Impact of Rice Amylose Content on Extrusion Cooking Properties

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Rice (*Oryza sativa* L.) is a major staple food consumed by half of the global population, providing about one-fifth of their daily energy needs (Fukagawa & Ziska, 2019). After harvest, paddy is dried to below 14% moisture, and the husk is removed to obtain brown rice, which retains the nutrient-rich bran layer. The bran is high in dietary fiber, essential fatty acids, vitamins, minerals, and gamma-oryzanol, an antioxidant. Further milling removes the bran, producing polished (white) rice, which enhances texture, cooking quality, and visual appeal (Mohapatra & Bal, 2006). The rice kernel consists mainly of starchy endosperm, rich in carbohydrates, providing 345–370 kCal per 100 grams (Ghanghas, Sharma, & Prabhakar, 2022).

Starch, the main carbohydrate in rice, consists of two primary polysaccharides: amylose and amylopectin. Amylose, a linear polysaccharide with α-(1→4) glucose linkages, has low water solubility and forms a gel upon cooling, making rice with higher amylose content firm and less sticky when cooked. Amylopectin, a branched polysaccharide with α-(1→4) and α-(1→6) bonds, is water-soluble and maintains a soft, sticky texture after cooking (Shoukat et al., 2025). Waxy (glutinous) rice has a higher proportion of amylopectin, making it exceptionally sticky. The ratio of amylose to amylopectin determines the texture, digestibility, and cooking properties of starch-rich foods like rice. Rice is classified into five categories based on their amylose (AM) content: waxy (1–2%), very low AM (2–9%), low AM (10–20%), intermediate AM (20–25%), and high AM (25–33%) (IRRI, 2009) (Fig. 1).

Over the past two decades, food extrusion technology has advanced rapidly, primarily due to its cost-effective ability to produce a wide range of products with desirable texture, size, and shape. Initially used for corn, wheat, and soybean, extrusion cooking expanded in the early 2000s to include rice as a key raw material for cereal-based foods (Kadan et al., 2001). Conventional extrusion cooking is characterized by high-temperature processing with a short residence time. Starch-rich ingredients, especially those with high moisture content, undergo expansion due to the combined effects of shear forces, elevated temperature, and pressure (Chengmei et al., 2011). Extrusion cooking causes both physical and chemical alterations in starch molecules. The intense shear conditions disrupt starch granules, breaking down their molecular structure, especially when amylose content is low. Extrusion facilitates the gelatinization of starch molecules, altering their crystalline structure through partial or complete breakdown. It also induces molecular fragmentation and promotes complex interactions between starch and lipids (Ho & Izzo, 1992). The extrusion cooking of starch-rich rice-based flour has enabled the development of innovative breakfast cereals with enhanced edible quality attributes (Harper, 1981).

The Water Absorption Index (WAI) is widely defined as the dispersion of starch in excess water, serving as an indicator of a flour's water absorption capacity or the swelling ability. WAI reflects the extent of starch gelatinization and swelling capacity. Long-grain rice, known for its high amylose content, produces extrudates with higher WAI values. In contrast, glutinous and black rice, which have lower amylose content, result in extrudates with lower WAI values (Guha et al., 2003). The Water Solubility Index (WSI) is commonly used as an indicator of molecular component degradation and serves as a measure of the extent of starch breakdown during extrusion cooking (Sompong et al., 2011). Amylose, a linear starch polymer, plays a key role in gel formation and molecular entanglement, providing structural resistance to shear.

Glutinous and black rice, with very low amylose content, have higher WSI, indicating greater starch degradation during extrusion cooking. This is due to reduced molecular entanglement in the starch, making it more susceptible to dispersion and degradation under shear forces. WAI and WSI are inversely related; lower amylose content leads to higher WSI (higher starch solubility due to degradation) and, typically, a decrease in WAI (reduced water-holding capacity). Guha et al. (2003) noted that flour with high WSI is ideal for producing ready-to-eat snacks, breakfast cereals, and porridges.

Conclusion

The amylose content of rice significantly influences the efficiency of the extrusion process, impacting the expansion of the extrudate, influencing the texture, and overall quality of the final product. The selection of rice with the right proportion of amylose level is crucial for optimizing extruded rice-based food formulations. Rice with low amylose content produces highly expanded, puffed products as low amylose induce water absorption and enhance starch gelatinization, forming smooth and uniform structures. The lower amylose content also leads to increased starch degradation during extrusion cooking, resulting in softer, crispier extrudates ideal for snacks and breakfast cereals.

High amylose content reduces expansion and creates denser textures by resisting swelling and gelatinization, while its lower solubility further contributes to a more compact structure. It enhances shear resistance, producing firmer extrudates, making it ideal for texturized food applications. Amylose strongly interacts with lipids during extrusion, affecting texture and stability. Higher amylose content enhances these interactions, influencing digestibility and mouthfeel.

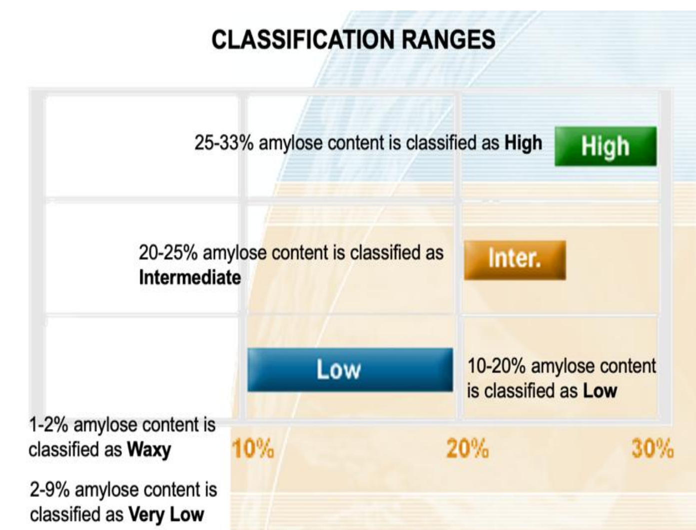

Fig. 1. Image showing the classification ranges of the rice based on amylose content

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