

Physicochemical and Pasting Properties of Raw Hom Thong Banana (*Musa sapientum* L.) Flour from Northern Thailand

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ABSTRACT

Growing interest in functional foods has increased the demand for alternative flour sources rich in resistant starch and dietary fiber for application in starch-based food products. Raw banana flour has attracted attention as a potential functional ingredient due to its favourable nutritional and physicochemical properties. The aims of this study were to determine proximate composition and pasting properties of raw Hom Thong banana flour (RBF). Hom Thong bananas (*Musa sapientum* L.) from Mae Taeng community, Chiang Mai Province, Thailand were processed into flour by hot-air drying at 60 °C and analyzed for the proximate composition and Rapid Visco Analysis (RVA) properties. The results showed that carbohydrate was the major component of the flour (86.82±0.18 g/100 g) followed by protein (4.20±0.28 g/100 g), ash (2.92±0.10 g/100 g), dietary fiber (2.53±0.14 g/100 g) and fat (0.30±0.05 g/100 g), whereas the moisture content was comparatively low (3.23±0.03 g/100 g) suggesting good storage stability. The RVA results revealed that the raw banana flour has different pasting properties compared to the conventional wheat and cassava flours. Banana flour showed moderate peak viscosity (213.05±16.17 RVU), high trough viscosity (191.35±10.25 RVU), low breakdown viscosity (63.75±1.13 RVU), high final viscosity (283.86±23.27 RVU) and relatively high pasting temperature (84.57±0.93 °C) indicating good thermal stability, limited swelling of the starch granules and strong gel-forming capability. These properties suggested that RBF possesses desirable physicochemical and functional characteristics for noodle processing applications. The physicochemical and pasting properties observed in this study suggested that RBF may be suitable application as a partial substitute for wheat flour in noodle or pasta formulations.

Keywords: Hom Thong banana flour, banana flour, pasting properties, Rapid Visco Analysis, physicochemical properties

INTRODUCTION

In the last several years, the demand for healthy carbohydrate-based meals has expanded dramatically, due to the increased consumer knowledge of the association between nutrition and chronic non-communicable diseases, including as obesity, diabetes and cardiovascular problems (Baptista *et al.*, 2024). Therefore, the food sector is increasingly interested in developing functional noodle products loaded with dietary fiber, resistant starch and bioactive substances. The strategy of incorporating alternative plant-based flours into traditional wheat-based noodle systems has been reported as an effective way to improve nutritional quality while keeping desired physicochemical and processing qualities (Kim *et al.*, 2021).

Recently, unripe banana flour has attracted much attention as a functional food ingredient due to its high resistant starch, dietary fiber, minerals and bioactive phytochemicals (Shini *et al.*, 2024). Unripe banana is rich in resistant starches, especially the type II resistant starch (RS2), which has compact crystalline structures and is resistant to enzymatic hydrolysis in the small intestine (Zhang *et al.*, 2005). Resistant starch is therefore fermented in the colon to produce short-chain fatty acids which can improve gastrointestinal health, modify the glycemic response and favor the enrichment of gut microbiota (Dong *et al.*, 2025). Furthermore, green banana flour has been revealed to have high amylose content, low digestibility and unique starch granule architectures responsible for its physicochemical and functional features in food processing (Kumar *et al.*, 2019).

Hom Thong banana is one of the most economically important cultivars among banana cultivars planted in Thailand and widely grown in many agricultural areas such as Mae Taeng district, Chiang Mai Province. The use of unripe Hom Thong banana for flour manufacturing might be an alternate option to add value to local agricultural resources and to avoid postharvest losses. Moreover, the conversion of surplus or underutilized bananas into flour products is in line with contemporary trends of sustainable food production and bio-circular economy development.

Kanoklerdrit (2022) investigated the development of noodle products supplemented with banana flour as a partial replacement for wheat flour. The study found that noodles containing Hom Thong banana flour received higher consumer acceptance scores than those prepared with Namwa banana flour. The formulation containing 40% Hom Thong banana flour substitution showed the highest overall acceptability. Banana flour is rich in dietary fiber, which can affect the textural properties of noodle products. Increasing the substitution level beyond 40% resulted in a firmer and coarser texture, leading to lower consumer acceptance.

The incorporation of banana flour and other plant-based flours with similar functional properties, such as whole-grain flours, has gained increasing attention in recent years due to their potential to enhance nutritional value and support the development of functional food products. Such ingredients can increase dietary fiber content and contribute to the production of value-added food products with improved nutritional profiles.

Use of green banana flour in bakery and noodle products has been reported to enhance dietary fiber content, reduce starch digestibility and alter product texture and functional properties (Ovando-Martinez *et al.*, 2009). Pasting characteristics of flour are important in determining the functional properties of flour in starch-based food systems as they give an idea of the extent of starch granule swelling, gelatinization, disintegration and retrogradation events during the heating and cooling processes (Singh *et al.*, 2003). It is known that physicochemical modifications influence notably water absorption, thermal stability, texture, cooking quality and structural integrity of noodle products (Shang *et al.*, 2025). Generally, the suitability of flour for noodles and other starch-based food applications are determined by Rapid Visco Analysis (RVA) to determine the peak viscosity, break down viscosity, final viscosity, setback viscosity and pasting temperature.

The pasting capabilities of banana flour are notably different from those of common wheat and cassava flours due to differences in starch composition, amylose to amylopectin ratio, resistant starch concentration and crystal structure (Xie *et al.*, 2026). The thermal stability, low granule swelling and high retrogradation tendency of banana starch are advantageous for the improvement of the structural stability and cooking tolerance of noodle systems (Khoozani *et al.*, 2019). However, a high level of retrogradation might also affect the textural qualities during storage and processing negatively (Yu *et al.*, 2024).

To our knowledge, there is minimal information on the physicochemical and pasting qualities of RBF in Northern Thailand, but several studies have investigated the nutritional and physicochemical features of RBF. The purpose of this study was to investigate the proximate composition and pasting properties of RBF and to assess its possibility for utilization as an alternative functional ingredient for noodle products.

MATERIALS AND METHODS

Raw material

Raw Hom Thong bananas (*Musa sapientum* L.) were collected from Mae Taeng community, Chiang Mai Province, Thailand. All-purpose wheat flour and cassava flour were purchased from the local market, Chiang Mai, Thailand. All chemicals and reagents used for chemical analyses were of analytical grade.

Preparation of Raw Hom Thong Banana Flour

Raw Hom Thong bananas (*Musa acuminata* AAA group) at ripening stage 3, according to the ripening classification of CSIRO (1972) were thoroughly washed with running water, manually peeled and sliced into pieces of approximately 5 mm thickness. The banana slices were dried in a hot-air oven at 60 °C until the moisture content was lower than 10%. (Ariyasukkosit *et al.*, 2022) The dried banana slices were ground using a laboratory grinder and sieved with an 80-mesh sieve to get fine flour particles (Figure 1). The banana flour was packed in polyethylene bags and stored at room temperature until further analysis.

Proximate Analysis

The proximate composition of RBF, including moisture, ash, crude fat, crude protein, and dietary fiber contents, was determined according to the standard methods of AOAC (2000). Carbohydrate

content was calculated by difference using the equation:

$$\text{Carbohydrate (\%)} = 100 - (\text{moisture} + \text{protein} + \text{fat} + \text{ash} + \text{dietary fiber}).$$

All analyses were conducted in triplicate and the results were expressed as g/100 g sample.

Determination of Pasting Properties

The pasting properties of raw banana flour, wheat flour, and cassava flour was determined using a Rapid Visco Analyser (RVA; Newport Scientific Pty. Ltd., Warriewood, Australia) according to the standard RVA method (AACC International, 2009). The parameters evaluated included peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, pasting temperature, and peak time. Flour suspensions were subjected to controlled heating and cooling cycles during analysis to evaluate the rheological and pasting behavior of the flour samples.

Statistical Analysis

All experiments were carried out in triplicate using a completely randomized design (CRD). Data were expressed as mean \pm standard deviation. Statistical analysis was performed using analysis of variance (ANOVA), and significant differences among means were determined using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.05$. Statistical analyses were conducted using SPSS software version (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Proximate Composition of Raw Hom Thong Banana Flour

Table 1 shows the proximate composition of RBF. The results indicated that the major component of the flour was carbohydrate followed by protein, ash, dietary fiber and fat, respectively. The flour also had a relatively low moisture content which indicates good storage stability.

The moisture content of RBF was 3.23 ± 0.03 g/100 g. This showed that drying procedure at 60°C was successful to reduce water content to create stable flour system. The moisture content of RBF obtained in this study was lower than that reported by Jiamjariyatam *et al.* (2019) who found a moisture

content of 11.52%. Differences in moisture content may be attributed to variations in processing and drying conditions during flour production. Low moisture content is important for flour stability as limited water availability might restrict microbiological development and diminish hydrolytic and enzymatic reactions which are associated with quality deterioration during storage. The obtained moisture content was much lower than the moisture limit commonly indicated for commercial flour products (12-14%), hinting that the flour developed in this study should have high shelf stability for dried food applications. Similar findings have been reported by Khoozani *et al.* (2019).

Table 1. Proximate composition of raw Hom Thong banana flour.

Parameters	Results (g/100 g)
Moisture	3.23 ± 0.03
Ash	2.92 ± 0.10
Fat	0.30 ± 0.05
Protein	4.20 ± 0.28
Carbohydrate	86.82 ± 0.18
Dietary fiber	2.53 ± 0.14

The ash level of the flour was 2.92 ± 0.10 g/100 g which was slightly higher than the usual range reported for the refined wheat flour. The finding reveals that unripe banana naturally possesses key mineral components such as potassium, magnesium and phosphorus. Ionic interactions between mineral components and starch molecules can potentially influence the starch functionality and thermal behavior in starch-based systems during processing. The ash content was comparable with raw banana flour of other cultivars (Shini *et al.*, 2024). Hot-air drying conditions have high effect on physicochemical stability and resistant starch retention of raw banana flour (Khoozani *et al.*, 2019).

The fat content of RBF was very low (0.30 ± 0.05 g/100 g) and this can be advantageous for the storage durability of the flour because a low lipid content minimizes the danger of oxidative rancidity and the development of off-flavours during storage. The low-fat content was also seen for green banana flours of other banana cultivars, demonstrating that banana flour is a low fat source of carbohydrates applicable for starch-based food products (Kumar *et al.*, 2019).

The protein content of the flour was 4.20 ± 0.28 g/100 g and lower than that usually seen in wheat flour but greater than reported values for

cassava flour. Banana flour proteins are not involved in the development of gluten networks, but the presence of proteins may affect flour functionality, through interactions with starch and dietary fiber components during thermal processing. In the noodle system these interactions can influence dough consistency, water uptake and textural qualities. The addition of banana flour changed the system structure of dough and the starch-protein interactions in wheat-based systems, according to Hu *et al.* (2025).

The carbohydrate content of RBF was 86.82 ± 0.18 g/100 g. Carbohydrates are the primary component of the flour. Unripe banana flour is claimed to include high quantities of starch and resistant starch which determine its functional and technological features. The high carbohydrate content found in this study indicates that the flour can be used as an alternate source of starch for noodles and other starch-based foods. Green banana flour was found to contain resistant starch associated with lower starch digestion and lower glycemic response, thus enhancing its potential as a functional food ingredient (Pacheco *et al.*, 2025).

The dietary fiber content of RBF was 2.53 ± 0.14 g/100 g. Dietary fiber may affect the functional properties of noodle products through the effect on water absorption, viscosity development and structural stability during processing (Singthong *et al.*, 2026). Starch granules may also compete with fiber components for water uptake that may affect swelling behavior and pasting properties of starch. Functional noodle formulations fortified with plant-derived materials have observed similar observations regarding the functional relevance of dietary fiber in starch-based systems (Singthong *et al.*, 2026).

The proximate composition suggested that RBF has potential as a functional flour ingredient for Khao Soi noodle applications. The flour possessed high carbohydrate, low fat and moderate dietary fiber and mineral content. These may contribute to nutritional improvement and functional qualities in starch-based food.

Pasting Properties of Raw Hom Thong Banana Flour

The pasting qualities of RBF analyzed by a Rapid Visco Analyser (RVA) are shown in Table 2. The RVA parameters of wheat flour and cassava flour reported in earlier studies are presented for comparative reasons.

Table 2. Pasting properties of raw banana flour compared with reported values for wheat flour and cassava flour.

Parameter	Banana flour	Wheat flour*	Cassava flour*
Peak viscosity (RVU)	213.05 ± 16.17	120–180	352.50 ± 4.15
Trough viscosity (RVU)	191.35 ± 10.25	80–140	152.86 ± 3.46
Breakdown (RVU)	63.75 ± 1.13	30–80	199.64 ± 3.16
Final viscosity (RVU)	283.86 ± 23.27	150–250	230.00 ± 2.53
Setback (RVU)	93.58 ± 4.38	50–150	77.14 ± 4.18
Pasting temperature (°C)	84.57 ± 0.93	60–70	67.80 ± 0.05
Peak time (min)	6.71 ± 0.20	5–6	3.65 ± 0.04

Values for banana flour are expressed as mean ± standard deviation (n = 3).

*Reported values for wheat flour were adapted from Dada *et al.* (2023), whereas cassava flour values were adapted from Ekeledo *et al.* (2024).

Important indicators of properties of starch-based flours are the pasting behavior, swelling characteristics and utility for food processing applications. RVA parameters are commonly used to determine starch gelatinization, paste stability and retrogradation behavior, all of which affect the texture and cooking quality of noodle products (Zhang *et al.*, 2025).

RBF had a peak viscosity of 213.05 ± 16.17 RVU which was higher than the reported range for wheat flour but lower than the value reported for cassava flour. Peak viscosity reflects the maximum swelling capacity of starch granules during heating in excess water. The moderate peak viscosity of banana flour shows its ability of starch granules to absorb water and, at the same time, structural resistance to excessive swelling. The behavior may be due to the presence of resistant starch, relatively high amylose content and compact structure of starch granules commonly found in unripe banana flour (Kumar *et al.*, 2019). The lower peak viscosity compared to cassava flour may suggest stronger internal molecular associations which limit the granule expansion during heating.

The trough viscosity of banana flour was 191.35 ± 10.25 RVU, which was higher compared to the values reported for wheat and cassava flours. Trough viscosity is the resistance of swollen starch granules to prolonged heating and mechanical shear. The higher trough viscosity of banana flour indicates that its starch paste is more stable to heat and shear during processing. This behavior has been observed in starch systems with a higher content of resistant starch and crystalline structures that prevent the granule breakdown upon heating (Pacheco *et al.*, 2025). It is useful in maintaining the structure during

cooking and better paste stability is needed for use in noodles.

Breakdown viscosity is an index of the ease of disintegration of starch granules under the effect of heat and mechanical stress. Compared to cassava flour, raw banana flour had relatively low breakdown viscosity (63.75 ± 1.13 RVU) implying higher resistance of its starch granules to disintegration on heating. The lower breakdown viscosity is related to higher paste stability and less granule swelling, because the interaction between the molecules in the starch structures increases (Xie *et al.*, 2026). This property may lead to reduced cooking losses and increased firmness of noodle products.

The final viscosity of banana flour was 283.86 ± 23.27 RVU which was higher than those reported for wheat and cassava flours. The final viscosity is a measure of the capacity of starch molecules, especially amylose fractions, to reassociate and form a viscous paste on cooling. The increased final viscosity of banana flour reflects high gel forming capacity and stability of the paste on cooling. Similar results were found in green banana starches. Increase in resistant starch and amylose content which increases the molecular reassociation and the paste viscosity (Sharath Kumar *et al.*, 2025). In noodle systems, the increased final viscosity can lead to a firmer texture and improved structural stability on cooking.

Setback viscosity is associated with starch retrogradation and reassociation of starch molecules during cooling. The setback value of banana flour (93.58 ± 4.38 RVU) was higher than that reported for cassava flour and within the reported range for wheat flour. This implies a moderate tendency of starch molecules to re-organize in ordered structures after gelatinization. Higher amylose starches and resistant starches show more distinct retrogradation behavior owing to higher likelihood of re-association of the linear chains of starch during cooling (Rammohan *et al.*, 2025). Moderate retrogradation may be advantageous for the firmness and structural stability of the noodles but excess retrogradation may have adverse effect on the textural softness during storage.

The pasting temperature of banana flour was 84.57 ± 0.93 °C, which was considerably higher than the reported values for wheat and cassava flours. Pasting temperature is the minimum temperature required to initiate starch gelatinization. The higher the pasting temperature, the higher the crystalline stability of the banana starch granules and the stronger the binding within the starch matrix.

Similar increase in gelatinization temperature has been reported for green banana flours with high resistant starch and ordered crystalline structures (Khoozani *et al.*, 2019). Higher pasting temperature may require greater thermal energy during noodle processing but could also improve resistance to overcooking.

Banana flour also exhibited a longer peak time (6.71 ± 0.20 min) than cassava flour and slightly higher values than wheat flour. Longer peak time reflects slower starch granule swelling and delayed gelatinization behavior during heating. A slower gelatinization profile may suggest a better process tolerance with less over-degradation of starch during cooking. Similar findings have been reported for functional noodle systems where fortification with ingredients rich in resistant starch gave slower gelatinization which led to improved cooking stability and texture (Singthong *et al.*, 2026).

The RVA analysis results showed that the RBF had different pasting properties from the typical wheat and cassava flours. The flour showed good thermal stability, moderate swelling, high peak viscosity and high pasting temperature, indicating its potential application in the development of noodle products with higher structural integrity and firmer texture. Moreover, the resistant starch and dietary fiber content may be beneficial in the development of functional noodle products with improved physicochemical properties.

CONCLUSIONS

Raw Hom Thong banana flour (RBF) exhibited distinctive proximate composition and pasting properties. The flour was characterized by high carbohydrate, low fat, moderate dietary fiber and mineral contents and low moisture content, suggesting good storage stability and suitability for dried food applications. The proximate composition data provide baseline information regarding the nutritional characteristics of RBF.

The RVA analysis demonstrated that RBF exhibited different pasting properties compared with reported values for wheat flour and cassava flour. RBF showed moderate peak viscosity, high trough viscosity, low breakdown viscosity, high final viscosity, and a relatively high pasting temperature. These characteristics suggest that RBF possesses unique physicochemical properties that may influence its behavior during food processing.

The findings of this study provide fundamental information on the physicochemical

and pasting properties of RBF produced in Chiang Mai Province, Thailand. The results may serve as a basis for future investigations on the application of RBF in noodles and other starch-based food products.

Future studies should be performed to investigate the effects of banana flour incorporation on the cooking quality, textural properties, starch digestibility, sensory acceptance and shelf stability of noodles to support potential commercial applications.

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