Bridging Food Technology and Local Enterprise Through Process Characterization for Sustainable Sagon Powder Production

Rizki Aditya Surya Prathama[1]*, Susi Sulistia[1], Dadan Rohdiana[1]

[1]Department of Food Technology, Al-Ghifari University, Bandung, Indonesia.

*Email: raditya@unfari.ac.id

Abstract. Indonesian traditional foods such as sagon powder play an important role in supporting local economies and preserving culinary heritage. However, many producers still face challenges in maintaining consistent quality, which can limit the growth and sustainability of Micro, Small, and Medium Enterprises (MSMEs). This study connects modern food technology with local business practices by analyzing the production process to support sustainable quality improvement. Sagon powder from three MSME producers was examined and compared with two commercial products. Particle uniformity was measured using the sieving method, while flow properties were evaluated through specific gravity, Hausner Factor, compressibility, and angle of repose. The results showed that sagon powder made using traditional methods had excellent physical characteristics, including uniform particle size distribution and good moisture control for easier handling. The samples showed a high level of homogeneity, in some cases surpassing commercial products, indicating uniform texture and composition. They also had favorable flow properties, supporting efficient packaging and reducing the risk of clumping during storage. These results highlight that process characterization provides MSMEs with practical quality benchmarks to standardize production, limit variability, and enhance competitiveness.

Keywords: food technology, powder flowability, sagon powder, sustainable MSMEs, traditional food

Introduction

Indonesia possesses a rich biodiversity of local food resources, particularly starch sources such as sago and various rice varieties, which form the basis of its culinary heritage. Scientific characterization of these local commodities is a critical first step towards innovation and value addition. Recent studies have focused on exploring the unique properties of these materials, such as Bangka sago, to establish them as superior starch sources (Pratiwi, 2024), and developing novel products like rice analogues from sago and corn flour to enhance food security (Handayani et al., 2024). This approach of understanding and utilizing local resources is fundamental for sustainable food development. One such traditional product derived from these resources is sagon cake, a popular and durable dry cake based on glutinous rice flour and coconut (Adira, 2024).

As with many traditional foods, sagon powder is predominantly produced by Micro, Small, and Medium Enterprises (MSMEs). A significant challenge faced by these producers is the inconsistency of product quality, particularly in texture, which often fails to meet the ideal characteristic of being fragile and melting in the mouth. This variability hinders the product's competitiveness in a wider market, creating a need for process innovation and standardization. Improving the quality and consistency of traditional food products is a key strategy for ensuring their sustainability and enhancing the economic stability of local producers.

The quality of a powder-based food product is intrinsically linked to its physicochemical and rheological properties. The homogeneity of the powder mixture is a primary determinant of the final product's uniformity, directly impacting consumer sensory experience (Kumare et al., 2022). Powder homogeneity and flow properties are strongly influenced by various factors, including the particle size distribution, shape, and density of each ingredient. In a composite mixture like sagon powder, the interaction between different components is critical. As demonstrated in studies on composite flours, the particle size and proportion of each ingredient significantly affect the final quality attributes of the product (Chikpah et al., 2020).
Controlling these physical properties is essential in food powder production. According to Cuq et al. (2013), managing agglomeration and granulation is fundamental to preventing component segregation and ensuring consistent product quality from batch to batch. Therefore, the scientific characterization of these properties is not merely an academic exercise but a practical tool for process innovation and standardization. By understanding the key physical parameters, producers can identify critical control points in their manufacturing process to achieve a more uniform and desirable final product.
This research, therefore, focuses on the detailed physical characterization of sagon powder to address the aforementioned quality inconsistency. The aim of this research is to determine the particle uniformity and flow properties of sagon powder as a basis for obtaining a homogeneous and uniformly quality product, thereby increasing the competitiveness of local food products.

Methods

This research was designed as a descriptive experimental study with the primary objective of characterizing the physical properties of sagon powder to establish a baseline quality profile and observe variations among different producers. The main materials consisted of three distinct sagon powders sourced from MSMEs in the Bandung area (Sagon Bubuk Pak Yuyu, Sagon Bubuk Kaum Ngemil, and Sagon Bubuk Dhevikka_id), which were benchmarked against two commercial products (Quaker Original and Energen Vanilla Flavor). The primary instruments for analysis were a set of Tyler sieves (mesh 10–100) for physical particle size fractionation, an analytical balance for precise mass measurements, 250 mL graduated cylinders for bulk volume determination, and a standard laboratory funnel with a stopwatch for flow rate assessment.
The first experimental stage focused on a detailed analysis of particle uniformity. A 100 g sample of each powder was placed atop a stacked set of Tyler sieves, arranged from the coarsest to the finest, and was manually sieved for exactly 1 minute. The mass of the powder retained on each individual sieve was then precisely weighed. This particle size distribution data formed the basis for two key analyses: first, the calculation of the Fineness Modulus (FM), derived from the cumulative percentage of material retained on the sieves to provide a single index of the powder's overall fineness. Second, the classification of the sample's homogeneity level, which was determined by analyzing the concentration of particles within coarse, medium, and fine sieve groupings. The homogeneity classification used in this study is divided into four categories based on particle size distribution: Absolutely Homogeneous (AH), indicating complete uniformity; Extremely Homogeneous (EH), indicating very high uniformity; Homogeneous (HM), indicating moderate uniformity; and Fairly Homogeneous (FH), indicating noticeable variation in particle sizes.
The second stage involved a comprehensive assessment of the powder's bulk and rheological properties. Apparent density was determined by measuring the volume of a 100 g sample poured gently into a graduated cylinder without compaction, while tapped density was subsequently measured after mechanically tapping the cylinder until a constant minimum volume was achieved. These two density values were used to calculate the Hausner Factor and the Compressibility Index, which serve as indirect indicators of flowability by quantifying inter-particle friction and cohesiveness. To complement these findings, direct flow properties were measured by determining the flow rate (the time required for 100 g of powder to pass freely through a standard funnel) and the angle of repose (calculated from the height and radius of the resulting conical powder pile). Finally, all collected data were analyzed descriptively to quantitatively evaluate and compare the physical characteristics of each sample. Key parameters such as the homogeneity level and angle of repose were then interpreted using established scientific classifications to provide a definitive assessment of the powder's overall quality and flow behavior.

Result and Discussion

The initial phase of the analysis focused on particle uniformity and homogeneity, as these are foundational physical characteristics that directly influence the final quality of sagon powder, including its texture, appearance, and mouthfeel. To quantify these attributes, two main analyses were conducted: the calculation of the Fineness Modulus (FM), which provides a numerical index of the powder's overall coarseness, and a qualitative classification of the Homogeneity Level, which describes the uniformity of the particle size distribution. A key preliminary finding across all tested samples was that the bulk of the particles consistently fell within the medium size classification, providing a common baseline for comparison. A detailed comparison of these parameters for the three sagon powder samples from MSMEs and the two commercial benchmarks is presented in Table 1.

Table 1: Analysis Results of Particle Uniformity and Sample Homogeneity Level

No.	Sample	FM	Size Classification	Homogeneity Level
1	SP PY	4.44	Medium	Absolutely Homogeneous (AH)
2	SP KN	5.46	Medium	Extremely Homogeneous (EH)
3	SP DV	5.49	Medium	Absolutely Homogeneous (AH)
4	QK OR	6.94	Medium	Homogeneous (HM)
5	EG VN	3.91	Medium	Fairly Homogeneous (FH)

Notes:

1. SP PY = Sagon Powder Pak Yuyu
2. SP KN = Sagon Powder Kaum Ngemil
3. SP DV = Sagon Powder Dhevikka_id Vanilla Flavor
4. QK OR = Quaker Original
5. EG VN = Energen Vanilla Flavor
6. FM = Fineness Modulus, an index number that represents the mean particle size of the powder.

An interesting aspect of the results in Table 1 is the homogeneity level of sagon powder produced by MSMEs. The data reveals that the MSME samples possess exceptional uniformity. Specifically, samples such as SP PY and SP DV achieved the highest possible classification, 'Absolutely Homogeneous' (AH), while SP KN was classified as 'Extremely Homogeneous' (EH). This high degree of homogeneity is a significant finding, as it implies a very uniform distribution of the sagon powder components. From a quality standpoint, this uniformity is crucial for ensuring consistency in taste, texture, and mouthfeel in every serving, which is a primary indicator of a high-quality food powder and can ultimately increase consumer sensory acceptance (Kumare et al., 2022). Furthermore, the Fineness Modulus (FM) values show that the sagon powders (FM 4.44–5.49) occupy a specific particle size profile, moderately coarser than one commercial product (EG VN, FM 3.91) but finer than the other (QK OR, FM 6.94), indicating a unique textural fingerprint for the traditional product. The high level of homogeneity indicates that the traditional production process carried out by these MSME producers, although simple, is remarkably effective at creating a uniform particle mixture. This becomes even more significant when compared to the commercial product EG VN, which was classified as only 'Fairly Homogeneous' (FH). This result provides quantitative evidence that challenges the common assumption that industrial-scale production always yields a more uniform product. This insight is a key novelty of this research, confirming that the physical properties of local MSME products are highly competitive. This finding can serve as a scientific basis for MSMEs to standardize their production processes and use this unique quality attribute as a marketing advantage to enhance their product's value and competitiveness.

Beyond the static characteristic of particle homogeneity, the dynamic behavior of the powder during processing, commonly known as its flow properties or powder rheology, is critically important for ensuring a consistent and efficient manufacturing process. For MSMEs, where production may be manual or semi-automated, these properties are paramount. Good flowability ensures uniform filling of packaging, prevents blockages in equipment like hoppers, and contributes to the overall stability and quality of the final product. Poor flow, conversely, can lead to inconsistent product weight and production delays. Therefore, a thorough

characterization of these rheological properties is essential for any process innovation aimed at standardization and scalability.
To provide a comprehensive assessment of these characteristics, this study employed a two-pronged approach utilizing both indirect and direct measurement methods. Indirect indicators of flow, namely the Hausner Factor and the Compressibility Index, were calculated from the powder's apparent and tapped densities to provide insight into inter-particle friction and cohesiveness. These were then validated with a direct measurement of the Angle of Repose, which empirically quantifies the powder's ability to flow under gravity. The combined results from these analyses for all sagon powder samples and the commercial benchmarks are summarized in Table 2.

Table 2: Physical Characteristics and Flow Properties of Powder Samples

No.	Sample	Apparent Density (g/ml)	Hausner Factor	Compressibility (%)	Angle of Repose (°)	Flow Property
1	SP PY	0.431	1.011	0.431	24.84	Very Good
2	SP KN	0.450	1.037	0.45	24.27	Very Good
3	SP DV	0.420	1.090	0.42	23.98	Very Good
4	QK OR	0.384	1.031	0.384	21.94	Very Good
5	EG VN	0.581	1.283	0.581	24.27	Very Good

The rheological properties presented in Table 2 are arguably the most critical findings of this research, as they directly relate to the processability and potential for standardization of sagon powder at the MSME level. In food science, rheological quality is a key determinant not only of manufacturing efficiency but also of the final product's sensory perception by consumers (Kumare et al., 2022). For small-scale producers, mastering these properties represents a significant leap from traditional craft to a scientifically-grounded, scalable production model. This section provides a detailed discussion of the powder's excellent flow characteristics, confirmed through multiple, corroborating parameters.
The analysis began with indirect flow indicators derived from density measurements: the Hausner Factor (HF) and the Compressibility Index (Cp). The Hausner Factor for the MSME sagon samples was exceptionally low, ranging from 1.011 to 1.090. A value this close to 1 indicates that the powder's bulk volume barely decreases upon tapping, a characteristic of non-cohesive particles with minimal inter-particle friction. This was further reinforced by the extremely low Compressibility Index values, all of which were below 1%. According to fundamental powder technology principles, low compressibility signifies that cohesive forces between particles (such as electrostatic or moisture-related bonds) are minimal compared to gravitational forces, which promotes flow (Cuq et al., 2013). This suggests that the traditional roasting process (*sangrai*) in sagon production is highly effective at reducing moisture, resulting in a granular, non-cohesive powder that is inherently free-flowing.
To validate these indirect measurements, a direct assessment of powder flow was conducted by measuring the angle of repose. This parameter is a macroscopic manifestation of the microscopic inter-particle forces and provides a powerful, empirical confirmation of flowability. As shown in Table 2, all sagon powder samples exhibited an angle of repose within a very narrow and ideal range of 23.98° to 24.84°. These values are not only within the 'Very Good' flow category (typically <30°) but are at the lower end of this range, indicating exceptional flow. Research on other flours, such as sweet potato flour, has shown a direct correlation between particle size and flow properties (Chikpah et al., 2020). The consistent, low angle of repose across the sagon samples suggests that their particle size distribution, confirmed as highly homogeneous in the previous section, is in an optimal range that minimizes friction and promotes smooth flow.
The overall significance of these findings is very substantial especially for the sustainable development of MSMEs. The consistent, excellent free-flowing nature of the sagon powder is a major technical advantage that can be leveraged for process innovation. In practice, this translates to easier handling, reduced product loss during transfer, and most importantly, the potential for highly consistent dosing into packaging. This also mitigates common manufacturing issues like hopper bridging or 'rat-holing', which can cause production stoppages and inconsistent package weights—a critical quality control point. The data presented here provides a scientific blueprint for standardization; for example, MSMEs could implement simple quality

control checks to ensure the angle of repose for their product consistently remains below 25°. This approach validates a key quality attribute of traditional sagon powder, confirming its suitability for process optimization and scaling, and directly supporting the enhancement of its market competitiveness.

Conclusion

This study concludes that sagon powder, a traditional food product manufactured by local MSMEs, possesses excellent and highly competitive physical characteristics. The principal results demonstrate that the powder exhibits a very high degree of particle homogeneity, in some cases superior to commercial counterparts, which is essential for consistent product quality. Furthermore, the product displays superior free-flowing properties, as robustly confirmed by ideal Hausner Factor, compressibility, and angle of repose values. The major conclusion is that these scientifically characterized parameters (homogeneity and flowability) can serve as key indicators for developing a modern quality control and standardization framework for this traditional product. This approach effectively bridges artisanal manufacturing with food technology, providing a practical and sustainable innovation strategy for local enterprises to enhance product consistency and market competitiveness. As a recommendation for future research, a sensory analysis should be conducted to formally link these excellent physical properties with consumer acceptance and preference.

Acknowledgments

The authors would like to express their gratitude to the Faculty of Agricultural Technology, Al-Ghifari University, for the facilities and support to conduct this research. A special acknowledgment is given specifically to Susi Sulistia, S.T.P. for her contribution to the data collection process and to Dr. Dadan Rohdiana for his guidance in the preparation of this manuscript. The authors also wish to thank the producers who provided the research samples: Sagon Bubuk Pak Yuyu, Sagon Bubuk Kaum Ngemil, and Sagon Bubuk Dhevikka_id.

References

Adira, M. (2024). *Pengaruh substitusi tepung ketan dengan tepung tempe terhadap karakteristik kue sagon* [S1 thesis, Universitas Andalas]. http://scholar.unand.ac.id/482609/

Chikpah, S. K., Korese, J. K., Hensel, O., & Sturm, B. (2020). Effect of harvest period and sieve size on the physical and chemical properties of orange-fleshed sweet potato flour. *Foods*, *9*(6), 740. https://www.mdpi.com/2304-8158/9/6/740

Cuq, B., Mandato, S., Jeantet, R., Saleh, K., & Ruiz, T. (2013). Agglomeration/granulation in food powder production. In B. Bhandari, N. Bansal, M. Zhang, & P. Schuck (Eds.), *Handbook of food powders: Process and properties* (pp. 153–193). Woodhead Publishing. https://www.sciencedirect.com/science/article/pii/B9780857095138500078

Handayani, N. A., Sumardiono, S., Purbasari, A., Fatikah, A. F., & Alhakim, I. M. (2024). Physicochemical properties of sago- and corn flour-based rice analogues fortified with black-eyed bean flour and skimmed milk powder. Food Technology and Biotechnology, *62*(4), 461–471. https://doi.org/10.17113/ftb.62.04.24.8357

Kumare, K. D., Londhe, G. K., & Anarthe, N. K. (2022). Effect of black pepper (Piper nigrum) and turmeric (Curcuma longa) powder on sensory and rheological quality of burfi. The Pharma Innovation Journal, *11*(1S), 669–672. https://www.thepharmajournal.com/archives/2022/vol11issue1S/PartI/S-11-1-81-780.pdf

Pratiwi, S. (2024). Bangka sago as a superior starch source: Processing, morphology, chemical properties, and heavy metal content. *Jurnal Teknologi Pertanian*, *25*(1), 13–22. https://jurnal.fp.unila.ac.id/index.php/JTP/article/view/10202

Tuhumury, H. C. D. (2024). Functional properties of sago grub protein concentrates with different initial drying methods. *AGRITEKNO: Jurnal Teknologi Pertanian*, *13*(1), 22–30. https://ojs3.unpatti.ac.id/index.php/agritekno/article/view/10049