjacks	Bassett's jelly babies
Fruit and nut milk chocolate	Banana
Salted jumbo peanuts	Apple

During test days, all participants were confined to the lab and ate either HFLC or LFHC meals throughout the whole day. On both the HFLC and LFHC test days, participants consumed *ad libitum* (as much as they

wanted) breakfast and dinner meals, while lunch was a fixed 800 calories. All meals were served four hours apart. *Ad libitum* snack boxes were provided after dinner, when participants were allowed to leave the

## Satiety vs. satiation: what's the difference?

While sometimes used interchangeably in the lay press, satiety and satiation do have distinct and separate definitions. Satiation is the combination of biological processes that bring about an end to an eating episode. This process begins during the meal and culminates in the point at which you feel you have had enough to eat and do not want to consume any more food. Satiation may be influenced by the volume of food you consume and the time it takes you to eat your meal. Satiety is the process that inhibits you from eating until the next meal. Feelings of satiety may be influenced by fiber, protein, and caloric density.

research facility. Researchers tracked the caloric intake of participants by weighing food before and after meals.

Ratings of appetite were collected via a visual scale using an electronic appetite rating system. Satiety was calculated using the satiety quotient (SQ), which is computed by taking the change in appetite and dividing it by calorie intake. In other words, how much a given number of calories decrease appetite. A higher SQ means that the meal was more satiating.

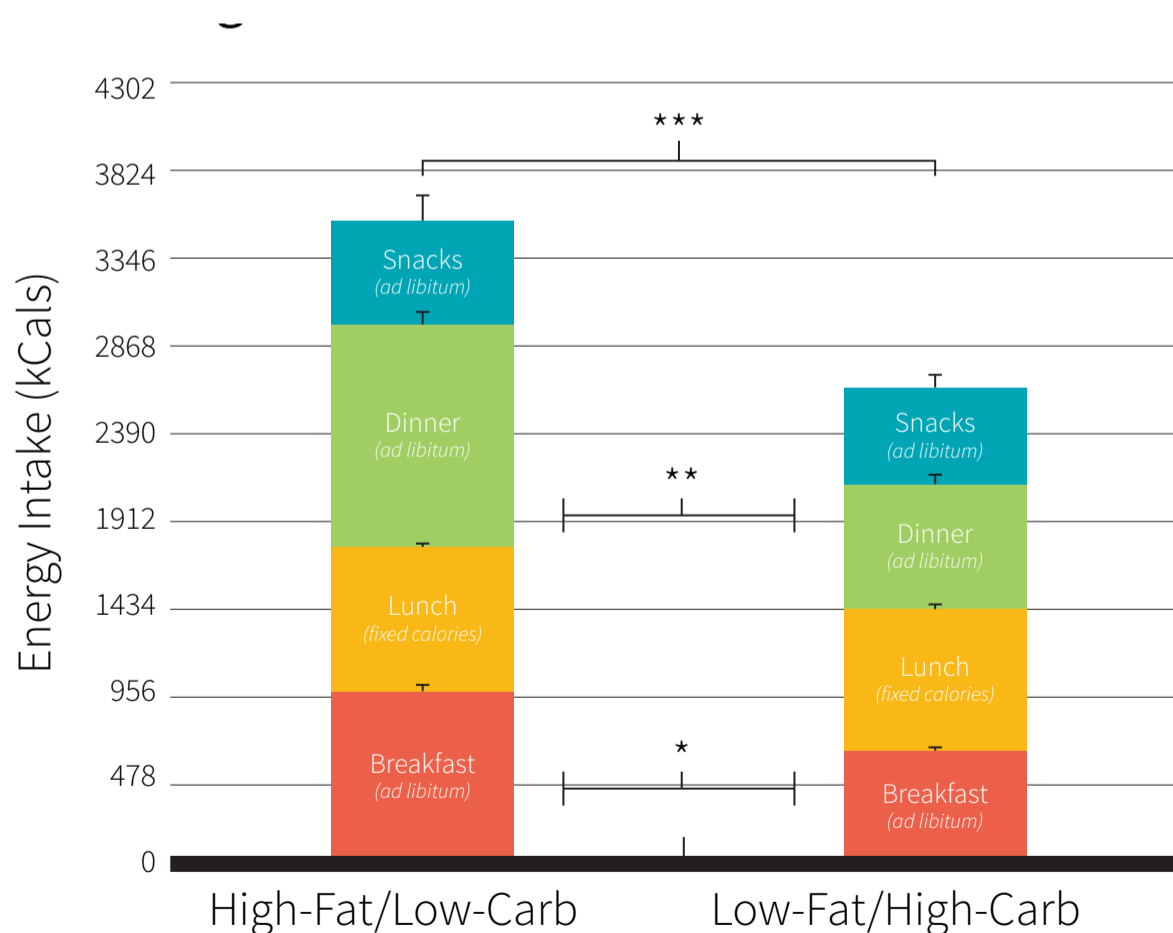
Explicit liking and implicit wanting and food preferences were assessed immediately before and after the fixed-calorie lunch meal. To measure explicit liking, participants were asked to rate pictures of 16 different foods based on how pleasant it would be to consume that food then and there. For assessing implicit wanting, participants had to rank food pairs, indicating the foods they wanted to eat the most at that time.

**Sixty-five individuals participated in this cross-over trial. Participants were fed both high-fat/low-carbohydrate (HFLC) or low-fat/high-carbohydrate (LFHC) meals for a full day, separated by a minimum two-day washout period. All meals and snacks were provided. Participants could eat as much as they wanted of breakfast, dinner, and snacks, but lunch was a fixed 800 calorie meal. Ratings of appetite, satiety, explicit liking, and implicit wanting were assessed.**

## What were the findings?

While on the HFLC meal plan, the participants consumed more calories during the *ad libitum* breakfast and dinner meals. On average, when participants were on the HFLC meals they ate 990 more calories (as detailed in Figure 2) in the day compared to when they were consuming LFHC meals.

Figure 2: HFLC versus LFHC food intake



\*Significant difference in breakfast intakes ( $P < 0.05$ )

\*\*Significant difference in dinner intakes ( $P < 0.05$ )

\*\*\*Significant difference in total daily energy intake ( $P < 0.05$ )

When comparing the HFLC and LFHC testing days, there were no significant differences in measures of hunger and fullness prior to eating either the *ad libitum* breakfast or calorie-fixed lunch. After measuring post-breakfast satiety, researchers observed that the LFHC macronutrient meals produced a significantly higher SQ compared to the HFLC meals. In addition, satiety remained significantly higher when consuming the LFHC meal than the HFLC meals for two hours after breakfast, although this difference disappeared at hours 3 and 4. In short, the *ad libitum* LFHC breakfast meals produced greater feelings of “fullness” than the HFLC meals.

Overall, explicit liking for HFLC foods was greater when participants were eating HFLC foods.

While explicit liking did not differ between the HFLC and LFHC conditions when measurements were taken prior to eating a meal, the explicit liking for HFLC foods was significantly lower in the LFHC group after meals had been consumed.

Implicit wanting for HFLC foods was greater when participants were consuming a HFLC diet in both the pre- and post-meal measures. The HFLC meal also significantly increased wanting for HFLC foods after consuming a HFLC meal. Consumption of LFHC meals saw a decrease in wanting of HFLC items. A weak but positive association was observed between

explicit liking and implicit wanting in both the hungry and fed states during the HFLC and LFHC meals.

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**When on the HFLC meal plan, participants consumed an average of 990 calories more than when on the LFHC meals. The LFHC meals produced greater satiety, and decreased explicit liking and explicit wanting of HFLC foods more so than the HFLC meals. Eating LFHC food decreased their desire to eat HFLC foods more than actually eating HFLC foods did.**

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## What does the study really tell us?

This study indicates that switching between HFLC to LFHC foods can not only reduce overall caloric intake, but also increase the strength of the post-meal satiety in *ad libitum* and matched-calorie feeding conditions.

It is possible that difference in energy density of the two diets could explain much of the satiety effect via increased stomach distension. While the study authors went to great lengths to match the sensory properties and taste of the foods between the two diets, the meals and snacks presented in the HFLC portion of the study were consistently higher in total calories than their LFHC counterparts. Calorie-dense foods [tend to be more palatable](#) which further reduces satiety, at

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least within a meal (which is technically called satiation). While the exact intake for each participant was not reported, the average daily intake for participants while consuming HFLC foods was 990 calories more than while consuming LFHC foods. This suggests that caloric density of the HFLC foods may have played a role in explaining the over consumption reported. Fiber content of both meal conditions, which can also affect satiation, was not reported. But by using the highly scientific method of “guessing”, it appears fiber was kept at least comparable between the high-fat and low-fat meals.

Additionally, the hedonic assessment showed that the explicit liking for high-fat foods was reduced while participants were on the low-fat meal plan. This same trend was observed in implicit wanting of high-fat foods as well. It should be noted that the LFHC and HFLC meals were not entirely made up of unrefined carbohydrates. Meals included items like Kellogg’s Corn Flakes, white bread, chips, biscuits, and jelly candies. So, it cannot be said that the greater satiety seen in the LFHC arm was due to ingestion of low-GI or complex carbohydrate foods. Because protein, the most satiating macronutrient, was kept equal between groups, it is a possibility that the increased carbohydrate content in the LFHC condition played a role in the observed results. But the increase in carbohydrate content of the LFHC meals occurred with a simultaneous decrease in fat content, which means that the reduction in fat could also be an influencing factor as to why the LFHC group consumed fewer total calories.

A few caveats concerning this study’s interpretation should be kept in mind. This was a short-term study, and each participant was only tested once on each meal condition. The results of a trial this brief might not be the same as what happens over weeks and months. All participants were overweight or had obesity. As such, inferences about the long term effects of HFLC and LFHC diets should not be made based on this study. Body composition, health considerations, and personal

preferences should be considered when assessing the applicability of macronutrient manipulation as a means to controlling energy intake, or satiety. No controls were set in place to account for menstrual cycle phases for the female participants, which may have added to the variability seen in some of the food hedonics results.

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**Relative to the HFLC condition, the LFHC meals saw a reduction in energy intake, increased satiety, and decreased food hedonics of HFLC foods. As this was an acute study conducted on overweight or obese participants, the results cannot be extrapolated to potential long-term results or lean individuals.**

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## The big picture

The researchers conducting this study were able to more accurately represent a natural, real-world eating pattern by using meals of mixed macronutrient content. While this was only a short-term study measuring just two days of appetite responses, the results indicate that while the LFHC condition ate fewer overall calories, they still consumed about 2,500 calories. Given that the average height and weight of participants was 5’8” and 198 pounds (90 kilograms), the act of just switching a diet to a LFHC template may not be enough to reduce calories to a level that would bring about weight loss. Keep in mind that both meal conditions were comprised of many refined foods, so using a whole-foods approach may yield better results. Nevertheless, participants’ caloric intake was much lower on the LFHC meal plan than when on the HFLC meal plan, where approximately 3,400 calories were consumed in a day.

When examining food preferences of people who are on [long-term HFLC or LFHC diets](#), researchers observed that individuals on a HFLC diet report being less bothered by hunger, although this did not drastically differ from the responses of people on a LFHC diet. Low-carb diets also tend to be higher in protein, which can abate

“ [...] participants on an *ad libitum*, high protein diet were able to spontaneously decrease their caloric intake by 441 calories a day.”

feelings of hunger. However, in agreement with the results of the study under review, the long-term HFLC dieters experienced an increased craving for fatty items and a decrease in carbohydrate cravings. The LFHC dieters saw little to no change in carbohydrate cravings and a decrease in cravings for fat.

Over the two-year period of this trial, no significant differences in weight loss were seen between groups. These results have been echoed [in a recent meta-analysis](#) comparing very-low-carbohydrate ketogenic diets to low-fat diets for long-term weight loss. The analysis found that the average weight loss difference between these diets, after a year or more of being on them, was just two pounds. Bear in mind that dietary adherence [tends to be very low](#) in studies of longer duration.

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**While increasing carbohydrate and/or lowering fat intake may lead to a decrease in the hedonic reward of high-fat foods in the short-term, it is not known if these effects would hold over months or years. Studies comparing the long-term weight loss effects of low fat versus low carb diets show no clinically relevant differences although adherence in these studies tends to be low over the long term.**

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## Frequently asked questions

### *Why do people report fewer feelings of hunger while on a low carb diet?*

Low-carb diets can often be paired with an increase in protein intake. The highly satiating nature of protein can help people feel full even when they are in a caloric deficit. One study even showed that participants on an *ad libitum*, high protein diet were able to [spontaneously decrease their caloric intake](#) by 441 calories a day. When carbohydrate intake is low enough to place the body in a state of diet-induced ketosis, where your body primarily runs on fats and their metabolites, this state may produce further appetite suppressing effects.

When individuals who were either overweight or obese were placed on a [very-low-energy ketogenic diet](#) for 8 weeks, they saw a suppression of the hormone ghrelin, which can stimulate appetite. But these effects were reversed once the patients came off their strict ketogenic regimen. Some may find it difficult to adhere to a low-carb diet, in which case a high-protein, high-carbohydrate diet may elicit similar benefits.

### *What can influence the satiety of a meal?*

A wide range of factors can influence satiety. [Palatability](#), the [volume of food consumed](#), [caloric density](#), amount and type of [fiber](#), and whether the food is delivered [as a liquid or solid](#) can all play a role. A [preliminary](#)



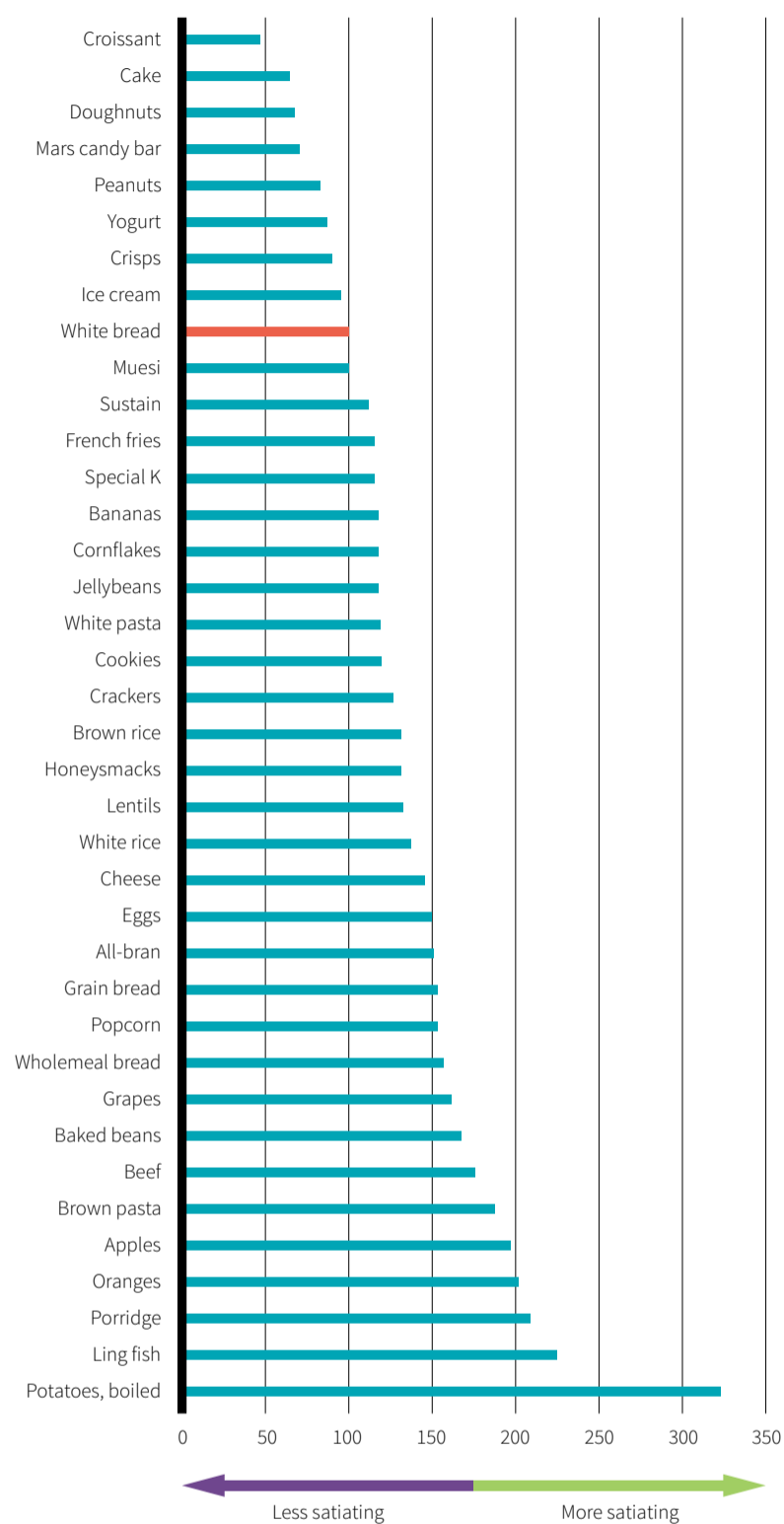
[study evaluating the satiating effects](#) of common foods (summarized in Figure 3) found that food items such as boiled white potatoes, porridge, whitefish, and brown pasta all produced high satiety. Unsurprisingly, foods such as croissants, cakes, and donuts all produced low satiety.

## What should I know?

When participants were eating freely, the LFHC foods yielded greater satiety, decreased energy intake, and reduced the hedonic value of high-fat foods. These results are examining short-term appetite control and it cannot be assumed that these effects would remain sustained over longer periods. Long-term research examining the effects macronutrient compositions can have on food hedonics will be needed to see if higher carbohydrate intake can provide lasting benefits. ♦

This is one of those interesting issues that you shouldn't ignore (as high fat, lower carb diets can lead to unexpected weight gain in some people), but you also shouldn't treat as gospel due the complexity and individual variation in satiety. Discuss satiety and macros at the [ERD private Facebook forum](#).

Figure 3: Satiety index of common foods



Source: Holt et al. Eur J Clin Nutr. 1995 Sep.