



Hi-maize[®] Resistant Starch and Weight Management

A National Starch Paper
Answering Frequently Asked Questions



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Hi-maize Resistant Starch and Weight Management

Two books released in the fall of 2010 highlight eating foods containing resistant starch from natural or added sources as a strategy for healthier eating and losing weight:

The CarbLovers Diet (from the editors of *Health* magazine – www.carblov.com) and

The Skinny Carbs Diet (from *Prevention* magazine/Rodale www.skinnycarbsdietbook.com).

We have been getting a lot of questions about resistant starch, particularly about Hi-maize®, the natural high-amylose resistant corn starch, which was used in most of the research studies supporting these two books. Here are the common questions and our answers.

Q. These books link weight loss to resistant starch. Is there really a connection?

A. Twenty years of research (over 300+ studies, nearly 100 in humans) on resistant starch, much of it using Hi-maize resistant starch (see Q&A below: Why is Hi-maize used in so many of the resistant starch studies?), has demonstrated significant health benefits including those related to weight control and glycemic management (insulin and glucose control) as well as digestive health.

Regarding weight management, several human studies show that people were less hungry or ate less after consuming Hi-maize, categorized as RS2 (see Q&A below: I heard there are a couple different types of resistant starch. Do they all have these benefits?):

- A 2009 study out of the University of Minnesota¹ published by Holly J. Willis, Joanne Slavin and team showed people were less hungry two hours after eating a muffin made with 8 grams of fiber from Hi-maize compared to muffins made with ~9 grams of fiber from other types of fiber, such as oat fiber and beta glucan vs. a low fiber muffin (~2g fiber). Results demonstrated that resistant starch provided the greatest satiety effects and concluded that not all fibers influence satiety equally.



- A 2008 study out of Lund University (Sweden) published by Anne C. Nilsson in the *Journal of Nutrition*,² showed increased satiety 10 to 14 hours after consumption of Hi-maize resistant starch or barley kernel resistant starch.

- A University of Toronto (Canada) research team, led by G. Harvey Anderson, reported in the *American Journal of Clinical Nutrition*³ that Hi-maize increased satiety and reduced food intake when fed two hours prior to a meal compared with high glycemic maltodextrin (study supported by NSF).

- A 2010 study from researchers at the University of Surrey (UK) by Drs. Bodinham, Frost and Robertson published in the *British Journal of Nutrition*⁴ titled,

“Acute ingestion of resistant starch reduces food intake in healthy adults,” shows the consumption of Hi-maize can help individuals eat 10% less food over 24 hours without being hungry.



Human studies also show that Hi-maize may improve insulin sensitivity and help people achieve healthier blood glucose levels.⁵ Because endogenous insulin (made and secreted from the pancreas) is strongly believed to impact weight regulation and storage, improvements in this important hormone likely contribute to weight management as well as glucose control.

Animal studies are also supportive and show positive results regarding body composition (significantly less fat), as well as increased production of important satiety hormones. Studies from several groups have shown that Hi-maize resistant starch results in less body fat in animal models.⁶ Studies have also shown that Hi-maize resistant starch increases the production of the satiety hormones glucagon-like peptide-1 (“GLP-1”) and Peptide YY (“PYY”) within the large, as well as small, intestine.⁷ Animal studies are also clearly identifying the mechanisms of action and are exploring potential interactions with other dietary components.

Hi-maize resistant starch also contains fewer calories (2-3 kcal/g) than other starches including flour (4 kcal/g). So, when Hi-maize replaces some of the flour in foods, the calories in the product are reduced.

Q. How much resistant starch will help me lose weight?

A. While resistant starch is not alone a magic bullet for weight loss, the research is pointing to its health benefits in general, and potential benefits, for weight management. However, incorporating an increased amount of resistant starch into an otherwise healthy and lower-calorie eating plan, balanced with sufficient exercise, may well help people lose weight and keep it off.

Research published in the Journal of the American Dietetic Association⁸ shows that Americans (children and adults) get about 5 grams of resistant starch per day. Some experts recommend 15 to 20 grams of resistant starch per day for optimum health benefits. We recommend people start by simply doubling their current intake of resistant starch, say from the average of 5 grams to 10 grams/day.

Q. I heard there are a couple different types of resistant starch. Do they all have these benefits?

A. There are four types of resistant starches. Hi-maize is an all-natural type of resistant starch isolated from non-genetically modified high amylose corn called an RS2. Slightly green bananas are another excellent source of RS2. Legumes, which are an excellent source of resistant starch, are in the other common category of natural resistant starch, RS1. Resistant starch that is formed when starch-containing foods are cooked and cooled (think potato and pasta salad, sushi rice, etc.) is categorized as RS3. Resistant starch can also be made by chemically treating starch to make it indigestible to humans, which is called RS4.

Hi-maize has strong scientific evidence (300+ total studies/nearly 100 human) to support its health benefits. In contrast, there isn't nearly as much known about other types of modified and synthetic resistant starches (RS3 and RS4) being incorporated into some foods today. Early studies suggest that modified and synthetic resistant starches are digested and fermented differently. Future studies will have to determine their physiological and health benefits.

Q. Why is Hi-maize used in so many of the resistant starch studies?

A. Researchers doing resistant starch research have used Hi-maize for years because it has been available, it retains the fiber content



when it's put into foods, assures a consistent quantity of resistant starch and allows the use of high amounts as it causes no gastrointestinal side effects even in large amounts (up to 45 grams/day). Unlike newer forms of resistant starch, which have been available only a few years, high amylose corn resistant starch has been commercially available from National Starch since 1993.



Q. How can I eat more resistant starch?

A. There are three ways to eat more resistant starch:

- Natural resistant starch is found in common foods such as legumes (beans and peas), grains and even slightly green bananas. When cooked and served cold as in salads, several starches including potatoes, pasta and rice, are especially rich in resistant starch.

- Hi-maize resistant starch is found in a growing number of supermarket foods such as breads and pastas. Visit resistantstarch.com for a listing of these products. Hi-maize is all natural and isolated from traditionally bred (non-genetically modified) high amylose corn.

- Hi-maize is also available for home cooking through King Arthur Flour (www.kingarthurfLOUR.com). Just one tablespoon (approximately 9.5 grams) of Hi-maize mixed into casseroles, hot cereals, batters (pancakes, waffles, muffins) and smoothies adds an extra 5 grams of natural resistant starch and dietary fiber. A source of certified gluten-free Hi-maize is Celiac Specialties (www.CeliacSpecialties.com).

Q. Does resistant starch cause any gastrointestinal (GI) effects such as gas, bloating, abdominal discomfort or diarrhea commonly associated with other fibers being added to foods?

A. No. Studies using Hi-maize have shown that high levels (even up to 45 grams/day which exceeds the recommended intake of dietary fiber of 19-38 grams/day depending on age and sex) can be consumed with modest or no digestive side effects. This is far from the case with other functional and synthetic fibers being added to foods to boost fiber intake.

For more information about Hi-maize resistant starch, visit www.foodinnovation.com/hi-maize or send an e-mail to hi-maize@nationalstarch.com. For more information about the health benefits and published studies, visit www.resistantstarch.com.

References

- 1 Willis HJ, Eldridge AL, Beiseigel J, Thomas W, Slavin JL. Greater satiety response with resistant starch and corn bran in human subjects. *Nutrition Research*. February 2009; 29(2):100-105.
- 2 Nilsson A, Ostman EM, Holst JJ, Bjorck IME. Including indigestible carbohydrates in the evening meal of healthy subjects improves glucose tolerance, lowers inflammatory markers, and increases satiety after a subsequent standardized breakfast. *Journal of Nutrition* (April 2008) 138:732-739.
- 3 Anderson GH, Cho CE, Akhavan T, Mollard RC, Luhovyy BL, Finocchiaro ET. Relation between estimates of cornstarch digestibility by the Englyst in vitro method and glycemic response, subjective appetite, and short-term food intake in young men. *American Journal of Clinical Nutrition* (2010) 91:932-9. Epub ahead of print Feb 17, 2010.
- 4 Bodinham CL, Frost GS, Robertson MD. Acute ingestion of resistant starch reduces food intake in healthy adults. *British Journal of Nutrition*. (Mar 2010) 103(6):917-22. Epub 2009 Oct 27.
- 5 Robertson, M.D., Bickerton, A.S., Dennis, A.L., Vidal, H., Frayn, K.N. Insulin-sensitizing effects of dietary resistant starch and effects on skeletal muscle and adipose tissue metabolism. *American Journal of Clinical Nutrition*, (2005), 82, 559-567.
- Robertson, M.D., Currie, J.M., Morgan, L.M., Jewell, D.P., Frayn, K.N. Prior short-term consumption of resistant starch enhances postprandial insulin sensitivity in healthy subjects. *Diabetologia*, (2003), 46, 659-665.
- Robertson, M.D., Wright J.W., Batt J., Russell-Jones D., Umpleby A.M. Orals: Nick Hales Young Investigator Award - Dietary resistant starch is an insulin sensitizer A37(P37). *Diabetic Medicine*. March 2009;26(1)(Suppl.1):14.
- Johnston KL, Thomas EL, Bell JD, Frost GS, Robertson MD. Resistant starch improves insulin sensitivity in metabolic syndrome. *Diabetic Medicine* (2010) 27, 391-397.
- 6 Higgins, J.A., Brown, M.A., Storlein, L.H. Consumption of resistant starch decreases postprandial lipogenesis in white adipose tissue of the rat. *Nutrition Journal*, (2006), 5:25, 1-4.
- Keenan, M.J., Zhou, J., McCutcheon, K.L., Raggio, A.M., Bateman, H.G., Todd, E., Jones, C.K., Tulley, R.T., Melton, S., Martin, R.J., Hegsted, M. Effects of resistant starch, a non-digestible fermentable fiber, on reducing body fat. *Obesity*, (2006), 14 (9), 1523-1534.
- Scribner, K.B., Pawlak, D.B., Ludwig, D.S. Hepatic steatosis and increased adiposity in mice consuming rapidly vs. slowly absorbed carbohydrate. *Obesity*, (2007), 15 9, 2190-2199.
- Isken F, Klaus S, Petzke KJ, Loddenkemper C, Pfeiffer AF, Weickert MO. Impairment of fat oxidation under high vs low glycemic index diet occurs prior to the development of an obese phenotype. *Am J Physiol Endocrinol Metab*. (2010) 298:287-295. Epub ahead of print. Nov 24, 2009.
- Coate KC, Huggins KW. Consumption of a high glycemic index diet increases abdominal adiposity but does not influence adipose tissue pro-oxidant and antioxidant gene expression in C57BL/6 mice. *Nutrition Research* 30 (2010): 141-150.
- 7 Zhou J, Martin RJ, Tulley RT, Raggio AM, McCutcheon KL, Shen L, Danna SC, Tripathy S, Hegsted M, Keenan MJ. Dietary resistant starch up-regulates total GLP-1 and PYY in a sustained daylong manner through fermentation in rodents. *Am J Physiol Endocrinol Metab*. (2008) 295: 1160-1166.
- Mochizuki K, Sato Y, Takase S, Goda T. Changes in mucosal alpha-glucosidase activities along the jejunal-ileal axis by an Hm-HACS diet intake are associated with decreased lipogenic enzyme activity in epididymal adipose tissue. *Journal of Agricultural and Food Chemistry*. (2010) Epub ahead of print May 18.
- 8 Murphy, M.M., Douglass, J.S., Birkett, A. Resistant starch intakes in the United States. *Journal of the American Dietetic Association*, (2008), 108, 67-78.

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