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Impact of resistant starch on human health: A review

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Abstract

A kind of carbohydrate known as resistant starch ferments in the large intestine rather than being digested in the small intestine, which enhances its health advantages. Numerous studies have demonstrated that Resistant Starch (RS) can be very helpful in both enhancing the digestive system and controlling blood sugar levels. It also aids in the control of the body's weight imbalance. The RS can provide help in cases of cardio-vascular disease. It occasionally functions as a prebiotic and healthy gut flora. This promotes the synthesis of short-chain fatty acids. It also plays a major part in preserving the dietary control of both type 1 and type 2 diabetes. All things considered, the RS is an important tool for managing and preventing a variety of chronic diseases in the human body.

Keywords: Resistant starch, human health, diabetes

Introduction

Importantly stored in a variety of forms, including grains, tubers, and seeds, starch is the main storage polysaccharide in plants. It is widely distributed in basic foods like wheat, rice, and potatoes and makes up a significant portion of the human diet. However, there is a specific subset of starch called Resistant Starch (RS) (Bojarczuk *et al.*, 2022; Bello-Perez and Paredes-Lopez, 2008) [3, 26]. RS is resistant to digestion and makes it to the colon undigested, in contrast to traditional starches that are broken down in the small intestine. Beneficial short-chain fatty acids (SCFAs) are produced here as a result of fermentation by local microbes. In the context of human nutrition and digestive health, this lecture examines the special qualities and possible health advantages of resistant starch.

Starch and its breakdown products that are difficult for healthy people's small intestines to digest are referred to as resistant starch. It can be purposefully added as an addition to raw or prepared foods, as well as occurring naturally in foods.

Acetate, propionate and butyrate are the main short-chain fatty acids (SCFAs) produced when RS enters the colon and is fermented by gut microbiota members (Bach Knudsen *et al.*, 2018) [5]. Although both propionate and acetate can have an effect on health, butyrate is the SCFA that is most elevated by RS ingestion and has been specifically identified for improving health. Butyrate is important for human gut health because it improves gut barrier function, lowers the incidence of colon cancer, and reduces inflammation. Although it has been demonstrated that RS is one of the best fibres for raising butyrate levels in the general population, it is also evident that not everyone benefits equally, with some people not responding to RS supplementation (Venkataraman *et al.*, 2016) [23]. This implies that variations in individual microbiomes have a significant impact on how RS consumption turns out and calls for further research into the processes of RS digestion and how they result in the generation of butyrate. Furthermore, further research is required to comprehend the consequences of RS consumption on health that go beyond butyrate levels. This review reviews recent breakthroughs in these essential questions for understanding the health advantages of RS (Venkataraman *et al.*, 2016) [23].

Classification

Resistant starch is divided into four categories based on its chemical and physical characteristics. RS1, RS2, RS3, and RS4 in that order.

Table 1: Types of Resistant Starch (Kim *et al.*, 2024; Rosin *et al.*, 2002) ^[13, 27]

Classification	Description	Example of Food
RS1	Physically inaccessible starch	Whole or partly milled grains and seeds
RS2	Raw granular starch	Uncooked potato starch, green banana starch, ginkgo starch, high-amylose maize starch
RS3	Retrograded starch	Cooked and cooled potatoes and cornflakes
RS4	Chemically modified starch	Cross-linked starch and octenyl succinate starch
RS5	Amylose-lipid complexes	Stearic acid-complexed high amylose starch

Health Benefits of Resistant Starch

Boosts gut health. Normal starches break down into glucose when digested. Resistant starches do not break down. As resistant starch ferments in your large intestine, more good bacteria are created, boosting your overall gut health. You'll also get less constipation, lower cholesterol levels, and a lower risk of colon cancer.

Increases sensitivity to insulin. The body's reaction to insulin can be enhanced by resistant carbohydrates. The more sensitive you are to insulin, the more adept your body will be in managing elevated blood sugar levels. As a result, your risk of developing diseases including heart disease, Alzheimer's, and type 2 diabetes will be reduced. Your likelihood of avoiding certain problems is influenced by a variety of other lifestyle choices, your genes, and your access to healthcare. For a detailed approach to reduce your risk, ask your doctor.

Prolongs the feeling of fullness. Your body will expend more energy attempting to break down resistant carbohydrates since they are more difficult to digest. You might eat less because you won't be as hungry, which could be beneficial if you are trying to lose your weight (Bojarczuk *et al.*, 2022) ^[3].

Impact of Resistant Starch Disease

Apart from the elevated butyrate generation, RS has further noteworthy health advantages. RS has a lesser release of glucose due to its reduced digestibility (Shaikh *et al.*, 2019) ^[19]. It has been demonstrated that eating RS lowers post-prandial glucose and leptin responses in people, which lowers the risk of insulin and leptin resistance (Zhang *et al.*, 2019; Stewart and Zimmer, 2017; Sandberg *et al.*, 2017; Maziarz *et al.*, 2017; Stewart *et al.*, 2018) ^[25, 20, 18, 21]. Following RS consumption, there was also an increase in peptide YY (PYY), a crucial gut hormone that may contribute to decreased hunger and food intake (Sandberg *et al.*, 2017; Maziarz *et al.*, 2017; Ble-Castillo *et al.*, 2017) ^[18, 15, 2]. These findings suggest that people who are obese or at risk for type 2 diabetes may benefit. However, in a pre-diabetic population, the STARCH experiment (Peterson *et al.*, 2018) ^[17], which sought to examine the effectiveness of RS supplementation in a long-term double blind, placebo controlled clinical trial, revealed no discernible benefit of RS supplementation. The majority of the studies discussed above have examined healthy people and extrapolated their findings to people with diabetes or prediabetes. The results of the STARCH trial's microbiome research have not yet been released, but it's possible that modifications in the microbiome that occur with the onset of diabetes hinder the body's capacity to respond favourably to resistant starch. According to a recent meta-analysis, resistant starch can reduce low-density cholesterol and total blood cholesterol (Yuan *et al.*, 2018) ^[24]. This relationship is interesting

because, among the short-chain fatty acids, propionate—rather than butyrate—has been linked to preventing the synthesis of cholesterol, and increases in propionate are not typically observed when using RS supplements. The majority of the trials in the meta-analysis involved high amylose corn starch (RS2), but there were also two trials involving pinto beans (An additional source of RS2) and two with retrograded corn starch (RS3). The length of the studies also varied greatly, ranging from as short as two weeks to as long as fifty-two weeks. The longer studies showed greater improvements in cholesterol. The authors hypothesise that the mechanism of action may involve bile salt binding and/or viscosity increases that hinder the binding of cholesterol and triglycerides.

Application & Uses of Resistant Starch

The indigestible part of starch, known as resistant starch (RS), can pass through the small intestine and ferment in the colon. Over the last three decades, our understanding of the origins, applications, and physiological impacts of resistant starch has steadily expanded. However, using components with a high resistant starch concentration in food has just been done in the last ten years, first in Australia and now globally. In addition to staple foods like bread and breakfast cereals, foods made for people with specific physiological or medical requirements, like coeliac sensitivity and ulcerative colitis, or for people trying to control their energy intake, also contain these resistant starch-rich ingredients. Resistant starch has other benefits when compared with traditional sources of dietary fiber in that the preparation and design of foods with additional health benefits have the appearance, taste, and texture characteristics that encourage people to consume these “better for you” foods. As our knowledge of the range of physiological effects that occur through the consumption of resistant starch increases, more applications will be found for their inclusion in an expanding range of foods around the world.

Novel Approaches of Resistant Starch

Studying systems at several levels, such as the genome (Metagenomics), transcript (Metatranscriptomics), protein (Metaproteomics), and metabolome (Metabolomics), is becoming more and more popular in microbiome research. This has also been used in RS research and enables the study of not only the organisms but also the dynamics of the systems involved. Thus, for example, butyrate and butyrate After RS supplementation, forming genes can be quantified. On the other hand, RS supplementation may have hitherto unidentified effects, like connections to lipid metabolism (Maier *et al.*, 2017; Kim *et al.*, 2018) ^[14, 10]. Using isotopically labelled resistant starch to track the metabolic fate *in vivo* is another intriguing strategy. In a mouse model,

this has been done with potato starch (Herrmann *et al.*, 2018; Herrmann *et al.*, 2017) [7, 8], and the results indicate that butyrate is the most common short chain fatty acid with the label. The network of bacteria involved in this processing may be more complex than previously believed, as the bacteria that were most involved in assimilation of the labelled starch were, interestingly, various unclassified members of the Clostridiales and Dorea, rather than the typical bacteria discussed throughout this review that increase in abundance upon RS supplementation. Other technologies that have been used in microbiome research, such as germ-free animal models, gut-on-a-chip systems, and organoids, may also be applied to studies involving RS in the future (Pearce *et al.*, 2018) [16]. These technologies could all offer crucial information about how RS affects the gut microbiome and human health.

Conclusion

Resistant starch is increasingly recognized for its potential as a functional additive in convenience foods, offering health benefits such as improved glucose tolerance, insulin sensitivity, and enhanced post-meal satiety. Despite its promise, resistant starch remains underappreciated and poorly understood in dietary contexts, with insufficient evidence to support its effects on weight or appetite reduction in various populations. Further research focusing on larger cohorts and investigating the impact of food processing methods is essential to fully elucidate its benefits and optimize its utilization in diverse diets and food products for effective disease prevention.

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