Importance of Prebiotic- Resistant Starch in our life

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Abstract: All over the world, scientists and researchers are relentlessly working to provide an effective vaccine against the dreadful Covid19. Nationwide lockdowns to arrest the spread of infection has indirectly led to the development of obesity and various other adverse health conditions among population. In such a scenario, strengthening one's immune system has become highly important. World Health Organisation (WHO) has found convincing evidence on beneficial effects of dietary fibres against weight gain and obesity which are one of the main factors in the development of other comorbidities. One of the best sources of dietary fibres in our daily diet is resistant starch (RS) as it exerts a protective effect on human health. The gastrointestinal tract is colonized by a high density of commensal bacteria and is a major site of pathogen entry and hence requires robust barrier function. The mucosal immune system, located deep within the intestinal epithelium contains upto70% of immune cells of the entire human body. Here, prebiotics like resistant starch - a form of starch resistant to digestion in colonic lumen, stimulates the growth of specific probiotic bacteria beneficial for human health especially *lactobacillus* and *bifidobacteria* species. The fermented products of resistant starch by gut microbes lead to the production of gases, lesser amounts of organic acids, short-chain fatty acids (SCFAs) like butyrate, propionate and acetate etc, of which butyrate is of vital importance. It not only acts as the primary source of energy for the colonocytes but also reduces pH level, acts as the first line of defence against pathogens, exerts a positive effect on the immune system by increasing expression of anti-inflammatory cytokines and decreasing expression of pro-inflammatory cytokines, promotes regulatory T-cells in the colon, regulates stem cell turnover etc. Therefore, reduced butyrate production can lead to various gastrointestinal disorders like irritable bowel diseases, colon cancer, puts the immune system under threat by harmful pathogens, type 2 diabetes mellitus etc. So, inclusion of good dietary sources of resistant starch like oats, cooked and cooled rice and potatoes, raw and ripe banana, legumes, mostly all pasta, maize flour etc. in our daily diet can deliver immense health benefits and promote wellness.

Key Words: Prebiotics, Resistant Starch, Short-Chain Fatty Acids, Immune System.

Introduction

Population with pre-existing comorbidities like diabetes, hypertension, cardiovascular diseases, respiratory issues have been and continue to be the most vulnerable victims of coronavirus infection. [(1)] So, the best people can do to safeguard themselves is to

boost their immunity which protects the body from various harmful pathogens, substances, cell changes and ultimately maintain good health. [2] According to World Health Organisation (WHO) [3], dietary fibres have shown convincing evidence of exerting a protective effect against weight gain and obesity which are the main causative agents behind the development of other adverse ill effects in the body. Resistant Starch (RS) is one of the best sources of fibre available through the diet that has positive effects on human health. The human large intestine harbours a complex microbiota containing many hundreds of different bacterial species which plays an important role in maintaining homeostasis in the body. [4] The main substrates for bacterial fermentation primarily for *lactobacillus* and *Bifidobacterium* species are dietary fibres, resistant starch, inulin, oat bran, wheat bran, cellulose, guar gum and pectin which exerts positive health benefits to host by the production of short-chain fatty acids (SCFAs) mainly acetate, propionate and butyrate which are fermentation metabolites of carbohydrates. [5-6] Some members of beneficial microflora also synthesize valuable vitamins like folate, biotin and vitamin K in our gut.

Resistant starch is defined as a portion of starch that cannot be digested by amylases in the small intestine and passes to the colon to be fermented by microbiota. [7] The gut microflora acts upon these resistant starches and thereby help in boosting host immune system, nutritional status as well as protection against pathogens but this symbiotic relationship when hampered can lead to the development of diabetes, obesity, inflammatory bowel disease, colorectal cancer etc. [8] All these beneficial activities of microbes are dependent on certain factors like our lifestyle, age, gender, diet etc.

The SCFAs thus produced are absorbed by the colonic epithelial cells, pass the portal vein, metabolized by the hepatocytes in the liver and form a link between dietary intake and improved health outcomes. [6] The main butyrate-producing bacteria in the human gut belong to the phylum Firmicutes, [9] whereas production of other SCFAs is mediated by bacteria such as bifidobacterium species during carbohydrate fermentation.

The Physiological Effects Of Scfas :[10-11]

- lowers the pH in the gastrointestinal tract, which in turn reduces the colonization of pathogenic bacteria which is acid sensitive. Lowering of pH also increases ionization of toxic compound thereby reducing their absorption;
- stimulates colonic blood flow and motor activity;
- enhance water and electrolyte absorption;
- stimulate colonocyte proliferation;
- butyrate is a preferred substrate for colonocytes and contributes to the energy needs of the colonic epithelial cell. Acetate and to a lesser extent propionate are absorbed into the system and contribute to energy needs of the host and exert beneficial effects over intestinal epithelial cells (IECs) and immune cells through induction of intracellular or extracellular processes. It is also instrumental in maintaining intestinal homeostasis.
- butyrate enhances DNA stabilization and repair, induces apoptosis in potential cancer cells and thus promote a normal cell phenotype. Butyrate also promotes the epithelial barrier function by production of antimicrobial peptides (AMPs) by IECs as first-line defence effectors against pathogens.

- SCFAs exert anti-inflammatory effects on intestinal mucosa by histone deacetylases inhibition and activating the G protein-coupled receptor (GPCRs) present in IECs and immune cells

All these have a positive effect on intestinal function and health and subsequently whole body.

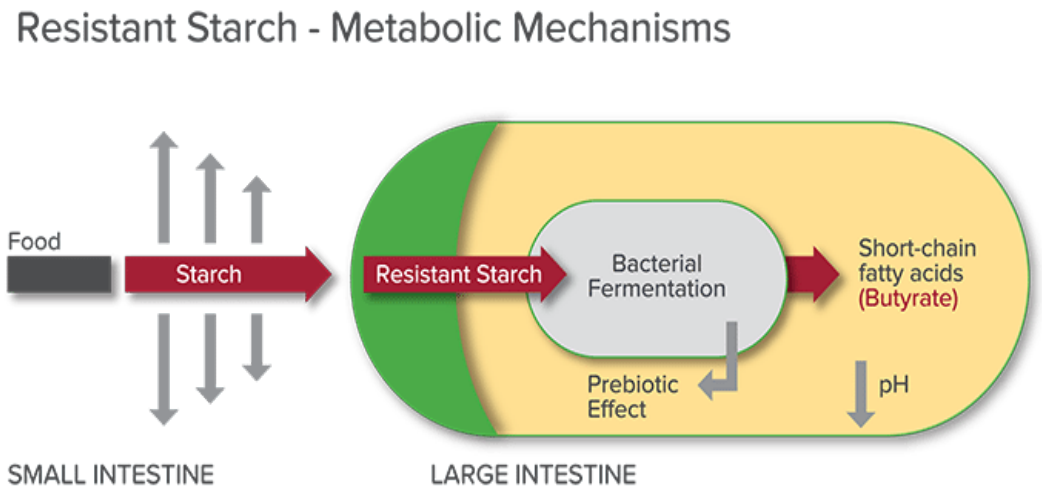
Types of Resistant Starch: [7,12]

There are five types of Resistant Starch (RS):

- RS1: The starch granules are physically enclosed within the cell wall of plants, hence not accessible to digestive enzymes. They are found in seeds, legumes, unprocessed whole grains.
- RS II: These resist digestion due to its crystalline structure. This starch is ungelatinized and cooking reduces the amount of this starch in food. Found in uncooked raw potato, green banana, some legumes like peas, beans, maize flour.
- RS III: This is the retrograded starch primarily found in cooked and cooled starchy food items like potatoes, rice etc. It resists digestion because after cooking the starch molecules associate together again and form a compact structure.
- RS IV: These starches are chemically modified to decrease their digestibility. It finds its utility in bakery items as it imparts desired properties like colour, stability altering viscosity.
- RSV: This refers
- to the amylose-lipid complex that resists amylase digestion. RS V has been found to promote the formation of short-chain fatty acids like butyrate, which can prevent colon cancer.

Source: https://www.thehealthygrain.com/six-facts-about-resistant-starch/

Metabolism of Resistant Starch by Gut Microbiota:



Source: https://www.thehealthygrain.com/six-facts-about-resistant-starch/

People all over are developing interest in Resistant starch due to its associated health benefits. [13] These resistant starches which resists digestion in the upper gastro-intestinal tract serve as food for trillions of microbial species present in the colon and play a major role in host health. The fermented products of resistant starch by gut microbes lead to the production of gases (methane, hydrogen, carbon dioxide), lesser amounts of organic acids (lactate, succinate and formate), short-chain fatty acids (SCFAs) like butyrate, propionate, acetate and valerate, of which butyrate is most important [4,7] and alcohols like methanol and ethanol. SCFAs synthesis is controlled by different factors such as dietary, environmental, microbial factors. The majority of SCFAs in the gut are derived from bacterial breakdown of complex carbohydrates, especially in the proximal bowel but digestion of proteins and peptides makes an increasing contribution to SCFA production as food residues pass through the bowel. [14]

The starch breakdown takes place as follows:

1) starch polymers degrade into glucose;

2) glycolysis with SCFA or other organic acids as end products; and

3) methane, hydrogen and carbon dioxide products of bacterial metabolism of resistant starch.

Butyrate acts as the primary source of energy for the colonocytes, reduces pH level, acts as the first line of defence against pathogens, exerts a positive effect on the immune system by increasing expression of anti-inflammatory cytokines and decreasing expression of pro-inflammatory cytokines, promotes regulatory T-cells in the colon, regulates stem cell turnover etc. [12,15] Resistant starch can increase the production of SCFAs and therefore may help improve colonic health. A lower pH is thought to depress the conversion rate of primary to secondary bile acids and lower their carcinogenic potential, furthermore, a low Ph in combination with high concentrations of SCFA is thought to prevent the overgrowth of pH-sensitive pathogenic bacteria. [16] Reduced activity of certain bacterial enzymes like Beta-glucuronidase depresses the formation of toxic and carcinogenic metabolites from dietary and endogenous compounds. [17] Various forms of RS (chiefly RS2 and RS3) appear to consistently increase faecal output and weight, decrease levels of ammonia and favourably

modulate the activity of bacterial enzymes.RS has been reported to influence immune function, particularly the production of several pro-inflammatory cytokines (eg. tumour necrosis factor-alpha) and the expression of many receptors on T- and -B lymphocytes and macrophages that are required for the initiation of the immune response. [18] RS decreases total cholesterol absorption, to alter the balance of secretion of the hormones glucagon and insulin, to enhance bile acid secretion all these directly affect lipid and glucose metabolism. [12]

PHYSIOLOGICAL EFFECTS OF RESISTANT STARCH ON HUMAN HEALTH: [12]

Potential Physiological Effects	Health Benefits
Improved glycaemic and insulinemic response	Diabetes, impaired glucose & insulin response, metabolic syndrome
Improved bowel health	Colorectal cancer, ulcerative colitis, Inflammatory bowel disease, diverticulitis, constipation
Improved blood lipid profile	Cardiovascular disease, lipid metabolism, metabolic syndrome
Prebiotic and culture protagonist	Colonic health
Increased satiety and reduced energy intake	Obesity
Increased micronutrient absorption	Enhanced mineral absorption, osteoporosis
Adjunct to oral rehydration therapies	Treatment of cholera, chronic diarrhoea
Synergistic interactions with other dietary components, e.g. dietary fibres, proteins, lipids	Improved metabolic control and enhanced bowel health
Thermogenesis	Obesity, diabetes

Health Benefits of Resistant Starch:

A. RS and colon cancer prevention : RS helps the body to resist colorectal cancer through mechanisms including killing pre-cancerous cells and reducing inflammation that can otherwise promote cancer. [19] Improved colon function is associated with increased production of SCFA. Most RS is readily fermentable and a good source of SCFA such as butyric acid.

B. RS and type II diabetes prevention: RS containing foods release glucose slowly resulting in lowered insulin response and greater access to and use of stored fat. This helps in the management of diabetes and impaired glucose tolerance and hence in the treatment of obesity and weight management. [20] Replacement of ordinary starch in foods with resistant starch can be a beneficial lifestyle change for diabetics because of its low glycaemic index. Also, consuming less digestible starches may decrease glycaemic response to a subsequent meal, the "second meal effect". RS helps to reduce diabetic complications especially kidney function and leads to better maintenance of adequate nutritional status, particularly concerning vitamin D.

C. **Satiety and weight loss :** Ingestion of diet high in RS can delay postprandial carbohydrate oxidation and increase satiety in healthy subjects. Delayed hunger after a meal helps in calorie restriction by subjects and thereby maintain or lose weight. [20] Replacing rapidly digestible starch with RS may promote fat mobilization as the result of a reduction in insulin secretion.

D. **RS and Lipid metabolism :**

Replacement of 5.4% of total dietary carbohydrate with RS can significantly increase postprandial lipid oxidation and therefore reduce long term fat accumulation. [20] RS decreases total cholesterol absorption, to alter the balance of secretion of the hormones glucagon and insulin, to enhance bile acid secretion all these directly affect lipid and glucose metabolism. [12]

E. **RS as Prebiotic**

RS imparts great benefits to gut health as it decreases the transit time and increases faecal output. The prebiotic effects of RS consumption are the multiplication of gut-friendly microbial population and lowered activity of certain bacterial enzymes like beta-glucuronidase. A large proportion of the positive effects of RS is exerted by the actions of SCFA. As mentioned earlier, SCFA act as the primary source of fuel for colonocytes, maintain normal colonic functions, regulate colonocyte gene expression, cell cycle and apoptosis and also exert trophic effects on colonic epithelium. Addition of RS to ORS reduced faecal fluid loss and shortened the duration of diarrhoea. These benefits probably stem from the increased absorption of sodium and water. [21]

Potential of Resistant Starch in the consumer market

Increasing health consciousness and rising demand for functional foods by consumers are leading to the development of innovative food products with health benefits and RS is one of them. RS only contributes 1.6-2.5 kcal/gm in comparison to rapidly digestible starches so it is of paramount importance to calorie-conscious people and greatly helps to combat obesity, diabetes, colon cancer etc. adverse health conditions. [22] A daily intake of 12-20 gm of RS through various dietary sources like oats, raw bananas, cooked and cooled rice, maize flour, pasta etc is considered beneficial. [21]

RS can be used in a variety of foods due to numerous desirable properties such as swelling, viscosity increase, gel formation and water-binding capacity. The food industry is successfully using RS in a range of baked and extruded products. [22]

Conclusion

Resistant starch has gained immense popularity due to its unique functional properties and health benefits such as glycaemic control, cholesterol levels, absorption of minerals, colon cancer, obesity etc. Commercial preparations of RS are available in the market and are in high demand due to their low calorific value, organoleptic and textural improvement characteristics. Daily inclusion of RS through readily available food sources can help in overall health and promote wellness.

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