

**Ingredient Intelligence:
Dietary Fiber**



Hi-maize[®] Resistant Starch, Hi-maize Whole Grain Corn Flour & Satiety

A National Starch Position Paper



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Hi-maize® & Satiety Position Paper



Introduction

Weight management is a strong driver within the food industry. It has been estimated that 2/3 of Americans are overweight or obese, and the health consequences of an overweight/obese population are staggering. Previously, calorie reduction had been the food industry's primary approach to weight management. However, reducing food intake often leads to increased hunger. It is almost impossible for people to stay on a low calorie diet if they are hungry. As a result of this unmet need, satiety and hunger management are the new hot topics of food development for weight management.

The ultimate goal of satiety is feeling less hungry while reducing food intake. The purpose of this paper is to outline the satiety benefits of Hi-maize® resistant starch and Hi-maize® whole grain corn flour.

What is Satiety?

Definitions: During a meal or snack, you stop eating when you become satiated or feel full. Thus, *satiation* is the process involved during eating causing you to stop eating. *Satiety* is the effect after eating the food has ended and its impact on subsequent feelings of hunger and fullness and ultimately the amount of food you eat at your next meal or snack. For instance, a lunch consisting of Food A may cause you to *feel* less hungry mid-afternoon than Food B. Thus, Food A has stronger effects on subjective satiety (how you feel) than Food B. Eating less at dinner after Food A, would also be interpreted as a satiety effect. In short, the term satiety is used to describe both feelings of not being hungry and eating less as a result of eating a specific food.



Mechanisms of Satiety: Only recently have the multiple, interconnecting mechanisms controlling appetite and satiety become recognized within the research and scientific communities. Many mechanisms play a role in maintaining energy balance and food consumption. At this point in time, researchers do not know if one or more of these mechanisms are more powerful than the others, or which mechanism(s) actually results in reduced food intake (the ultimate goal). (If you are interested in learning more about this topic, "What Fuels Fat" September 2007, *Scientific American* provides an excellent summary). In short, many ingredients are claiming satiety benefits supported by a wide variety of data.

Measuring Satiety

Two methods are generally accepted by researchers as valid measures of satiety:

- 1) **Visual Analogue Scale (VAS)** – A VAS scale is simply a line with anchors at each end, indicating two extremes, such as "Not at all full" to "Very full" and a question is given, such as "How full do you feel right now?" Typically, the line is 100 mm long and the research participant is asked to make a mark on the line indicating their level of fullness, hunger, or other sensations they may feel, such as their desire to eat a food. VAS are accepted as valid measures of subjective feelings of satiety
- 2) **Food Intake** – Satiety can also be measured by measuring how much food a person eats at a subsequent eating occasion or over a defined period of time. This eating occasion can be presented at any interval. For instance, the test food could be eaten 30 minutes before a meal (called a "preload") or the test food could be a meal itself with the subsequent meal measured 2-4 hours later, or even total food intake measured for the next 24 hours. These details are very important as the time course of the satiety effects of various ingredients may differ.

The Satiety Benefits of Hi-maize Resistant Starch

Numerous published studies (but not all) show positive effects of Hi-maize resistant starch on satiety. And recent data from animal studies have identified potential mechanisms underlying these effects. This information has led to better study designs, which have a greater likelihood of capturing Hi-maize's satiety benefits (compared with less well-designed studies published 10+ years ago).

Short-term satiety benefits: Hi-maize enhances short-term satiety because its slow glycaemic carbohydrates are digested lower in the small intestine compared to rapidly digested carbohydrates like traditional starches and glucose, which are digested high within the small intestine. Animal studies are demonstrating that the physical location of absorption impacts satiety signaling. Two recent human studies (Willis 2009 and Anderson 2010) confirmed the effect in healthy people. The Willis study showed that the combination of Hi-maize® RS2 and Novelose® RS3 in a muffin evoked greater subjective satiety than muffins made with either a

rapidly digested maltodextrin or polydextrose (a soluble fiber), over a three-hour period. The Anderson study showed that dietary consumption of Hi-maize 260 and Hi-maize whole grain corn flour in tomato soup reduced food intake after two hours compared to tomato soup containing high glycemic dextrin.

Long-term satiety benefits: Hi-maize also offers longer-term satiety – which is an unexpected timing for satiety benefits. The mechanism is believed to be related to fermentation in the large intestine. In animal studies, Hi-maize resistant starch significantly increases the production of glucagon-like peptide-1, “GLP-1” and peptide YY, “PYY”, both of which are linked to satiety. Within the same studies, cellulose (a non-fermenting insoluble fiber) had no effect, demonstrating that the long-term satiety benefit is driven by fermentation and not by bulking or energy content, (Keenan 2006). The short-chain fatty acid butyrate has also been shown to trigger the production of the same satiety hormones in the large intestine, (Zhou 2006). It is also true that the fermentation of resistant starch produces more butyrate than other types of dietary fiber: “As was shown in other studies, (resistant) starch consistently produces relatively more butyrate whereas oligofructose and inulin are the lowest producers” (Cummings, 2001, p 417S) And because Hi-maize is insoluble and fermented over many hours, satiety hormones are produced and stay elevated for 20+ hours (Zhou 2008). Two recent human clinical studies have confirmed these long-term satiety effects in healthy people: Nilsson 2008 showed increased satiety after 10.5 hours (measured by VAS) and Bodinham 2009 showed reduced food intake after 7 hours as well as after 24 hours.

In summary, the multiple satiety enhancing benefits of Hi-maize resistant starch are a new discovery. Previously, most people thought that satiety effects could last only a few hours, but Hi-maize is demonstrating longer-term, as well as shorter-term, satiety, which is an important breakthrough and point of differentiation compared to other dietary fiber sources.

The Satiety Benefits of Hi-maize Whole Grain Corn Flour

Many studies suggest that whole grains are health-promoting and enhance satiety. A 2010 study (Anderson 2010) demonstrated that Hi-maize whole grain corn flour significantly enhances satiety, even more so than Hi-maize resistant starch. This effect was noted by measuring food intake after 2 hours. Further studies are needed to determine if whole grain corn flour also enhances longer-term satiety.



Resistant Starch vs. Other Types of Dietary Fiber

Dietary fiber and whole grain foods are commonly believed to enhance satiety. However, the data is mostly observational – i.e., people who eat more dietary fiber tend to eat less and tend to weigh less. Prospective studies with individual dietary fibers have had mixed results. Many studies on individual dietary fibers have shown no impact on satiety. Even different types and sources of resistant starch have different digestion and fermentation characteristics and must be considered individually. Specifically, dietary fiber and resistant starch that contains a high percentage of dietary fiber (i.e., 85-95%) may not increase short term satiety in the same way as Hi-maize resistant starch, because they lack the slowly digestible starch portion contained within natural Hi-maize. Thus, while it is generally accepted that dietary fiber in general enhances satiety, the association between individual dietary fibers and satiety must be considered individually, as data varies widely and multiple mechanisms are involved.

Conclusion

Satiety is a strong trend in the food industry. However, it is physiologically complicated and the scientific evidence on satiety is still emerging. Hi-maize resistant starch and Hi-maize whole grain corn flour have published studies demonstrating enhanced satiety, which suggest they would be ideal ingredients for formulating into foods for weight management.

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