Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(3): 55-58
Received: 28-03-2017
Accepted: 30-04-2017

E Jyoshna
Research Associate (Home Science), Krishi, Vigyan, Kendra, Telangana, India

TV Hymavathi
Professor, Department of Foods and Nutrition, PGRC, PJTSAU, Rajendra Nagar, Hyderabad, India

Correspondence
E Jyoshna
Research Associate (Home Science), Krishi, Vigyan, Kendra, Delhi, India

Review of studies on effect of resistant starch supplementation on glucose and insulin

E Jyoshna and Dr. TV Hymavathi

Abstract
Resistant starch is a type of starch that isn't fully broken down and absorbed, but rather turned into short-chain fatty acids by intestinal bacteria. This may lead to some unique health benefits. The present study is a review study on effect of resistant starch supplementation on glucose and insulin.

Keywords: Resistant starch, glucose, insulin, short chain fatty acids and satiety value

Introduction
Starch is the predominant important component in human diet which contributes 60–70% of the total energy consumed mainly derived from cereals and pulses. Resistant starch (RS) is structure modified starch in terms of ratio and crystalline nature of amylopectin and amylase which resists the digestion. The functional properties of resistant starch are acknowledged for the control of obesity, diabetes and subsequently, for reducing the risk of cardiovascular diseases (Asp, 1997; Morita *et al*. 2005) [2, 19] and in prevention of colon cancer by decreasing the concentration of secondary bile acids, ammonia and phenol content (Birkett *et al.* 1996; Hylla *et al*. 1998) [8, 14] due to the increased short chain fatty acid (SCFA) levels, especially butyric acid produced by the fermentation of RS by the gut microflora in the colon.
Digestion over a 5-7 hours period reduces postprandial glycemia and insulinemia and has the potential for increasing the period of satiety (Raben *et al*. 1994; Reader *et al.* 1997) [24, 25]. RS was reported to particularly affect lipid metabolism based on studies in rats where reductions in a number of measures of lipid metabolism have been observed. In most studies, reductions of up to 22–32% in plasma cholesterol levels and 29–42% in plasma triglyceride levels were noted. Retrograded amylose is responsible for the generation of resistant starch RS3. According to this, the prolonged intake of an amylose-rich diet improves fasting triglyceride and cholesterol levels more than a corresponding amylopectin-rich diet.

Glycemic index of starchy foods
The Glycemic index of starchy foods may depend upon various factors such as the amylose/amylopectin ratio, the native environment of the starch granule, gelatinization of starch, water content and baking temperature of the processed foods. Thus, the factors affecting the GI values are in accordance with those of RS formation. With glucose as reference, reported GI values range from about 10 for starch from legumes to close to 100 in certain potato or rice products and breakfast cereals (Sharma *et al*. 2008) [26]. Thus foods containing RS reduce the rate of digestion. The slow digestion of RS has implications for its use in controlled glucose release applications (Sajilata *et al*. 2006) [27] and therefore, a lowered insulin response and greater access to the use of stored fat can be expected (Nugent, 2005) [20]. This is clearly important for diabetes and has led to major changes in dietary recommendations for diabetics (Cummings *et al*. 2004) [9].
The metabolism of RS occurs 5–7 h after consumption, in contrast to normally cooked starch, which is digested almost immediately. Digestion over a 5–7 h period reduces postprandial glycemia and insulinemia and has the potential for increasing the period of satiety (Raben *et al*. 1994; Reader *et al*. 1997) [24, 25].

Studies on effects of different forms and doses of RS on glucose and insulin
In a study on humans, Reader *et al*. (1997) [25] reported that the consumption of RS3 resulted in lower serum glucose and insulin levels than obtained with other carbohydrates. The study showed that food containing RS decreased postprandial blood glucose and might play a role in providing improved metabolic control in type II diabetes. From a human study, using a commercial RS3 ingredient (CrystaLean), the maximum blood glucose level was found to be

significantly lower than that of other carbohydrates (simple sugars, oligosaccharides, and common starch). Higher glycemic index values have been reported in humans consuming potatoes and cornflakes – foods that contain significant amounts of retrograded starch (Truwell, 1992) [29]. In general, positive effects were usually observed shortly (within the first 2–8 h) after heavy meal (Higgins, 2004) [13].

An RS3-containing bar decreased postprandial blood glucose and could play a role in providing improved metabolic control in type II diabetes (non-insulin dependent) (Sajilata *et al*. 2006) [27]. RS must contribute at least 14% of total starch intake in order to confer any benefits to glycemic or insulinaemic responses (Behall and Hallfrisch, 2002; Brown *et al*. 2003 and Higgins, 2004) [6, 7, 13]. More recently, a study showed that RS reduces levels of glucose dependent insulinotropic polypeptide m-RNA along the jejunum and ileum in both normal and type 2 diabetes rats (Shimada *et al*. 2008) [28].

Chemically-modified starches (RS4) have also been found to generate different glucose responses. The effect of two test meals containing 1–2% acetylated potato starch and beta cyclodextrin enriched potato starch (2–3%), respectively, was studied in humans and only the latter was found to lower body glucose levels. This may be due to the more distal absorption of beta cyclodextrin in the intestine or to delayed gastric emptying (Raben *et al*. 1997) [24].

As RS has a low glycemic response, adding it as an ingredient to foods will help lower the overall GI value of the food (particularly if it is replacing existing readily absorbed forms of carbohydrate). RS is likely to become an increasingly attractive ingredient to many food manufacturers (particularly those of breads and cakes or similar products which traditionally may have had higher GI values) (Nugent, 2005) [20].

Achour *et al.* (1997) [1] studied that postprandial glucose and insulin and satiety response in absorptive and post absorptive states. Study conducted in cross over design of two test meals of high resistant starch and low resistant starch. 50g of porridge consisting of 70% of retrograded amylose resulted that the lowered area under the curve in glucose and insulin during the absorptive state and no difference between glucose and insulin found in post absorptive state of satiety.

Behall *et al*. (1989) [3] studied the diet containing high amylose vs amylopectin starch effect on metabolic variables in human subjects.12 healthy adults of ideal body weight subjects were involved in a cross over design. This study measured the postprandial glucose and insulin responses and glucose and insulin tolerance. Diet containing the 16% of RS2 incorporated in the daily meal supplemented for 5 weeks. This study resulted that amylose load produced lower glucose in first hour and higher at third hour and lower insulin levels in first 2 hours.

Behall and Howe (1995) [4] studied that effect of long term consumption of Amylose vs Amylopectin starch on metabolic variables in human subjects. Study conducted in a cross over design 14 ideal weight and 10 over weight subjects were included in this study 16% of RS2 distributed within the normal daily diet supplemented for 10 weeks. This study resulted that amylose starch load reduced glucose and insulin responses in both normal and overweight subjects.

Behall And Hallfrisch (2002) [6] studied that plasma glucose and insulin reduction after consumption of breads varying in amylose content. 25 healthy ideal body weight adults were included the test meal contains the Rs2 (2, 8, 12 &15%) in breads these containing 30%, 40%,50%,60%,70% amylose. This study resulted that 60-70% amylose breads lowered insulin and glucose response than all other breads.

Behall *et al.* (2006) [6] studied that increases of resistant starch can show the positive result in decreasing the insulin and glucose response in 10 ideal and 10 over weight adults in a cross over study design. controlled diet followed by tolerance test of glucose solution and muffins containing low medium and high resistant starch this study showed that high resistant starch treatment decreased glucose (59%) and insulin (38%) when compared with the low resistant starch treatment.

Behall and Scholfield (2005) [5] studied Food amylose content effects post prandial glucose and insulin responses in 12 healthy ideal body weight and 12 over weight adults. Test meal containing the Rs2 in corn chips (8g) and muffins (24g) in 60-70g of carbohydrate meal. High amylose chips and muffins resulted in lower average insulin and glucose response. Over weight subjects had higher insulin and glucose responses when compared with normal individual.

Kendall *et al*. (2010) [16] studied the effect of a pre load meal containing resistant starch on spontaneous food intake and glucose and insulin response in 22 healthy ideal body weight adults. 5 Test meals consisting of cereal bar and beverage of varying levels of Rs3 (58%, 0%, 5%, 15% and 25%) this study resulted that glucose and insulin Area Under Curve were not different.

Hasjim *et al*. (2010) [15] studied characterization of a novel resistant starch and its effects on postprandial plasma glucose and insulin responses in 10 ideal weight and 10 over weight adults. Study designed as randomized cross over design of 2 test meals consisting of Rs 3 (50g, 37%) in bread it is used as treatment meal and white bread used as control. This study resulted that glucose (55%) and insulin (43%) AUC reduced compared to control mean glucose and insulin concentration were different by treatment.

Li *et al*. (2010) [18] studied postprandial glucose and insulin response in 16 adults of ideal body weight in this cross over design 3 test meals were used those are glucose Resistant starch Rice and white Resistant starch rice. Rs2 (8g 20%) meal showed the reduced glucose and insulin AUC by consumption of resistant starch.

Vanamelsvoort and Weststrate (1992) [30] studied the post prandial glucose and insulin response in 11 ideal body weight and 11 over weight adults. Study conducted as the cross over design test meal used as Rs3 in Rice 65-122g of carbohydrates per meal. This study resulted as glucose lower at 0.5,1 hr and higher 2, 4, 6 hr in the test meal.

Robertson *et al*. (2003) [23] prior short term consumption of resistant starch enhances postprandial insulin sensitivity in healthy subjects. In this study meal tolerance test after 24hr diet with low resistant starch and high resistant starch. The test meal contains Rs2 (100g, 60%) in jelly. This study resulted as glucose and insulin response lower and insulin sensitivity improved after 24hr diet of high resistant starch.

Robertson *et al*. (2005) [22] studied the hyper insulinemic glycemic clamped postprandial glucose and insulin after meal tolerance test.in this study has designed as cross over study 10 ideal weight and 10 over weight subjects were included in this study low and high resistant starch diet (Rs2 50g,60%) mixed in daily meals and supplemented for 4 weeks. This study resulted that glucose and insulin responses are lower after consumption of resistant starch.

Krishna kumari and Thayumanavan (1997) [17] studied that suplimentation of both native starch and treated starch to the 2 group of rats for 2 weeks. The native starch is extracted from rice and five different minor millets, when subjected to five autoclaving and cooling cycles. These are contained higher amount of resistant starch. This study resulted that rats fed with diet both (native and treated starch) had the lowest blood glucose and serum cholesterol and triglycerides than the rice and other minor millets.

De Roos *et al*. (1995) [11] compared daily supplement of 30 g RS2 (highamylose corn starch) to RS3 (retrograded high-amylose corn starch), using glucose as a control. They determined C-peptide excretion as a measure for the 24-hour insulin secretion. They concluded that consumption of 30 g/day RS3 (but not RS2) during one week reduced the insulin secretion.

Carla *et al*. (2011) [10] studied that maize and resistant starch enriched breads reduce the postprandial glycemic response in rats. In this study resistant starch was incorporated in to formulations of breads at 20% of the inclusion rate of wheat and maize flours. 36 rats were divided in to 4 groups and fed either wheat bread, resistant starch wheat bread, maize bread. This study result suggest that maize bread has a lower glycemic index than wheat bread, and the magnitude of the effect of Resistant starch on glycemic response depends on type of bread.

Park *et al*. (2004) [21] resistant starch supplementation influences blood lipid concentration and glucose control in over weight subjects. In this study healthy over weight subjects were fed either 24g/day of resistant corn starch or regular corn starch for 21 days with their regular meals. This study result suggest that Resistant starch supplementation improve the blood glucose levels in healthy over weight subjects.

Raben *et al*. (1994) [24] studied the effect of Resistant starch on postprandial plasma concentration of glucose lipids and harmones and on subjective satiety and palatability ratings. In 10 healthy normal weight young males. Test meal consisted of 50g pregelatinized starch (0%Rs) or 50g raw potato starch (54%Rs) together with 500g artificially sweetened syrup. This study suggest that replacement of digestible starch with resistant starch resulted in significant reduction in postprandial glycemia and insulinemia and in the subjective sensation of satiety.

Yamada *et al*. (2003) [31] studied the inhibitory effect of single ingestion of bread containing resistant starch (60g of Rs). The study was conducted in 20 subjects using the cross over method either bread containing resistant starch is usefull for prevention of life style related diseases such as diabetes mellitus.

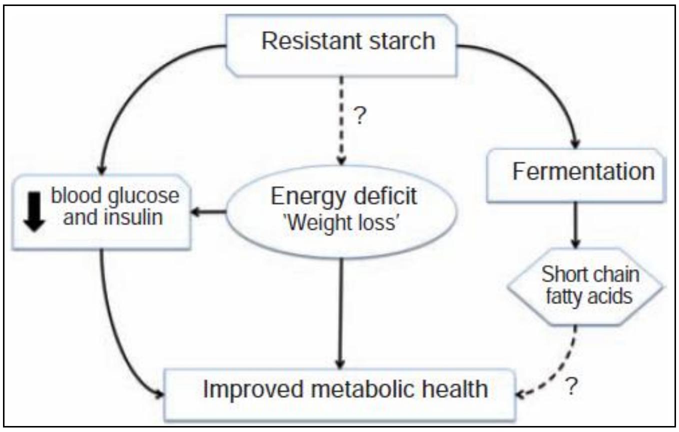

Fig 1: Metabolic benefits of resistant starch

Above figure depicts means through which RS is suggested to elicit metabolic benefits. It has been established that RS decreases blood glucose and insulin, which decreases risk for type 2 diabetes over time. It has, also, been shown to be fermented by gut microbiota, thereby changing the gut ecology and producing products (short chain fatty acids) that have been suggested to improve metabolic health (Johnston *et al*. 2010) [12]

Conclusion

Resistant starch is a type of starch that isn't fully broken down and absorbed, but rather turned into short-chain fatty acids by intestinal bacteria. This may lead to some unique health benefits. To get the most from resistant starch, choose whole, unprocessed sources of carbohydrate such as whole grains, fruits, vegetables, and beans/legumes. The benefits of resistance starch include improved blood fat, better satiety, insulin sensitivity and improved digestion.

References

1. Achour L, Flourie B, Briet F. Metabolic effects of digestible and partially indigestible cornstarch: a study in the absorptive and post absorptive periods in healthy humans. American Journal of Clinical Nutrition. 1997; 66(5):1151-9.
2. Asp NG. Resistant starch-an update on its physiological effects. Advances in Experimental Medicine and Biology. 1997; 427:201-210.
3. Behall KM, Scholfield DJ, Yuhaniak I, Canary J. Diets containing high amylose vs amylopectin starch–Effects on metabolic variables in human - subjects. American Journal of Clinical Nutrition. 1989; 49(2):337-44.
4. Behall KM, Howe JC. Effect of long-term consumption of amylose vs amylopectin starch on metabolic variables in human-subjects. American Journal of Clinical Nutrition. 1995; 61(2):334-40.
5. Behall KM, Scholfield DJ. Food amylose content affects postprandial glucose and insulin responses. Cereal Chemistry. 2005; 82(6):654-9.
6. Behall KM, Scholfield DJ, Hallfrisch JG, Liljeberg-Elmstah. Consumption of both resistant starch and beta-glucan improves postprandial plasma glucose and insulin in women. Diabetes Care. 2006; 29(5):976-81.
7. Brown MA, Storlien LH, Brown IL. Cooking attenuates the ability of high amylose meals to reduce plasma insulin concentrations in rats. British Journal of Nutrition. 2003; 90:823-827.
8. Birkett A, Muir JG, Phillips J, Jones GP, Deak O. Resistant starch lowers fecal concentrations of ammonia and phenols in humans. American Journal of Clinical Nutrition. 1996; 63:766-772.
9. Cummings JH, Edmond LM, Magee EA. Dietary carbohydrates and health: Do we still need the fibre concept? Clinical Nutrition Supplements. 2004; 1:5-17.
10. Carla M, Brites Maria J, Trigo Belmira, Carrapie O, Marcela Alvif A. Maize and Resistant Starch Enriched Breads Reduce Postprandial Glycemic Responses in Rats. Nutrition Research. 2011; 31:302-308.
11. De Roos N, Heijnen ML, de Graaf C. Resistant starch has little effect on appetite, food intake and insulin secretion of healthy young men. European Journal of Clinical Nutrition. 1995; 49:532-541.
12. Johnston KL, Thomas EL, Bell JD, Frost GS, Robertson MD. Resistant starch improves insulin sensitivity in metabolic syndrome. Diabetic Medicine. 2010; 27:391-397.
13. Higgins JA, Higbee DR, Donahoo WT, Brown IL, Bell

ML, Bessesen DH. Resistant starch consumption promotes lipid oxidation. Nutrition and Metabolism, 2004, 1-8.
14. Hylla S, Gostner A, Dusel G, Anger H, Hans PB, Stefan UC. Effects of resistant starch on the colon in healthy volunteers: possible implications for cancer prevention. American Journal of Clinical Nutrition. 1998; 67:136-142.
15. Hasjim J, Lee SO, Hendrich S, Setiawan S, Ai YF, Jane JL. Characterization of a Novel Resistant-Starch and Its Effects on Postprandial Plasma-Glucose and Insulin Responses. *Cereal Chemistry*. 2010; 87:257-62.
16. Kendall CWC, Esfahani A, Sanders LM, Potte RSM, Vidgen E. The effect of a pre-load meal containing resistant starch on spontaneous food intake and glucose and insulin responses. Journal of Food Technology. 2010; 8(2):67-73
17. Krishna Kumari S, Thayumanavan B. Comparative Study of Resistant Starch from Minor Millets on Intestinal Responses, Blood Glucose, Serum Cholesterol and Triglycerides in Rats. Journal of the Science of Food and Agriculture. 1997; 75:296-302.
18. Li M, Piao JH, Tian Y, Li WD, Li KJ, Yang XG. Postprandial glycaemic and insulinaemic responses to GM-resistant starch-enriched rice and the production of fermentation related H-2 in healthy Chinese adults. British Journal of Nutrition. 2010; 103(7):1029-34.
19. Morita T, Hayashi J, Motoi H, Yagishita T, Takeya K, Sugiyama K. In vitro and in vivo digestibility of recrystallized amylose and its application for low glycemic foods. Journal of Food Science. 2005; 70:179-185.
20. Nugent AP. Health properties of resistant starch. British Nutrition Foundation, Nutrition Bulletin. 2005; 30:27-54.
21. Park OJ, Kang NE, Chang MJ, Kim WK. Resistant starch supplementation influences blood lipid concentrations and glucose control in overweight subjects. Journal of Nutritional Science Vitaminol. 2004; 50(2):93-9.
22. Robertson MD, Bickerton AS, Dennis AL, Vidal H, Frayn KN. Insulin-sensitizing effects of dietary resistant starch and effects on skeletal muscle and adipose tissue metabolism. American Journal of Clinical Nutrition. 2005; 82(3):559-67.
23. Robertson MD, Currie JM, Morgan LM, Jewell DP, Frayn KN. Prior short-term consumption of resistant starch enhances postprandial insulin sensitivity in healthy subjects. *Diabetologia*. 2003; 46:659-65.
24. Raben A, Tagliabue A, Christensen NJ, Madsn J, Holst JJ, Astrup A. Resistant starch: The effect on postprandial glycemia, hormonal response and satiety. American Journal of Clinical Nutrition. 1994; 60:544-551.
25. Reader D, Johnson ML, Hollander P, Franz M. Response of resistant starch in a food bar vs. two commercially available bars in persons with type II diabetes mellitus. *Diabetes*. 1997; 46:254.
26. Sharma A, Yadav BS, Ritika. Resistant starch: Physiological roles and food applications. Food Reviews International. 2008; 24:193-234.
27. Sajilata MG, Singhal RS, Kulkarni PR.. Resistant starch – A review. Comprehensive Reviews in Food Science and Food Safety. 2006; 5:1-17.
28. Shimada M, Mochizuki K, Goda T. Dietary resistant starch reduces levels of glucose-dependent insulinotropic polypeptide mRNA along the jejunum–ileum in both normal and type 2 diabetics rats. Biotechnology and Biochemistry. 2008; 72(8):2206-2209.
29. Truwell AS. Glycemic index of foods. European Journal of Clinical Nutrition, 1992; 46:91-101.
30. Vanamelsvoort JMM, Weststrate JA. Amylose-Amylopectin ratio in a meal affects postprandial variables in male-volunteers. American Journal of Clinical Nutrition. 1992; 55(3):712-8.
31. Yamada Y, Hosoya S, Nishimura S, Tanaka T, Kajimoto Y, Nishimura A, *et al.* Effect of bread containing resistant starch on postprandial blood glucose levels in humans. *Diabetologia*. 2003; 46:659-65.