



Resistant Starch

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What is Resistant Starch?

- Although this may be the first you've heard of resistant starch, it's likely been a part of your diet most of your life
- Resistant starch is a **type of dietary fiber** naturally found in many carbohydrate-rich foods such as potatoes, grains, and beans, particularly when these foods are **cooked and cooled**.
- It gets its name because it **"resists" digestion in the body**, and though this is true of many types of fiber, what makes resistant starch so special is the **powerful impact it has on weight loss and overall health**

What is Resistant Starch?

- Over the past several years there has been an exponential increase in the number of studies **linking imbalances or disturbances of the gut microbiota to a wide range of diseases including obesity, inflammatory bowel diseases, depression and anxiety**
- The normal human gut has **hundreds** of bacterial species, some good and some not so good.
- The overall number and relative quantity of each type has a **profound effect on our health and well being.**
- Resistant starch **selectively stimulates the good bacteria** in our intestines, helping to maintain a healthy balance of bacteria

What is Resistant Starch?



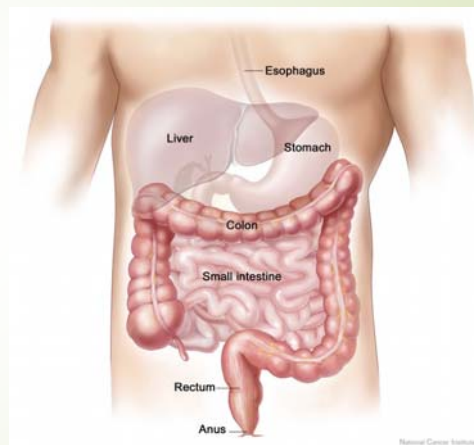
- Most of the carbohydrates that we eat in the diet are **starches**: grains, legumes and starchy vegetables such as potatoes, corn, peas, winter squash and sweet potatoes.
- Starches are **long chains of glucose** that are found in these foods.
- But not all of the starch we eat gets digested.

What is Resistant Starch?

- ▶ Some parts of some food can pass through the digestive tract **unchanged**.
- ▶ In other words, it is **resistant to digestion**
- ▶ This type of starch is called **resistant starch**, which functions kind of like **soluble fiber**
- ▶ Many studies in humans show that resistant starch can have **powerful health benefits**:
- ▶ **Improved insulin sensitivity, lower blood sugar levels, reduced appetite and various benefits for digestion**

What is Resistant Starch?

- ▶ Resistant starch is starch that escapes digestion in the small intestine and that is **fermented in the large intestine**



4 Different Types of Resistant Starch

- ▶ Not all resistant starches are the same. There are 4 different types
- ▶ **Type 1** is found in **grains, seeds and legumes** and resists digestion because it is bound within the fibrous cell walls.
- ▶ **Type 2** is found in some starchy foods, including **raw potatoes and green (unripe) bananas**.
- ▶ **Type 3** is formed when certain starchy foods, including potatoes and rice, are **cooked and then cooled**. The cooling turns some of the digestible starches into resistant starches via a process called **retrogradation**
- ▶ **Type 4** is man-made and formed via a chemical process.

What is Resistant Starch?

- ▶ The classification is not that simple, though, as several different types of resistant starch can **co-exist in the same food**.
- ▶ Depending on how foods are **prepared**, the amount of resistant starch changes.
- ▶ For example, allowing a banana to ripen (turn yellow) will degrade the resistant starches and turn them into regular starches.



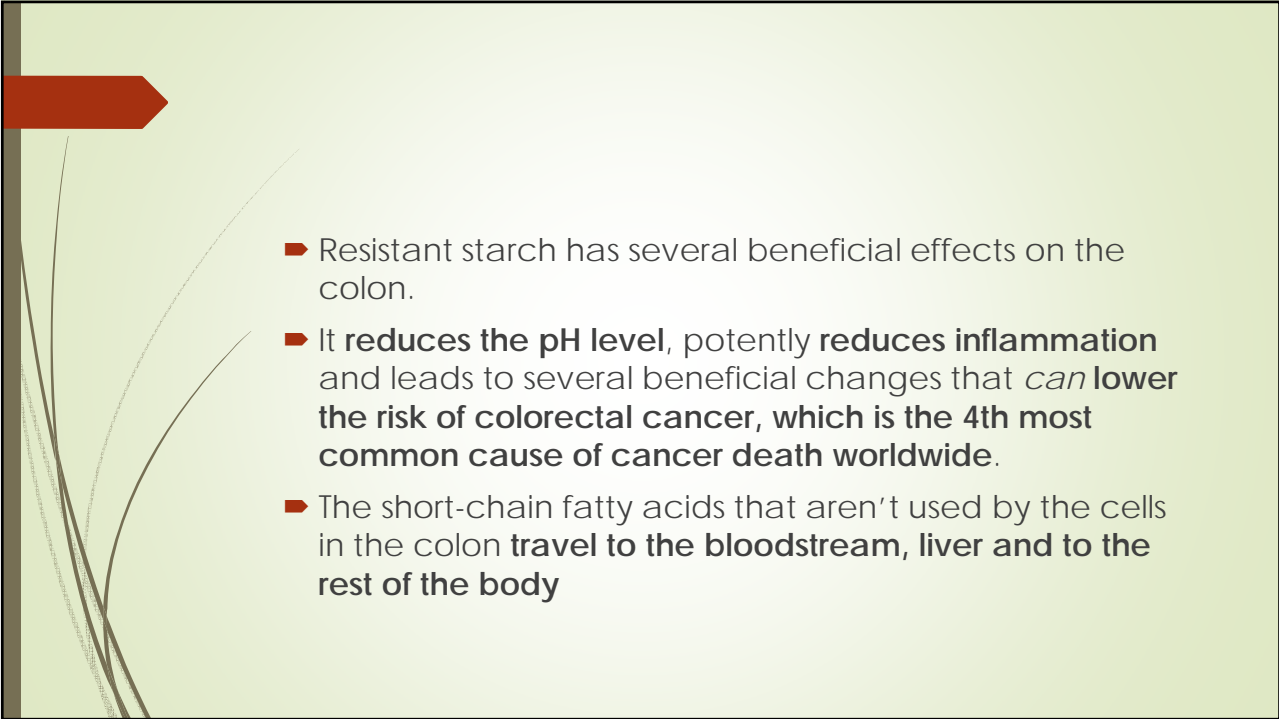
Resistant Starch

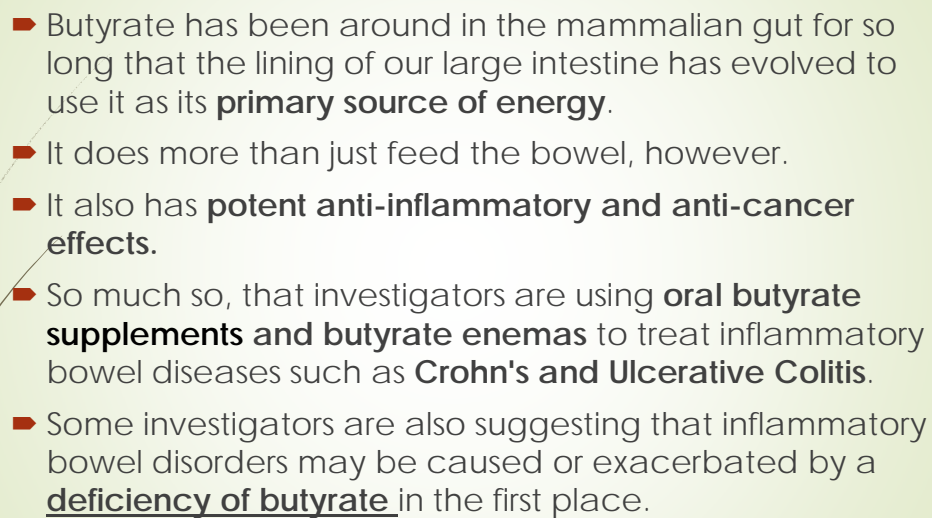
- ▶ The main reason **why** resistant starch works, is that it functions like **soluble, fermentable fiber**.
- ▶ It goes through the stomach and small intestine **undigested**, eventually reaching the colon where it **feeds the friendly bacteria in the gut**
- ▶ Resistant starch feeds the friendly bacteria in the intestine, having a **positive effect on the type of bacteria as well as the number of them**
- ▶ When the bacteria digest resistant starches, they form several compounds, including gases and short-chain fatty acids, most notably a **fatty acid called butyrate**.

Butyrate

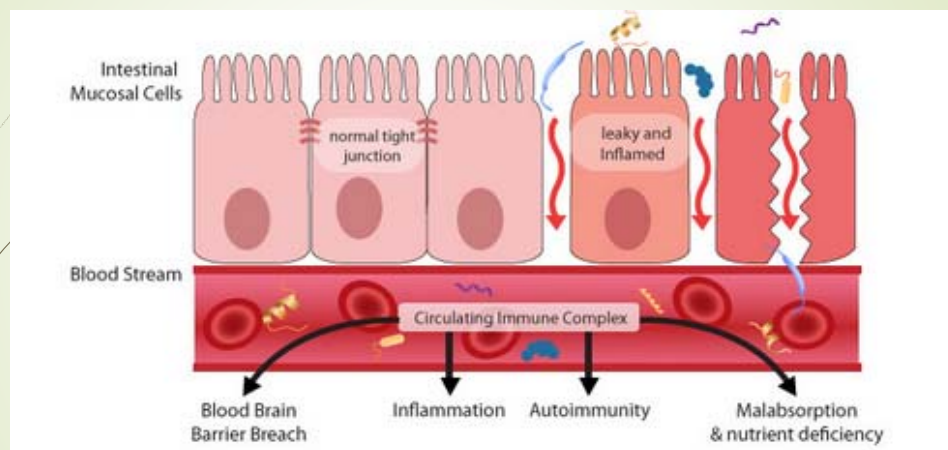
- ▶ Butyrate is actually the **preferred fuel** of the cells that line the colon
- ▶ Therefore, resistant starch both feeds the friendly bacteria and indirectly **feeds the cells in the colon** by increasing the amount of butyrate

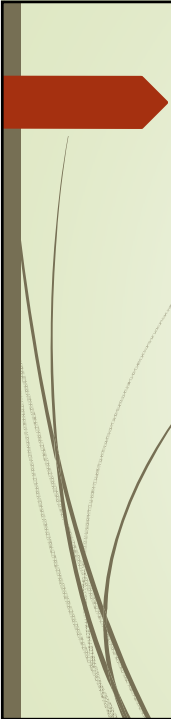


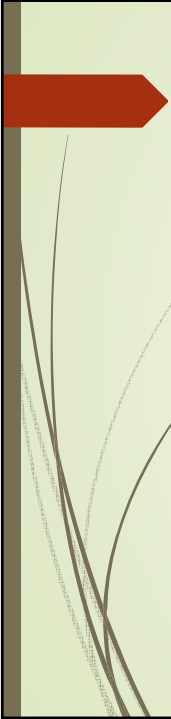
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- ▶ Resistant starch has several beneficial effects on the colon.
 - ▶ It **reduces the pH level**, potently **reduces inflammation** and leads to several beneficial changes that *can lower the risk of colorectal cancer, which is the 4th most common cause of cancer death worldwide*.
 - ▶ The short-chain fatty acids that aren't used by the cells in the colon **travel to the bloodstream, liver and to the rest of the body**

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- ▶ Butyrate has been around in the mammalian gut for so long that the lining of our large intestine has evolved to use it as its **primary source of energy**.
 - ▶ It does more than just feed the bowel, however.
 - ▶ It also has **potent anti-inflammatory and anti-cancer effects**.
 - ▶ So much so, that investigators are using **oral butyrate supplements and butyrate enemas** to treat inflammatory bowel diseases such as **Crohn's and Ulcerative Colitis**.
 - ▶ Some investigators are also suggesting that inflammatory bowel disorders may be caused or exacerbated by a **deficiency of butyrate** in the first place.

- Butyrate, and other short-chain fatty acids produced by gut bacteria, has a remarkable effect on **intestinal permeability**.
- In tissue culture and live rats, butyrate causes a large and rapid **decrease in intestinal permeability**.
- A permeable intestine is **very unhealthy**
- Butyrate, or dietary fiber, prevents the loss of intestinal permeability in rat models of ulcerative colitis.
- This shows that short-chain fatty acids, including butyrate, play an important role in the **maintenance of gut barrier integrity**.
- Impaired gut barrier integrity is associated with many diseases, including **fatty liver, heart failure and autoimmune diseases**



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- ▶ Because of its therapeutic effects on the colon, resistant starch may be useful for various **digestive disorders**.
 - ▶ This includes inflammatory bowel diseases like Ulcerative Colitis and Crohn's Disease, constipation, diverticulitis and diarrhea
 - ▶ Health benefits in the colon or large intestine include **enhanced fermentation and laxation; increased uptake of minerals such as calcium; changes in the microflora composition, including increased (good bacteria) *Bifidobacteria* and reduced pathogen levels; and reduced symptoms of diarrhea**

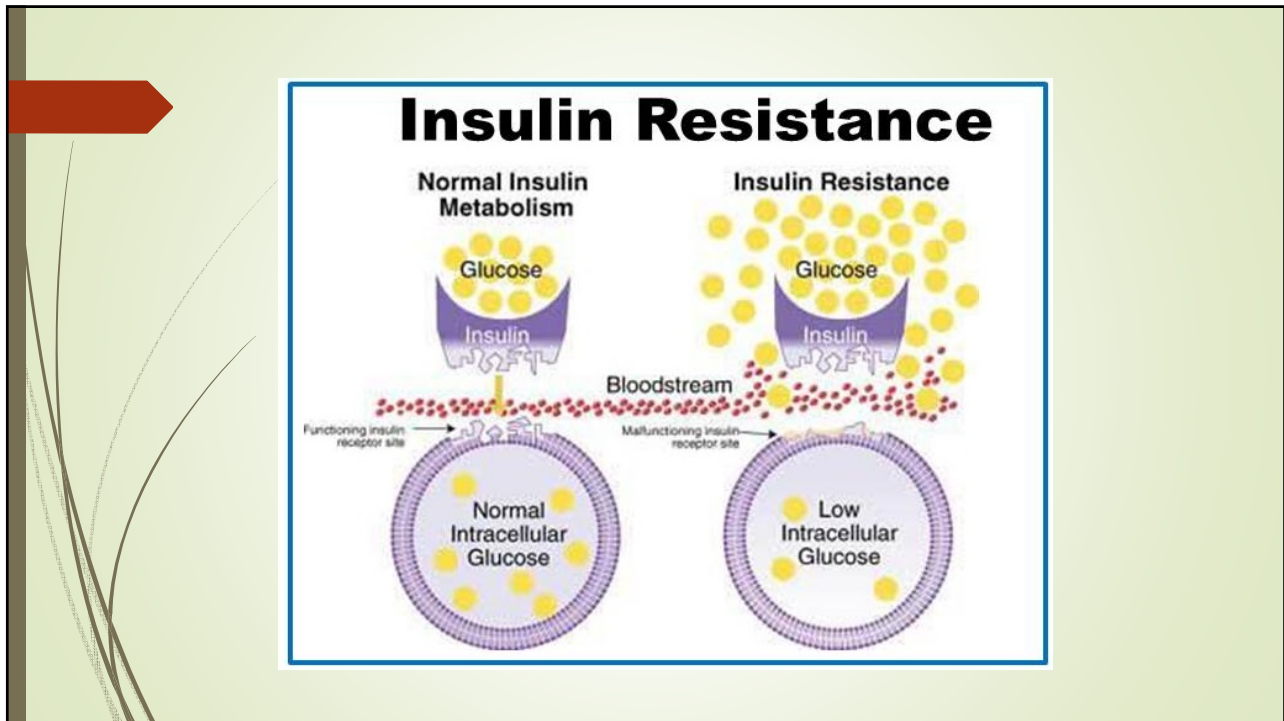
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- ▶ Resistant starch has various **benefits for metabolic health**.
 - ▶ Several studies published in *Diabetic Medicine* show that it can **improve insulin sensitivity** so the body responds better to insulin
 - ▶ Resistant starch is also very effective at **lowering blood sugar levels after meals**
 - ▶ It also has a "**second meal effect**" – meaning that if you eat resistant starch with breakfast, it will also lower the blood sugar spike **at lunch** .
 - ▶ Some studies have found a **33-50% improvement in insulin sensitivity after 4 weeks of consuming 15-30 grams of resistant starch per day**.

Short Chain Fatty Acids

- ▶ Short chain fatty acids, primarily **acetate, propionate, and butyrate**, are produced during resistant starch fermentation.
- ▶ They directly influence the large intestine environment, for example, by **lowering intestinal pH, which inhibits the growth of pathogenic bacteria, increases the absorptive potential of minerals, and inhibits absorption of compounds with toxic or carcinogenic potential.**
- ▶ Short chain fatty acids also **stimulate colonic blood flow, increase tone and nutrient flow, promote colon cell proliferation, and reverse atrophy associated with low fiber diets**

Insulin Resistance

- ▶ Insulin resistance and chronically elevated blood glucose are associated with a host of chronic diseases, including **metabolic syndrome**.
- ▶ Several studies have shown that RS may **improve insulin sensitivity, and decrease blood glucose levels in response to meals**.
- ▶ In one study, consumption of **15 and 30 grams per day of resistant starch** showed improved insulin sensitivity in overweight and obese men, **equivalent to the improvement that would be expected with weight loss equal to approximately 10% of body weight!**



Insulin Resistance



- Insulin resistance is a **major factor in some of the world's most serious diseases, including metabolic syndrome, type 2 diabetes, obesity, cardiovascular disease and Alzheimer's Disease.**
- By improving insulin sensitivity and lowering blood sugar, resistant starch may help to **avoid chronic disease**
- It also means long-term **heart protection**, because chronic **high levels of blood sugar and insulin cause delicate arteries to become clogged and harden.**

- Resistant starch has **fewer calories than regular starch** (2 vs 4 calories per gram).
- The more resistant starches found in a food, the **fewer calories it will contain.**
- Several studies show that **soluble fiber supplements can contribute to weight loss**, primarily by increasing feelings of fullness and reducing appetite
- Adding resistant starch to meals increases feelings of fullness and **makes people eat fewer calories.**



Store Less Fat

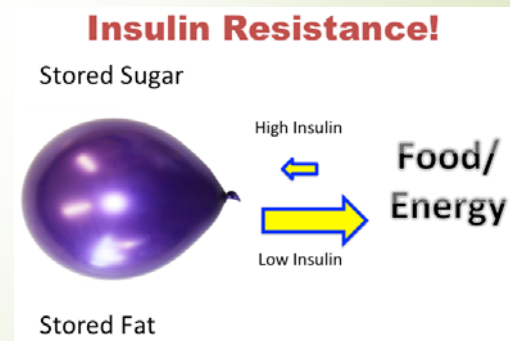
- Resistant starch is **bulky**, so it takes up space in your digestive system.
- And because you can't digest or absorb it, the starch never enters your bloodstream.
- That means it bypasses the fate of **most carbohydrates, which get socked away as body fat when you eat more than you can burn.**



- In one study published in the *British Journal of Nutrition*, 20 healthy adult males consumed either 48 g RS or the placebo divided equally between two mixed meals on two separate occasions.
- There was a **significantly lower energy (calorie) intake following the RS supplement compared to the placebo supplement at both the ad libitum test meal (allowed to eat as much as they want) and over the next 24 hours**
- Post meal plasma glucose concentrations were not significantly different between supplements, but there was a **significantly lower after meal insulin response** following the RS supplement

Insulin is a FAT STORAGE HORMONE

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- Study from the University of Toronto
- 30 men were randomly assigned to receive 1 or 3 cookies once a week for 3 weeks
- Cookies were formulated to contain 100% wheat flour (control) or the Hi-Maize resistant starch ingredient at a low or high dose
- Low dose was 63% wheat flour and 37% hi-Maize
- High dose was 33% wheat flour and 67% hi-Maize flour
- Food intake was assessed after a pizza meal 2 hours after eating the cookie while **blood glucose and appetite** were measured after consuming the cookie and then again after the pizza



- ▶ Results showed that the high-dose hi-Maize resistant starch could **reduce the glucose response by 34% compared to the control!**
- ▶ In another study **reductions in plasma glucose and insulin responses** were seen following meal-based resistant starch intakes of 11.5 g resistant starch whereas post meal **blood glucose and insulin responses in adults with untreated borderline diabetes were lower after eating a meal containing 6 g resistant starch.**

Increased Satiety



- ▶ Animal studies have found that resistant starch prompts the body to pump out **more satiety-inducing hormones.**
- ▶ A meal with resistant starch **triggers a hormonal response to shut off hunger, so you eat less.**
- ▶ Resistant starch fermentation is linked to **satiety**, with increased expression of **genes coding for the satiety hormones** PYY and GLP-1 when rat diets contain RS.
- ▶ Increased concentrations of these hormones were also measured in plasma



Resistant Starch Ups Your Calorie Burn

- ▶ Resistant starch gets fermented when it reaches the large intestine.
- ▶ This process creates beneficial fatty acids like butyrate, which may **block the body's ability to burn carbohydrates.**
- ▶ **"This can prevent the liver from using carbs as fuel and, instead, stored body fat and recently consumed fat are burned,"** explains Janine Higgins, PhD, nutrition research director for the University of Colorado's Adult and Pediatric General Clinical Research Center.



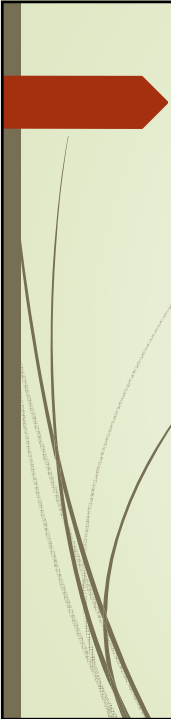
Resistant Starch Ups Your Calorie Burn

- ▶ In your body, carbohydrates are the preferred source of fuel, like gasoline that powers your car's engine.
- ▶ Butyrate essentially prevents some of the gas from getting into the tank, and your **cells turn to fat as an alternative.**
- ▶ One study found that replacing just 5.4% of total carbohydrate intake with resistant starch created a **20 to 30% increase in fat burning after a meal.**

- RS appears to have several beneficial effects that may contribute to weight loss, including **decreased blood insulin spikes after meals, decreased appetite, and decreased fat storage in fat cells.**
- There may also be **preservation of lean body mass**, though further studies in humans are needed to confirm if there is a significant impact in overall body weight



- Research in *Nutrition & Metabolism* 2004
- 12 subjects consumed meals containing 0%, 2.7%, 5.4%, and 10.7% RS (as a percentage of total carbohydrate).
- Blood samples were taken and analyzed for glucose, insulin, triglycerides and free fatty acid (FFA) concentrations.
- Data from indirect calorimetry and oxidation showed that the addition of 5.4% RS to the diet **significantly increased fat oxidation – the rate at which fat is burned**
- Post meal **fat oxidation was 23% greater** with the 5.4% RS meal than the 0% meal over the next 24 hr

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- Comparison of total and meal fat oxidation indicated that **BODY fat stores were the predominant source of fat utilized for energy, contributing approximately 80% of the total fat oxidized, with a much lower contribution from ingested meal fat.**
 - There was no difference in fat oxidation between the 5.4% and 10.7% RS meals so more wasn't better




Decreased Risk of Colon Cancer

- Research shows that the butyrate created by resistant starch may protect the lining of the colon, making it less vulnerable to the DNA damage that triggers diseases, such as colon cancer.
- It can also create a **pH drop inside the colon**, which boosts the absorption of calcium and **blocks the absorption of cancer-causing substances.**
- Resistant starch is associated with **decreased risk of colorectal cancer**, thought to occur through several different mechanisms including: protection from DNA damage, favorable changes in gene expression, and increased apoptosis (programmed cell death) of cancerous or pre-cancerous cells.



How to Add Resistant Starch to Your Diet

- ▶ There are two ways to add resistant starches to your diet... either get them from foods, or supplement with them.
- ▶ Several commonly consumed foods are high in resistant starch.
- ▶ This includes **raw potatoes, cooked and then cooled potatoes, green bananas, various legumes, cashews and raw oats**

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- ▶ You can add resistant starch to your diet without adding any digestible carbohydrates.
 - ▶ Bob's Red Mill Raw Potato Starch.
 - ▶ Raw potato starch contains about **8 grams of resistant starch per tablespoon** and almost no usable carbohydrate.
 - ▶ Add it to your diet by sprinkling it on your food, mixing it in water, putting it in smoothies, etc.
 - ▶ It is important to **start slowly and work your way up**, because too much, too soon can cause flatulence and discomfort.




- Right now, there is no specific target for resistant starch intake.
- Preliminary data shows that the average American consumes about 3-8 g of resistant starch each day.
- Experts believe the research is strong enough to advocate **doubling that at least**
- Adding just 1/2 to 1 cup of cooled resistant starch-rich food per day can do the trick.



How Much Do You Need?

- Intakes of as little as **6 to 12 g resistant starch at a meal** have been observed to have beneficial effects on postprandial glucose and insulin levels
- Resistant starch intakes of approximately **15-30 g/day** (equivalent to two to four tablespoons of potato starch) have been considered necessary to promote benefits in digestive health
- The estimated intake of resistant starch by Americans is in the range of approximately 3 to 8 g per person per day.

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- 15-30 g/day may be too much for some people to tolerate, particularly in the setting of gut dysbiosis, and going above this amount is not necessarily beneficial.

- ▶ Plantain flour and green banana flour are also excellent sources of RS, and there may be benefit to including all three of these sources (specifically alternating your source of RS rather than relying on a single one).
- ▶ These are relatively bland in flavor and can be added to cold or room temperature water, almond milk, or mixed into smoothies. But to maintain the benefits of RS, these **should not be heated above 130 degrees.**



- ▶ Make sure you take green banana flour or potato starch along WITH insoluble plant fibers or cooked resistant starch (eg brown rice, beans, lentils, whole cooked tubers, carrots, 3-5 servings fibrous vegetables or fruit/day)
- ▶ Make sure you are also getting inulin and oligosaccharides (eg onions, leeks, chives, Jerusalem sunchokes, asparagus, inulin supplementation, etc).
- ▶ This will help maintain a good balance in your gut populations.



- If you choose to try supplementing with RS, start with small doses of about $\frac{1}{4}$ teaspoon once daily, and very gradually increase the amount as tolerated.
- Some increased gas and bloating is expected as your gut flora changes and adapts, but you do not want to feel uncomfortable.
- If you experience marked discomfort, then decrease the amount you're taking for a few days until your symptoms resolve, and then try increasing again gradually.

Be Patient

- It may take time (2-4 weeks) for the production of short-chain fatty acids to increase and to notice all the benefits, so be patient.





Keep It Cool

- In cooked starchy foods, resistant starch is created **during cooling**.
- Cooking triggers starch to absorb water and swell, and as it slowly cools, portions of the starch become crystallized into the form that resists digestion.
- Cooling either at room temperature or in the refrigerator will **raise resistant starch levels**.



Hi - Maize

- A growing number of commercial foods have been bolstered with Hi-maize, the brand name of a resistant starch powder made from corn.
- You can use it in baking (and lower calories) by replacing up to one-quarter of traditional flour in any recipe without affecting taste or texture
- King Arthur Hi-maize Natural Fiber, \$5.95 per 12-ounce bag; kingarthurfLOUR.com.
- Or, look for packaged products that include Hi-maize, as another easy way to boost your intake.

Honeyville Hi-Maize at Amazon.com



Adding Resistant Starch to Your Diet

- So what foods can you add to your diet to increase your resistant starch?



Beans

- Snack on chilled pinto bean dip (www.eatingwell.com) with veggies
- Substitute hummus for mayo on sandwiches
- Add black beans to garden salads
- **RESISTANT STARCH: 8 g per 1/2 cup**



Bananas (Slightly Green)

- Slice and mix with yogurt and oats for breakfast
- Dip in yogurt, roll in chopped nuts, and freeze as an ice-cream alternative
- Dice and toss with lemon juice, salt, sugar, and onion to make tangy banana chutney
- **RESISTANT STARCH: 6 g per small**



Potatoes and Yams

- ▀ Serve cold potato salad as a side dish
- ▀ Add chilled, chunked red potatoes to a salad
- ▀ Puree cooked white potatoes to create a chilled garlic potato soup
- ▀ **RESISTANT STARCH: 4 g per 1/2 cup**



Barley

- ▀ Add to chilled lentil salad
- ▀ Mix into tuna, chicken, or tofu salad
- ▀ Sprinkle onto garden salads
- ▀ Make barley risotto, then chill and add to salad or as a side
- ▀ **RESISTANT STARCH: 3 g per 1/2 cup**



Brown Rice

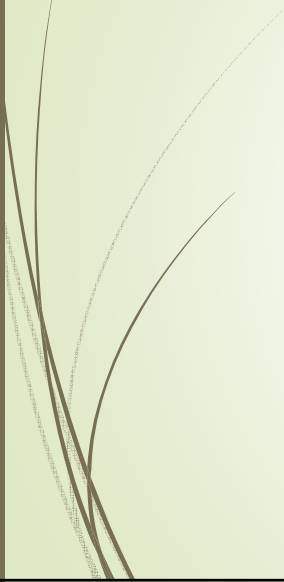
- ▶ Order brown rice sushi
- ▶ Mix chilled brown rice with fat-free milk, raisins, and cinnamon in place of cold cereal for breakfast
- ▶ Add to chilled marinated cucumbers as a side dish
- ▶ **RESISTANT STARCH: 3 g per 1/2 cup**



Corn

- ▶ Add to a taco salad, burrito, or quesadilla
- ▶ Sprinkle into salsa
- ▶ Make fresh corn relish
- ▶ **RESISTANT STARCH: 2 g per 1/2 cup**





Let's Get Cooking!

