A Comprehensive Review of Possible Resistant Starch in *Getuk*: Its Formation, Health Effects, and Potential Applications as Prebiotics

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Abstract

This review aims to give a thorough understanding of how resistant starch is produced, how it affects health, and how it probably contains in traditional Indonesian snack called getuk. Resistant starch, a type of starch that resists digestion in the small intestine, has drawn a lot of attention. In order to learn more about resistant starch formation in getuk, this review includes a thorough study of the relevant databases, research articles, and scientific literature that is currently available. It explains the effects of various processing techniques, including cooking and cooling on the possible formation of resistant starch in the snack. The potential health implications of resistant starch consumption in getuk are also examined in this review. It has been discovered that resistant starch provides a number of advantages, such as improved glycemic management, prolonged satiety, gut microbiota modulation, increased mineral absorption, and a decreased risk of obesity, type 2 diabetes, and colorectal cancer. The primary cause of these effects is attributed to the fermentation of resistant starch by colonic bacteria, which results in the production of short-chain fatty acids and other bioactive substances. The review looks at Getuk's potential uses as a resistant starch carrier in the creation of functional foods. The snack is a perfect candidate for adding extra bioactive substances such as fiber, and prebiotics to improve its nutritional profile and functional qualities because of its distinctive texture, flavor, and cultural importance. Overall, this review emphasizes the production of resistant starch during processing of getuk and indicates the potential health advantages of its ingestion. It offers insightful information about the importance of this traditional Indonesian snack as a carrier of resistant starch and its prospective uses in the creation of functional meals. To fully utilize getuk as a source of resistant starch in the production of functional foods, additional study is required to optimize processing methods, assess consumer acceptability, and explore novel formulations.

Keywords: *Gelatinization, Getuk, Resistant Starch, Retrogradation, Steaming*

1. INTRODUCTION

Getuk is a thaditional Indonesian food, made from steamed cassava, which is then mashed finely and topped with grated coconut (Lestari, et al., 2014). The nutritional content per serving (70 g) as reported by Lestari, et al., (2014) is as follows: carbohydrates make up 45.92% of the total, protein accounts for 1.79%, fat contributes 1.18%, water 50.07%, and minerals comprise 1.04%. The main component of *getuk* is carbohydrates. Besides cassava (Manihot esculenta), other carbohydrate sources can be used as the main ingredient for *getuk*, such as purple sweet potatoes (*Ipomoea batatas*) (Basuki et al., 2013), chinese yam (*Dioscorea esculenta*) (Koir, et al., 2017), bananas (*Musa paradisiaca*) (Lestari & Susanto, 2015), and *Dioscorea hispida* (Atmaja, 2019).

The process of making *getuk* displays a wide range of techniques across different regions in Indonesia. These techniques encompass variations in the types of sugars utilized, such as granulated sugar, fine sugar, and palm sugar. Some methods involve cold extrusion during production, resulting in *getuk lindri*, while others include frying processes to improve both flavor and shelf life (*getuk goreng*). Furthermore, manufacturers have experimented with crafting *getuk* products in a variety of colors and flavors to appeal to consumers. In essence, the fundamental process of making *getuk* involves steaming a source of carbohydrates, adding sugar, and then mashing and shaping the mixture (Muhami, 2018). Notably, original *getuk* from Magelang, Central Java, boasts a softer texture compared to traditional

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varieties, most likely attributed to the incorporation of solid fats in one of its key ingredients during production.

The potential health benefits of *getuk* are associated with its preparation process, particularly steaming. Modifying the steaming process for *getuk* starch can reduce starch digestibility and increase the level of resistant starch. Resistant starch is defined as a fraction of starch or starch product that resists degradation, making it difficult to be digested and absorbed by the small intestine due to its resistance to amylase enzymes. Consequently, resistant starch can be categorized as a beneficial dietary fiber with advantages such as colon cancer prevention, hypoglycemic and hypolipidemic effects, prebiotic properties, reduction in gallstone formation risk, inhibition of fat accumulation, and enhanced mineral absorption. Foods containing resistant starch can be considered functionally beneficial for the body (Sugiyono, et al., 2009).

The exploration of making *getuk* using various tubers is quite extensive, but the recorded research in this area is very limited. Research in Indonesia primarily focuses on incorporating substitutions to enhance nutritional value, shelf life, and appeal (Ningsih, et al., 2017), (Safitri, et al., 2016), (Chastelyna, et al., 2023) (Basuki, et al., 2013) (Atmaka & Sigit, 2013). This review can offer a fresh perspective on the processing of *getuk*. *Getuk* prepared with variations in steaming, such as autoclaving, has the potential to yield resistant starch. This resistant starch can have prebiotic effects on gut microflora, as it can function as dietary fiber

2. MATERIAL AND METHODS

The method used in the preparation of this review article is a literature study. The literature used consists of journals and books published. The journals obtained are both international and nationally accredited SINTA national journals published online, with an ISSN. Literature searches were conducted using Google Scholar and several journal websites, using keywords such as: "Getuk," "Prebiotic," "Resistant Starch," "Steaming," "Gelatinization," and "Retrogradation."

The selection of the main journal is based on journals that present research results related to *getuk*, especially various manufacturing processes, and modifications of various types of starch in tubers that produce resistant starch. Supporting journals are those that support data from the main journal and literature for this review article.

3. RESULTS AND DISCUSSION

3.1 The Steaming Process of *Getuk* and Gelatinization

The preparation of *getuk* encompasses several stages, including steaming, blending, and shaping. The making of *getuk* is done using the following method: (1) Cassava is washed, peeled, and then soaked in clean water for 24 hours. (2) The cassava is cut into small pieces, then steamed at a temperature of 80 - 100°C for 60 minutes. (3) The steamed cassava is mashed and mixed with other ingredients such as sugar, salt, water, and solid fats (margarine and butter). Steaming, in particular, plays a pivotal role in this process, and the steaming duration can differ according to various sources. Some research suggests a 30-minute steaming period, as documented by Lestari & Susanto (2015), Handayani & Sujiman (2019), and Chastelyna, et al., (2023). Conversely, alternative sources recommend a steaming time ranging from 45 to 60 minutes, as indicated by Basuki, et al., (2013), Atmaka & Sigit (2013), and Aji & Utama (2020). The variance in steaming durations may be attributed to different methods and variations in the production of *getuk*.

The transformation of *getuk* into its signature chewy and elastic texture is primarily attributed to the phenomenon of starch gelatinization, which takes place during the cooking and cooling stages of its preparation. Starch gelatinization is a critical process that profoundly influences the final texture and quality of *getuk*. This transformation is brought about by the interplay of various factors, including heat and moisture.

The gelatinization of starch is a complex molecular process in which the starch granules absorb water, swell, and eventually burst, leading to a remarkable change in their physical properties.

Gelatinization occurs due to the reaction of amylose and amylopectin in starch when exposed to high temperature and high water content. The double helix structure of amylopectin expands and unravels, breaking hydrogen bonds due to the high temperature. Water enters the starch granules, releasing amylose and coating the granules. Water binds to the hydroxyl groups of sugar in amylose and amylopectin, causing the starch granules to swell, resulting in a thick texture (Mailhot, 1988).

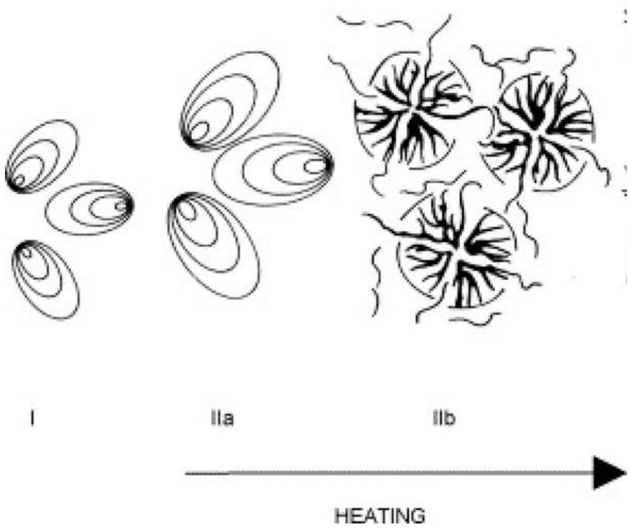

Figure 1. Starch gelatinization process (Wang, et al., 2015)

Food scientists employ advanced tools and techniques to examine the precise occurrence of starch gelatinization. In this context, a widely used instrument is the Rapid Visco Analyzer, which is capable of providing detailed insights into the starch's behavior as it is subjected to controlled heating and cooling cycles (Steffe, 1996). Through this analysis, researchers can better understand the gelatinization kinetics, peak viscosity, and pasting properties of the starch in *getuk*, shedding light on the factors that contribute to its unique texture.

It's important to note that the specific attributes of starch gelatinization in *getuk* can vary based on the type of starch used and its source. Starches derived from different botanical sources, such as tapioca, wheat, and rice, exhibit distinct gelatinization behaviors. Tapioca starch, for instance, typically achieves the highest peak viscosity rapidly but may show lower viscosity upon cooling. In contrast, wheat starch is known for its lower viscosity during the cooking process. Rice starch, on the other hand, takes a longer time to reach its peak viscosity but exhibits higher viscosity during the cooling phase. The choice of starch in the *getuk*-making process can significantly impact the resulting product's texture and quality, highlighting the importance of understanding starch gelatinization dynamics (Imanningsih, 2012; Howling, 1980; Manners, 1968).

3.2 Retrogradation and Resistant Starch

Resistant starch is a fraction of the starch that is not digested in the small intestine and enters the colon unchanged, where fermentation by resident microorganisms occurs, resulting in the formation of short-chain fatty acids (SCFAs) (Bojarczuk, et al., 2022). Resistant starch is divided into five types, depending on the different resistance mechanisms to digestion in the human body. Resistant starch can be analyzed through in vitro starch digestibility by imitation the condition of digestive enzymes. In various starches, studies reported that cereals showed lower resistant starch content compared to potato and legumes with an exception of maize which has slightly higher resistant starch value than potato starch. Legumes which have higher amylose content has been reported to show higher resistant starch content than corn, cereals and tuber starches (Remya and Jothi 2015). Percentage of resistant starch in different source of starch is compared in Table 1. Cassava may not be the highest content of resistant starch, however Katayama, et al., (2011) reported that variety methods of cooking can control the resistant starch levels.

Table 1. Resistant starch content in different various starches

Source	Resistant Starch (%)
Par-boiled rice	2.7±0.09
Wheat	2.7±0.01
Mung bean	5.1±0.19
Banana	3,3±0.00
Cassava (M4)	2.1±1.08
Sweet potato	3.3±0.38
Potato	4.0±0.03

Source: Remya and Jothi (2015)

Retrograded starch is a specific subset of resistant starch (Resistant starch type 3), forms as a consequence of cooling after the gelatinization process in starch-based materials. This transformation is marked by a significant molecular reconfiguration, particularly in the way hydrogen bonds within amylose and amylopectin molecules reestablish themselves. During this process of retrogradation, these bonds reform into a more robust and crystalline structure, creating a notable change in the starch's physical attributes (Haralampu, 2000).

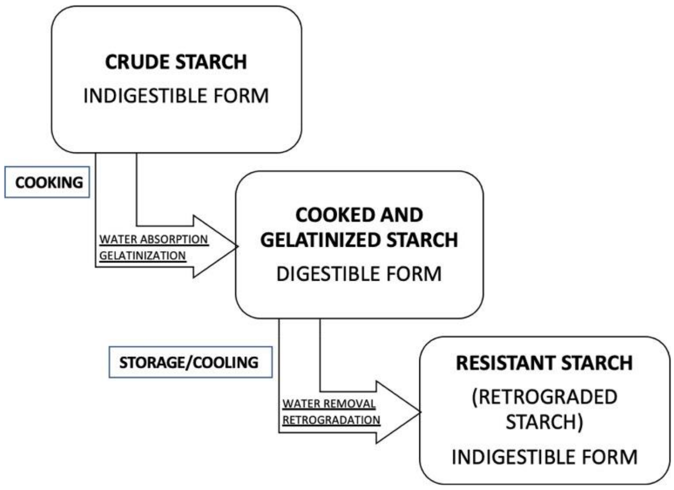

Figure 2. Resistant starch formation from retrograded starch (Bojarczuk, et al., 2022)

Resistant starch, on the other hand, is a broader category encompassing starches that exhibit resistance to digestion by enzymes within the human small intestine. This resistance results from structural alterations in the starch molecules, making them less susceptible to enzymatic breakdown. Resistant starches, although evading digestion in the small intestine, play a crucial role in the large intestine. There, they become substrates for fermentation by the resident gut microflora, ultimately producing short-chain fatty acids. These fatty acids have implications for gut health and can offer various health benefits (Reyes-Moreno & Paredes-Lopez, 1993) (Miksusanti, et al., 2020).

The process of retrogradation is a dynamic one, and its outcome is influenced by various factors. These factors include the number of cycles involving heating and cooling, the ratio of starch to water, the temperature during heating, as well as conditions related to drying and storage (Palguna, et al., 2013). Notably, the ratio of starch to water, or the quantity of water used, is a significant factor affecting the level of resistant starch obtained. A smaller ratio or reduced water content can lead to decreased levels of resistant starch due to the suboptimal completion of the gelatinization process (Sugiyono, et al., 2009).

Interestingly, studies have demonstrated that specific processing steps involving heat, such as heating, steaming, and the subsequent cooling of starch-containing materials, can be employed to deliberately enhance the content of resistant starch in various starch types (Rosida & Yulistiani, 2013), (Zhang, et al., 2009), (Ardhiyanti, et al., 2017). These findings underscore the significance of understanding the dynamics of starch transformations and the controllable factors that can influence the development of resistant starch, which has applications not only in the food industry but also in nutrition and human health. Research in this field continues to provide insights into harnessing the potential of resistant starch for beneficial purposes, both in food products and for its impact on gut health.

3.3 Resistant Starch as Prebiotics

Resistant starch serves a vital role as a prebiotic, acting as a substrate source for the microflora in the large intestine. This prebiotic function arises from its ability to function as a dietary fiber, as indicated by studies such as Hedemann & Knudsen (2007) and Sunarti (2018). Resistant starch can effectively influence the composition of the microbiota in the large intestine. Notably, the type of resistant starch plays a role in shaping the microbial balance. Type B starch (resulting from heat processing) stimulates the growth of *Bifidobacterium spp.,* while Type A starch (raw starch) induces the growth of *Atopobium spp* (Vieira, et al., 2013).

The retrogradation process, characterized by cooling after heating, plays a crucial role in the prebiotic activities of starch. For instance, in the case of corn starch, retrogradation over a 3-hour period has been shown to exhibit higher prebiotic activity for *B. Longum* and *L. Plantarum* compared to retrogradation over 0-2 hours (Interpares, et al., 2015). In another example, starch from banana, when subjected to autoclaving followed by retrogradation, displayed higher prebiotic activity compared to commercially available FOS (fructooligosaccharides), especially concerning three potential probiotic candidates: *L. acidophilus*, *L. plantarum sa28k*, and *L. fermentum 2B4* (Putra, 2020).

Furthermore, butyrogenic genera present in the human large intestine have the capability to ferment resistant starch, leading to the production of short-chain fatty acids (SCFA) like acetic acid, propionic acid, and butyric acid. These SCFAs are known to possess anti-carcinogenic properties, making them beneficial for gut health (Lesmes, et al., 2008) (Kamada, et al., 2013) (Prado-Silva, et al., 2014). The role of resistant starch in promoting the growth of specific beneficial bacteria and the production of health-promoting compounds like SCFAs underscores its importance not only in the context of nutrition but also for its potential contributions to overall well-being and disease prevention.

4. CONCLUSIONS

The process of making *getuk* involves steaming cassava for a long time, and cooling occurs when the ingredients are mixed to form a chewy texture. In the process of making *getuk* it is suspected that starch retrogradation occurred which caused *getuk* to contain resistant starch. Resistant starch is proven to increase the prebiotic activity of processed food. Optimization of processing *getuk* through the variation of cooking such as autoclaving can lead the *getuk* processing to produce resistant starch. *Getuk* with high resistant starch has the possibility to give health benefits as prebiotics.

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