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Effect of Resistant Starch from Green Banana Flour on Sensorial Properties of Noodles

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ABSTRACT
Starch, a complex carbohydrate found in plants, plays an important role in human and animal nutrition. It comes in a variety of forms, including resistant starch, slowly digestible starch (SDS), and digestible starch (RDS). Resistant starch offers numerous health benefits. Resistant starch fermentation results in short-chain fatty acid production, benefiting the body by reducing cholesterol, inhibiting pathogens, and nourishing colon cells. Innovations in starch processing, like green banana flour, have expanded starch's applications in the food industry, enhancing its nutritional value. In noodle production, wheat flour can be substituted with green banana flour to provide a healthier and safer alternative. Numerous aspects were examined in the research, including dough characteristics, texture, cooking quality, sensory evaluation, and glycemic index. The findings revealed changes in dough properties, texture, and cooking quality when resistant starch sources were incorporated. This might lead to the production of low-glycemic, healthier food items without compromising sensory attributes.

KEYWORDS: *GBF, noodles, resistant starch*

HIGHLIGHTS
- Innovation in starch processing, such as green banana flour in noodle production is explored for potential health benefits.
- The research analyzes the impact of these substitutions on dough properties, texture, quality cooking, sensory evaluations, and glycemic index of noodles.
- The comprehensive review is based on systematic literature analysis revealing insights into the benefits and challenges of incorporating resistant starch sources.
- Green banana flour and resistant starch affects the textural characteristics of dough, as well as color and cooking loss.
- Additional of up to 10% GBF may decrease glycemic index while maintaining quality and sensorial properties of the noodles.

INTRODUCTION
Starch is a complex carbohydrate polymer abundant in plants, particularly crops. Made up of glucose units connected by alpha 1,4 and beta 1,6, amylose and amylopectin make up this compound. This macromolecule serves an important function since both humans and animals depend on starch as a source

of nutrition and energy (Apriyanto et al., 2022). In the human body, starch is mainly hydrolyzed to simple sugars such as glucose for simpler digestion. However, not all types of starch can be hydrolyzed in the human body. Based on their digestibility, there are three kinds of starch, namely, digestible starch (RDS), slowly digestible starch (SDS), and resistant starch. RDS is digested by enzymes and converted to glucose in 20 minutes, thus rapidly increasing blood glucose, while SDS is digested fully and converted to glucose in 20 - 120 minutes. On the other hand, the human digestive system is unable to break down resistant starch and absorb it in the small intestine due to its resistance to digestive enzymes for up to 2 hours (Polesi et al., 2017). The form is unchanged as it enters the colon and is fermented by gut microbiota, producing hydrogen, methane, and short-chain fatty acids.

Short-chain fatty acids, such as acetate, propionate, and butyrate, may benefit the human body by reducing cholesterol and triglycerides, as well as reducing the rise of blood glucose. Propionic acid and acetic acid may help in decreasing pH in the digestive system, which could contribute to the inhibition of pathogenic microbes, while at the same time increasing the number of beneficial microbes rapidly (Shen et al., 2017). During fermentation in the large intestine, resistant starch also stimulates bacteria to produce butyric acid which nourishes the epithelial cells in the colon, and inhibits proliferation of cells which could lead to colon cancer. Additionally, due to the indigestible characteristics, resistant starch may increase bowel movement and accelerate transit time in the intestines which is one of the preventive measures for colorectal cancer (Bojarczuk et al., 2022).

Since starch resides in various plants, it can be processed into different kinds of flour by the source of the carbohydrate itself. For instance, tapioca can be processed to make tapioca flour (Pratama & Saragi, 2018). However, as time went by, various innovations in starch had developed in the food industry. One of the promising innovations is green banana flour, which is made using green bananas. When bananas are green and mature, their flesh consists of 70–80% starch, the majority of which is resistant starch. This makes bananas an excellent source of starch (Marta et al., 2022). Resistant starch is often utilized as an alternative in wheat products since it provides several health benefits and does not have a significant impact on the sensorial properties of food. Noodles usually contain wheat flour that is not suitable for consumers with specific conditions such as coeliac disease and gluten intolerance (Patty et al., 2023). Therefore, several approaches were made in order to provide an alternative, including substituting flour utilized in the production of the noodles. The application of resistant starch on several food products has been researched in previous studies, however, never before has it been applied on salted noodles. Therefore, different formulations of GBF incorporation are produced and observed for their glycemic index, characteristics, and quality.

METHODOLOGY

This review employs a systematic literature review approach. By systematically gathering and evaluating relevant journals, to deliver an impartial and all-encompassing analysis of the subject matter. The data sources for this review include academic databases such as PubMed, ScienceDirect, and Google Scholar. The search strategy required the use of a combination of keywords and controlled vocabulary related to “green-banana flour”, “noodles”, and “resistant starch”. The most relevant articles and reports were filtered using inclusion and exclusion criteria. Data extraction entailed classifying and summarizing data from multiple sources. The data were analyzed using content analysis, identifying, and emerging patterns in the literature.

DISCUSSION

Farinograph characteristics

A farinograph is a laboratory tool used to measure the rheological qualities of dough, which are an important factor in how well the dough performs when baked. The farinograph measures the rheological properties of dough by imparting mechanical energy to it using its kneading arms and measuring the force exerted by the dough throughout the kneading process(Tamba-Berehoiu et al., 2018). The addition of resistant starch may enhance the dough's mixing behavior significantly since it highly impacts the water absorption in the dough (Ansari et al., 2022). The difference in water adsorption could be attributed to the resistant starch's abundance of hydroxyl group, which allows for increased water adsorption via hydrogen bonding (Noor et al., 2021). This contributes to dough elasticity, consistency, and rate of fermentation which happens more effectively in softer dough compared to dry ones.

Several aspects such as breakdown time, dough development time, stability, and peak time values can be used to evaluate the dough strength. A dough is considered to have better strength and stability when it takes a longer time to develop and break down (Shyu et al., 2018). However, an addition of more than 20% of the resistant starch sources may cause a decline in the stability and breakdown time of dough. This impact could be attributed to the reduced gluten content, which gives the dough its viscoelastic properties and stability (Ansari et al., 2022). Another parameter used to assess the stability of the dough is the mixing tolerance index (MTI), which measures the dough's resistance to breakdown during mixing. Low MTI and high stability of the dough define its tolerance towards mixing (Madhvi & Hemlata, 2015).

Extensograph Measurements

The presence of resistant starch flour and gluten-free flour (GBF) has affected the dough's physical and textural properties, according to the extensograph measurements and texture profile studies, which provide thorough knowledge (Li et al., 2022). As the concentration of composite flour used increased, maximum resistance to extension rose, pointing to improved dough strength. However, as the amount of GBF increased, the dough's extensibility dropped. The binding structure of the dough decreased when resistant starch sources were used in place of wheat flour. This indicates that the addition of GBF significantly enhanced the material's hardness, gumminess, chewability, and shearing force (Murthy et al., 2014). In addition, this shows that changes in starch-gluten interactions may have caused the dough to become thicker and more cohesive. It's crucial to remember that the drop in springiness indicates a decrease in elasticity. These results are consistent with earlier studies on the effect of gluten-free flours on the texture of Noodle dough (Liu et al., 2018). Collectively, these findings imply that the addition of GBF transforms the textural characteristics of the noodles, making them harder and less springy, possibly as a result of variations in starch properties and gluten concentration (Li et al., 2023).

Texture, Color, and Flavor

The utilization of various types of flours can affect the texture of noodles as they have different types of composition in the flour. Several factors, such as starch, protein, and gluten concentration can determine the overall texture of noodles (Fukuzawa et al., 2016). Hence, the physicochemical properties of several products made with green banana flour can be significantly different compared to other types of flour. According to Yu et al. (2020), konjac-green banana noodles that were made using a higher concentration of GBF increased in firmness and elasticity after being cooked. Furthermore, according to Agama-Acevedo et al. (2009), the adhesiveness and chewiness of the noodle also increased with the higher banana flour concentration. The increase of firmness could be attributed to the gluten-free properties of green banana flour. Gluten helps create texture in the noodles by strengthening protein networks and tightly wrapping starch granules to generate denser and better protein starch granules with fewer holes (Yao et al., 2020). Without the gluten to impart the chewiness to the noodles, the noodle made using GBF will turn less elastic and hard (Yu et al., 2020). Noodles that are incorporated with green banana flour as a resistant source may exhibit a distinct brown color compared to the commercial wheat noodle. A similar research done by Fida et al. (2020) reported a slightly brown color in the final product when using green banana flour compared to regular wheat flour. This brown color could be attributed to the enzyme-induced browning of the green banana during the sample preparation and making of the product as a result of exposure to open air and heat. Despite the changes in texture and color, the incorporation of green banana flour as a resistant starch source does not affect the flavor of the noodles negatively. A study conducted by Anggraeni & Saputra (2018) showed that substituting flour with unripe banana flour by 20% remarkably increased the acceptability of noodles.

Cooking Quality

The amount of green banana flour incorporated may affect the dough quality in terms of cooking loss. Cooking loss defines the degree of shrinkage due to water leaching out during the cooking process. In noodle making, a low cooking loss indicates better quality since the dough is less brittle and does not break down easily when boiled (Rauf & Muna, 2018). A small amount of the starch in the noodles is released during cooking, which results in cooking loss. This produces turbidity in the water during cooking when the starch is suspended. Noodles made using a higher concentration of green banana flour experienced an increase in the water adsorption rate and solid loss value which measure the solid cooking loss of a sample (Anggraeni & Saputra, 2018). This strongly indicates that with the increase of GBF concentration, the cooking loss will be increased. The cooking loss is caused by the decrease of gluten concentration in the noodles as less wheat flour is used. A dense gluten network produces a strong adhesive connection with starch granules, allowing them to stick together. This interaction protects against starch leaching throughout the cooking process (Cao et al., 2021). However, adding a certain amount of resistant starch, in this case, green banana flour, up to 10% does not negatively affect the cooking quality of noodles significantly (Li et al., 2022).

Starch Digestibility (In Vitro) and eGI

Determining the physiological effect of adding green banana flour requires investigating the complexities of starch digestibility using vitro tests, such as the Englyst method (Abebe et al., 2015). These techniques enable the analysis of how different flours, in this case, GBF, influence the rate at which starch breaks down. Knowing the estimated glycemic index (eGI) is essential for assessing the possible health effects of noodles fortified with resistant starch derived from green banana flour since starch breakdown greatly affects postprandial glucose levels. The complex carbohydrate starch is digested to produce glucose, which affects a food's glycemic response. A measure used to quantify the postprandial blood glucose response to a given carbohydrate intake is called the glycemic index (GI) (Augustin et al., 2015). The estimated glycemic index (eGI) is especially useful for assessing how the resistant starch from green banana flour might affect the noodles that are being studied. The ability of resistant starch to lower the glycemic response has drawn attention, despite its reduced digestibility in the small intestine. Adding resistant starch-rich green banana flour to noodle recipes can change the product's total glycemic index. This modification is explained by resistant starch's capacity to withstand enzymatic digestion, which causes a delayed release of glucose into the bloodstream. The utilization of in vitro starch digestibility assays can clarify the ways in which the inclusion of green banana flour impacts the rate at which starch breaks down during the digestive process. This information, which shows how quickly carbohydrates—especially starch—are absorbed and transformed into glucose, is crucial for forecasting the possible glycemic effect of the noodles (Wang et al., 2023).

CONCLUSION

Starch, an essential energy source derived from plants, consists of amylose and amylopectin. However, not all starches are easily digestible. Resistant starch, which the body cannot digest in the small intestine, presents potential due to its unique properties. Green banana flour (GBF), made from resistant starch-rich green bananas, has become an intriguing addition to noodles. Various analyses like farinograph, extensograph, texture assessment, sensory evaluation, and glycemic index determination were utilized. Farinograph results reveal that adding GBF boosts dough elasticity but reduces stability in large quantities. Extensograph tests show higher GBF increases dough strength but decreases its flexibility, resulting in harder and less elastic noodles. When GBF is used, noodles exhibit textural changes like increased hardness, slight browning, and consistent taste. Cooking quality alterations include increased water absorption and loss during cooking due to reduced gluten from more GBF. In the in vitro tests and glycemic index evaluation, GBF changes starch breakdown, affecting how quickly glucose enters the bloodstream after meals. Moreover, GBF affects starch digestion, potentially impacting glucose release after meals, which can influence its health implications. However, further research is needed to thoroughly investigate the benefits and specifically the drawbacks of using banana flour to make other types of products to fully investigate its capability to qualify as an excellent resistant starch.

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