Rice starch's thermal and digestion properties as affected by starch molecular fine structure

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ABSTRACT

A significant staple diet for humans, whole white rice's placement in the digestive tract and rate of starch digestion are both crucial for maintaining good health. The multiscale structure of starch, which goes through order-disorder transitions when rice is cooking, plays a significant role in determining how digestible it is. The features of rice starch's ability to gelatinize are significantly influenced by the length distributions of the amylose and amylopectin chains. The nucleation and crystal growth rates, as well as the intra- and intermolecular interactions during retrogradation, are significantly influenced by the length of the starch chain and the molecular size distribution. A variety of first-order kinetics models have been created to suit starch digestograms, yielding new knowledge on the structural underpinnings of cooked whole rice's starch digestion properties. For the digestion of rice starch in completely gelatinized and retrograded forms, many starch digestible fractions with unique digestion patterns have been discovered, with the digestion kinetics being mostly dictated by starch fine molecular structures. The latest research and directions for furthering our understanding of the starch digestibility in whole cooked rice are outlined, leading to strategies to make whole rice a healthier food by slowing starch digestion.

Key Words: *Whole rice; Resistant starch; Gelatinization; Retrogradation*

INTRODUCTION

For a sizeable portion of the world's population, particularly in Asia and Africa, whole rice serves as their primary source of nutrition. It provides a variety of nutrients, such as protein, fats, and carbohydrates. In rice, starch is the most prevalent nutrient and accounts for more than 40% of the daily energy consumed by people worldwide. Human health depends on how quickly and where starch is digested in the gastrointestinal tract. Rapid starch digestion once it enters the duodenum can significantly alter the postprandial glycemic response, which increases the risk of developing several chronic diseases like type 2 diabetes. On the other hand, starch that is slowly absorbed across the entire digestive system causes a consistent postprandial glycemic response and provides long-lasting energy. In the human upper gastrointestinal tract, there is typically a tiny amount of starch that is resistant to digestion; this starch is known as "Resistant Starch" (RS). When RS enters the colon, the gut bacteria can ferment it to produce metabolites such Short-Chain Fatty Acids (SCFAs). SCFAs can enhance mineral absorption, regulate body weight, and lower blood fat in addition to helping to prevent or minimise a number of intestinal disorders (including diabetes and colorectal cancer). Humans virtually usually ingest whole rice grains after dehulling, polishing, and cooking; however, only a small percentage of individuals include unpolished rice (also known as "brown rice") in their diets. It is crucial for the rice business to develop whole rice or rice-based products with more slowly absorbed starch and higher resistant starch content since it would enhance public health. However, due to what is lost or degraded during dehulling and polishing, cooked polished whole rice grains have suffered a significant degree of starch gelatinization during cooking and also lack a physical barrier to digestive enzymes. Due to the solvation of orthorhombic nanocrystals, the starch in rice experiences order-disorder structural transitions during cooking, which alter the digestion of the starch. Due to the hull and the presence of stable structured structures including lamellae, crystalline areas (with an orthorhombic conformation revealed via XRD), and granules, raw rice starch in a whole grain is intrinsically difficult to digest. Because the starch in a seed will only break down when the plant releases the right enzymes for germination, such as when the seed is in moist soil, these structured structures have developed in nature to store starch. But almost no human civilizations consume a considerable amount of

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unrefined (raw) rice starch in their diet. Because boiling substantially destroys the crystalline structure, cooked whole white (polished) rice has a high Glycemic Index (GI) and little RS. When rice is cooked, it is typically allowed to cool slowly. This causes fully gelatinized starch to transition from an amorphous state to somewhat more ordered structures through intra- and intermolecular interactions, which lowers starch digestibility compared to freshly cooked whole rice. Types 3 (retrograded starch) and 5 (amylose-lipid complexes) RS can also be formed as a result of the retrogradation process. In order to increase the starch's ability to be digested, it is crucial to manage the order-to-disorder structural transitions that occur during the cooking of whole rice.

CONCLUSION

On the significance of starch fine molecular structures in affecting the starch gelatinization, retrogradation, and digestibility of cooked whole rice, many new insights have been gained. In whole rice grains, starch has a complex multiscale structure that transitions from order to disorder structurally when rice is cooked. Rice starch gelatinization capabilities are significantly influenced by amylose chain-length distributions and amylopectin chain length. The nucleation and crystal growth rates, as well as inter- and intramolecular interactions during retrogradation, are influenced by amylopectin and amylose with various CLDs and molecular size distributions.