Journal of Agritechnology and Food Processing
Volume 5, issue 2 (December 2025)
ISSN 2809-3607

Food safety evaluation of rice husk charcoal production as a natural food colorant: a good manufacturing practices (GMP) study in Purworejo Regency

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ABSTRACT

Rice husk charcoal powder is traditionally used in Indonesia as a natural black food colorant, offering potential as an eco-friendly additive while valorizing agricultural waste. However, ensuring its food safety is critical for broader market adoption. This study evaluated the safety and production quality of rice husk charcoal powder produced by a small-to-medium enterprise (SME) in Purworejo Regency, Central Java, using a combined Good Manufacturing Practices (GMP) assessment and laboratory testing. GMP compliance was assessed against 18 parameters outlined in the Indonesian Ministry of Industry Regulation No. 75/M-IND/PER/7/2010, scored on a 0–60 scale. Laboratory analyses measured heavy metal content, moisture, ash, pH, and Salmonella contamination. The facility scored 480/1,080 points (44.44%), classified as Category C (Adequate), with key deficiencies in process monitoring, product labeling, documentation, and recall procedures. Major deviations were linked to open-air carbonization and uncovered cooling, while minor deviations included partial personal protective equipment (PPE) use and semi-open storage. Laboratory results confirmed compliance with safety standards, with Pb <0.04 ppm (≤1.0 ppm limit) and negative Salmonella detection. However, moisture content (18.86%) exceeded typical thresholds for dry powdered additives, correlating with suboptimal storage and drying practices. This study concludes that rice husk charcoal powder meets essential chemical and microbiological safety requirements, yet improvements in moisture control, drying processes, and GMP documentation are necessary to enhance product stability and market readiness.

Keywords: food safety; Good Manufacturing Practices; natural colorant; rice husk charcoal

INTRODUCTION

The demand for natural food colorants has increased significantly in recent years, driven by consumer preferences for clean-label products and growing concerns over the safety of synthetic additives (Ferreyra-Suarez et al., 2024; Sigurdson et al., 2017). Natural colorants are often perceived as safer, more environmentally friendly, and compatible with traditional food processing practices (Hendry & Houghton, 1996; Sigurdson et al., 2017). Among various sources, plant-derived pigments, minerals, and carbon-based materials have attracted attention for their functional and aesthetic contributions to food products (Ghosh et al., 2022; Ngamwonglumlert et al., 2017; Novais et al., 2022).

Rice husk charcoal powder is one such natural colorant traditionally used in Indonesian food products such as dawet hitam and grass jelly. It is produced by carbonizing rice husks—an abundant agricultural by-product—into fine black powder (Wang et al., 2015). This approach not only adds value to rice husk waste but also supports sustainable food production and rural livelihoods (Kordi et al., 2024). However, the open-air burning and manual handling methods commonly used in small-scale production raise potential food safety concerns, including contamination from heavy metals, microbial hazards, and environmental pollutants (Matin et al., 2023; Piyathissa et al., 2023).

Ensuring the safety and quality of natural colorants is essential, particularly when they are used in ready-to-eat foods (Náthia-neves & Meireles, 2018; Rodriguez-Amaya, 2016; Sigurdson et al., 2017; Vega et al., 2023). In Indonesia, the application of Good Manufacturing Practices (GMP) is mandated under the Ministry of Industry Regulation No. 75/M-IND/PER/7/2010 as a key prerequisite for food safety assurance. GMP covers a wide range of parameters, including facility design, sanitation, process control, documentation, and product recall systems (Latif et al., 2017). Compliance with GMP is especially important for small-to-medium enterprises (SMEs), which often face resource and infrastructure limitations but still play a vital role in local food supply chains (Hasnan et al., 2022).

Previous studies on food-grade charcoal materials have primarily focused on activated carbon from coconut shells, bamboo, or wood, assessing adsorption properties and toxicological safety (Jia et al., 2024; Zhang et al., 2022). Limited research has been conducted on rice husk charcoal as a food colorant, particularly in relation to GMP compliance in small-scale production settings. This gap highlights the importance of evaluating both production practices and product safety to ensure that natural colorants meet regulatory and market standards.

This study is distinctive because it integrates GMP compliance scoring, deviation analysis, and laboratory-based safety assessment into a single comprehensive framework for evaluating rice husk charcoal powder production. To the best of our knowledge, this is the first research to directly correlate the quality of operational practices with both chemical and microbiological safety indicators for a food-grade carbon-based colorant produced within an SME setting. By focusing on a decentralized, rural-production model, the research addresses the practical realities of resource-limited facilities while aligning its evaluation with national regulatory requirements and the evolving demands of clean-label markets (Anjali et al., 2024; Cao & Miao, 2023)

This dual perspective enables the generation of actionable recommendations to help SMEs progress from basic compliance toward best-practice excellence, thereby enhancing competitiveness in both domestic and international markets. The primary aim of this study is to assess the safety and quality of rice husk charcoal powder as a natural food colorant through an integrated analysis of GMP implementation, deviation categorization, and laboratory verification. The findings are intended to provide a strategic roadmap for improving production standards, strengthening food safety assurance, and ensuring regulatory compliance.

METHODOLOGY

Location and Timeframe

The study was conducted in May 2025 at the production site of Tepung Oman Cap Daun, owned by Mr. Nurul Huda, in Purworejo Regency, Central Java. The facility specializes in producing rice husk charcoal powder used as a natural food colorant. Fieldwork was carried out on-site to observe all stages of production, from raw material reception to final packaging.

GMP Compliance Assessment

The evaluation followed the Indonesian Ministry of Industry Regulation No. 75/M-IND/PER/7/2010, which specifies 18 parameters of Good Manufacturing Practices (GMP) (Latif et al., 2017). Each parameter was scored on a 0–60 scale according to the criteria outlined by the Directorate of Processing and Marketing of Agricultural Products (Prakoso et al., 2023).

Determination of Implementation Level and Feasibility

The total GMP score was calculated by summing the scores for all parameters. The implementation level was classified following previous study. Deviations from GMP were identified and categorized in Table 1 (Malthufah & Lestari, 2023; Susanto et al., 2023).

Table 1. Classification of GMP deviations and associated risk levels)

Deviation Category	Implication / Risk Level
Minor	No significant risk to product quality or safety.
Major	Potential risk due to non-compliance with mandatory requirements.
Serious	Significant quality or safety risk requiring corrective action.
Critical	Immediate hazard to consumer health; urgent corrective action required.

Laboratory Analysis

Representative samples of rice husk charcoal powder were collected. Laboratory analysis was conducted to verify the chemical and microbiological safety of the rice husk charcoal powder. Lead (Pb) content was measured using previous method by Atomic Absorption Spectrophotometry (AAS) (Sardans et al., 2010). Moisture content was determined by the gravimetric oven-drying method (Zambrano et al., 2019), while ash content was obtained through gravimetric incineration at high temperature (Mortensen et al., 1989). The pH value was measured using the potentiometric method. Microbiological safety was assessed through the detection of Salmonella spp. using the BAM 5 method (Deng et al., 2023). All analyses were performed in triplicate, and the average values were reported. The tests were carried out by Sucofindo Laboratory (Semarang, Central Java, Indonesia).

RESULTS AND DISCUSSION

Production Process Mapping

The mapped process flow (Figure 1) provided critical insight into operational hazards and potential control points throughout the rice husk charcoal powder production chain. The sequence begins with raw husk reception, where husks are received in bulk from local rice mills. Although the raw material appeared relatively clean, no formal inspection or documentation procedures were in place to verify quality upon arrival. The next stage, open-air carbonization, involves burning husks in an open pit to achieve partial combustion and char formation. This method, while simple and cost-effective, poses risks of airborne particulate contamination and uneven carbonization due to inconsistent temperature control (Matin et al., 2023; Piyathissa et al., 2023).

Figure 1. Production process mapping of rice husk charcoal powder

Following combustion, the material undergoes cooling in open water basins, which was identified as a major contamination point. Uncovered basins are vulnerable to environmental debris, insect contact, and dust deposition. The process then proceeds to draining and drying, either by sun-drying on open tarpaulins or via small-scale mechanical dryers. Open-air drying, though inexpensive, prolongs moisture reduction and increases exposure to environmental contaminants (Alp & Bulantekin, 2021).

After drying, sieving and milling are conducted using a metal disk mill, producing a fine black powder. The final packaging stage employs clean plastic sacks, but without individual product labeling, date coding, or batch identification. Linking these mapped stages to GMP scores revealed that the lowest-performing parameters—building structure, sanitation facilities, and process monitoring—were directly associated with the open and unprotected nature of several critical operations (Blanchfield, 2005). This reinforces the need for infrastructural improvements, such as protective covers, enclosed processing areas, and standardized handling protocols.

GMP Compliance

The GMP assessment results (Table 2) indicate that the facility obtained a total score of 480 out of a possible 1,080 points, equivalent to 44.44%. This places the facility in Category C (Adequate) according to Directorate of Processing and Marketing of Agricultural Products classification, indicating that while basic requirements are met, significant improvements are necessary to achieve higher compliance levels (Prakoso et al., 2023).

Strengths in GMP implementation were primarily found in machinery and equipment hygiene, raw material quality, and final product safety. The metal disk mill used in the milling process was in good condition, easy to clean, and free from visible contamination (Blanchfield, 2005). Raw materials were relatively clean upon receipt, and the finished product met basic visual quality standards, free from coarse contaminants. These aspects suggest that the facility has a foundational level of hygiene and quality control in certain critical operations.

However, multiple GMP elements scored below 50% of the maximum points, revealing systemic gaps. The absence of product labeling (10 points) and formal documentation (12 points) severely limits traceability and accountability. Moreover, the lack of a written recall procedure (8 points) poses a serious risk in the event of a food safety incident, as there is no standardized mechanism for removing contaminated products from the market. Process monitoring was conducted solely through visual inspection without standardized operating procedures (SOPs), limiting consistency and reproducibility in production. Worker-related parameters also showed moderate compliance; although some use of personal protective equipment (PPE) was observed, training was irregular and not supported by a structured program.

Structural and environmental controls were also suboptimal. The semi-open building and uncovered cooling basin increase the risk of airborne contamination, dust infiltration, and microbial hazards. Similarly, semi-open storage facilities expose finished products to dust and potential pests (Blanchfield, 2005; Susanto et al., 2023). While cleaning routines are conducted, the outdoor exposure of production areas undermines sanitation effectiveness. These findings highlight the need for infrastructural improvements and stricter environmental control measures to safeguard product quality.

Overall, the GMP evaluation underscores the urgent need for targeted interventions. Priorities include the establishment of formal SOPs, implementation of regular staff training, installation of protective covers for open processing stages, and upgrading storage conditions. Addressing these issues would not only elevate the facility from Category C to B or even A but also enhance its ability to meet both national regulations and international market requirements for natural food colorants.

Table 2.
GMP compliance scores, remarks, and corrective action recommendations for rice husk charcoal powder production in Purworejo Regency (18 parameters, 0–60 scale)

No	GMP Parameter	Score	Remarks	Corrective Action / Improvement Suggestions
1	Location	34	Adequate distance from contamination sources, good access	Maintain buffer area; add boundary fencing to limit dust and animal access
2	Buildings	28	Semi-open structure; some production areas exposed	Install wall panels/screens; implement zoning between clean and dirty areas
3	Sanitation facilities	36	Clean water available; cooling basin uncovered	Cover cooling basin to prevent dust, insects, and microbial contamination
4	Machinery & equipment	42	Metal disk mill, good condition, easy to clean	Create sanitation checklist and cleaning log
5	Raw materials	40	Clean husks, but open burning poses contamination risk	Use covered pre-storage; assess enclosure to reduce contamination
6	Process monitoring	32	No written SOP, visual monitoring only	Develop written SOPs; use monitoring sheets/checklists
7	Finished product	44	Dry, free from visible contaminants	Improve packaging protection; monitor moisture
8	Laboratory	20	No in-house lab; periodic external testing	Schedule routine microbial & heavy metal testing
9	Workers	38	Partial PPE use, irregular training	Implement mandatory PPE and training routine
10	Packaging	36	Clean plastic sacks	Upgrade to food-grade sealed liner bags
11	Label & description	10	No product label	Create label (origin, batch, date, storage instruction)
12	Storage	30	Semi-open warehouse, dust risk present	Convert to enclosed warehouse; use pallets
13	Maintenance & sanitation	34	Routine cleaning; outdoor exposure remains	Implement preventive maintenance schedule
14	Transportation	36	Partially covered vehicles	Fully cover transport; use food-grade tarps
15	Documentation	12	No formal recordkeeping	Create traceability logbook; implement digital/paper records

No	GMP Parameter	Score	Remarks	Corrective Action / Improvement Suggestions
16	Training	20	No scheduled training program	Develop training matrix and schedule
17	Product recall	8	No written recall procedure	Prepare product recall SOP
18	GMP guideline implementation	20	Partial adherence to GMP guidelines	Conduct periodic internal audits

Deviation Analysis

The deviation analysis (Table 2) showed that minor deviations (n = 5) were the most prevalent, indicating small lapses in GMP implementation that, while not immediately hazardous to product quality, reflect areas where preventive measures could strengthen overall compliance. Examples of minor deviations observed included uncovered cooling basins, partial use of personal protective equipment (PPE) by workers, and semi-open storage areas susceptible to dust.

Major deviations (n = 3) were related to the absence of written standard operating procedures (SOPs), lack of a documented product recall system, and no scheduled training program for staff. These issues represent structural and procedural shortcomings that could lead to more serious risks if left unaddressed, particularly in ensuring consistent process control and traceability (Blanchfield, 2005). SOPs and recall systems are essential elements in food safety management systems, ensuring uniformity, rapid response, and consumer protection (DeBeer et al., 2024).

No serious or critical deviations were identified, suggesting that the current operational practices do not pose immediate threats to consumer health. However, the combined presence of minor and major deviations signals that the facility operates at a “compliance-maintenance” stage rather than a “continuous improvement” stage. Addressing these deviations—particularly those classified as major—would likely shift the facility toward Category A GMP compliance and align it more closely with both national regulations and international food safety benchmarks.

Table 3.
Categories and counts of GMP deviations identified in rice husk charcoal powder production in Purworejo Regency, Central Java

No	Deviation Category	Count
1	Minor	5
2	Major	3
3	Serious	0
4	Critical	0

Laboratory Results

Laboratory testing further validated the GMP compliance findings by confirming that the rice husk charcoal powder met essential food safety requirements (Table 4). The concentration of lead (Pb) was measured at <0.04 ppm, which is significantly below the maximum permissible limit of 1.0 ppm stipulated for food-grade materials (Nag & Cummins, 2022). Compared to previous studies that primarily focused on characterizing carbonized rice husk powder as a natural colorant and evaluating its physicochemical or functional properties—without assessing microbial safety or heavy metal (Almeida et al., 2019; Diya et al., 2023)—this study provides a more comprehensive evaluation by including Pb quantification and Salmonella screening. Microbiological analysis also showed that Salmonella spp. was absent, meeting the safety standards for ready-to-eat food ingredients and aligning with the GMP scores that indicated a low likelihood of critical contamination events.

Despite these positive safety results, certain parameters highlighted potential post-production concerns. The moisture content of 18.86% is higher than typically recommended for long-term storage of dry powdered food additives, potentially predisposing the product to microbial growth, clumping, or reduced shelf life under unfavorable storage conditions (Jung et al., 2018).

Beyond the analytical measurements, the laboratory data reinforce the observations made during the GMP assessment. This finding correlates with the observed weaknesses in GMP storage practices, particularly the use of semi-open warehouses and uncovered cooling basins, which increase exposure to environmental debris, dust, insects, and potential microbial contamination during handling and cooling. Meanwhile, the high ash content (65.72%) and alkaline pH (10.7) are characteristic of carbonized agricultural residues and may influence the functional properties of the colorant, including dispersibility and compatibility with different food matrices. Overall, while the laboratory results confirm that the product is chemically and microbiologically safe for use, these observations highlight the need to improve moisture control and storage practices. Implementing enhanced drying procedures, covered cooling and storage facilities, and improved packaging would not only maintain regulatory compliance but also extend product stability and ensure consistent quality for domestic and international markets (Anjali et al., 2024).

Table 4.
Laboratory analysis results of rice husk charcoal powder

Parameter	Unit	Result	Standard
Pb	ppm	<0.04	≤ 1.0
Moisture	%	18.86	-
Ash	%	65.72	-
pH	-	10.7	-
Salmonella	/25g	Negative	Negative

CONCLUSION

This study demonstrates that rice husk charcoal powder produced in Purworejo Regency meets basic chemical and microbiological safety requirements for use as a natural food colorant, with Pb content far below regulatory limits and no detection of Salmonella. However, the GMP compliance score of 44.44% (Category C) and identified deviations—particularly the absence of SOPs, uncovered processing stages, and semi-open storage—highlight structural and procedural gaps that could affect long-term product stability, as reflected in the relatively high moisture content. Targeted interventions, including infrastructural upgrades, moisture control improvements, implementation of formal documentation and recall systems, and regular worker training, are essential to transition the facility from basic compliance toward best-practice standards, thereby enhancing food safety assurance and market competitiveness both domestically and internationally.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Research and Community Service Institute of Universitas Semarang (LPPM USM) for funding this research through its research grant scheme.

REFERENCES

Alp, D., & Bulantekin, Ö. (2021). The microbiological quality of various foods dried by applying different drying methods: a review. European Food Research and Technology, 247(6), 1333. https://doi.org/10.1007/S00217-021-03731-Z

Anjali, M. K., Aswathy, V. A., Beegum, M. A. F., & Abidha, P. K. (2024). Revolutionizing Food Quality and Safety: Recent Advances in Clean-Label Technology. European Journal of Nutrition & Food Safety, 16(10), 76–91. https://doi.org/10.9734/EJNFS/2024/V16I101558

Blanchfield, J. R. (2005). Good manufacturing practice (GMP) in the food industry. Handbook of Hygiene Control in the Food Industry, 324–347. https://doi.org/10.1533/9781845690533.3.324

Cao, Y., & Miao, L. (2023). Consumer perception of clean food labels. British Food Journal, 125(2), 433–448. https://doi.org/10.1108/BFJ-03-2021-0246

DeBeer, J., Blickem, E. R., Rana, Y. S., Baumgartel, D. M., & Bell, J. W. (2024). An Analysis of Food Recalls in the United States, 2002–2023. Journal of Food Protection, 87(12), 100378. https://doi.org/10.1016/J.JFP.2024.100378

Deng, K., Wang, S. S., Kiener, S., Smith, E., Chen, K. S., Pamboukian, R., Laasri, A., Pelaez, C., Ulaszek, J., Kmet, M., De Jesus, A., Hammack, T., Reddy, R., & Wang, H. (2023). Multi-laboratory validation study of a real-time PCR method for detection of Salmonella in baby spinach. Food Microbiology, 114, 104299. https://doi.org/10.1016/J.FM.2023.104299

Ferreyra-Suarez, D., Paredes-Vargas, L., Jafari, S. M., García-Depraect, O., & Castro-Muñoz, R. (2024). Extraction pathways and purification strategies towards carminic acid as natural-based food colorant: A comprehensive review. Advances in Colloid and Interface Science, 323, 103052. https://doi.org/10.1016/j.cis.2023.103052

Ghosh, D., Singha, P. S., Firdaus, S. B., & Ghosh, S. (2017). Metanil yellow: The toxic food colorant. Asian Pacific Journal of Health Sciences, 4(4), 65–66. https://doi.org/10.21276/apjhs.2017.4.4.16

Hendry, G. A. F., & Houghton, J. D. (1996). Natural Food Colorants. Blackie Academic & Professional.

Jia, Z., Zhou, Y., Chen, X., Zhang, L., Li, Y., & Chen, J. (2024). Dietary bamboo charcoal powder ameliorates high-fat diet-induced hyperlipidemia by enhancing fecal lipid excretions in Sprague–Dawley rats. Frontiers in Nutrition, 11, 1458350. https://doi.org/10.3389/FNUT.2024.1458350/BIBTEX

Jung, H., Lee, Y. J., & Yoon, W. B. (2018). Effect of Moisture Content on the Grinding Process and Powder Properties in Food: A Review. Processes 2018, Vol. 6, Page 69, 6(6), 69. https://doi.org/10.3390/PR6060069

Kordi, M., Farrokhi, N., Pech-Canul, M. I., & Ahmadikhah, A. (2024). Rice Husk at a Glance: From Agro-Industrial to Modern Applications. Rice Science, 31(1), 14–32. https://doi.org/10.1016/J.RSCI.2023.08.005

Latif, R., Dirpan, A., & Indriani, S. (2017). The Status of Implementation of Good Manufacturing Practices (GMP) Shredded Fish Production in UMKM Az-Zahrah, Makassar. IOP Conference Series: Earth and Environmental Science, 101(1), 012040. https://doi.org/10.1088/1755-1315/101/1/012040

Malthufah, Y. R. A., & Lestari, K. S. (2023). Assisting Food Household Industries in Implementation of Good Manufacturing Practice (GMP) on Frozen Meat Kebab in Sidoarjo District. Media Gizi Kesmas, 12(2), 878–885. https://doi.org/10.20473/MGK.V12I2.2023.878-885

Matin, H. H. A., Syafrudin, S., & Suherman, S. (2023). Rice Husk Waste: Impact on Environmental Health and Potential as Biogas. Jurnal Kesehatan Masyarakat, 18(3), 431–436. https://doi.org/10.15294/kemas.v18i3.42467

Mortensen, A. B., Wallin, H., Appelqvist, L. A., Everitt, G., Gref, C. G., Jacobsen, J., Jensen, K., Jepsen, O. M., Johansen, I. L., & Julshamn, K. (1989). Gravimetric Determination of Ash in Foods: NMKL Collaborative Study. Journal of AOAC INTERNATIONAL, 72(3), 481–483. https://doi.org/10.1093/JAOAC/72.3.481

Nag, R., & Cummins, E. (2022). Human health risk assessment of lead (Pb) through the environmental-food pathway. Science of The Total Environment, 810, 151168. https://doi.org/10.1016/J.SCITOTENV.2021.151168

Náthia-neves, G., & Meireles, M. A. A. (2018). Genipap : A New Perspective on Natural Colorants for the Food Industry Genipap : A New Perspective on Natural Colorants for the Food Industry. 8(March), 21–33. https://doi.org/10.5923/j.fph.20180801.04

Ngamwonglumlert, L., Devahastin, S., & Chiewchan, N. (2017). Natural colorants: Pigment stability and extraction yield enhancement via utilization of appropriate pretreatment and extraction methods. Critical Reviews in Food Science and Nutrition, 57(15), 3243–3259. https://doi.org/10.1080/10408398.2015.1109498

Noor Hasnan, N. Z., Basha, R. K., Amin, N. A. M., Ramli, S. H. M., Tang, J. Y. H., & Aziz, N. A. (2022). Analysis of the most frequent nonconformance aspects related to Good Manufacturing Practices (GMP) among small and medium enterprises (SMEs) in the food industry and their main factors. Food Control, 141, 109205. https://doi.org/10.1016/J.FOODCONT.2022.109205

Novais, C., Molina, A. K., Abreu, R. M. V., Santo-Buelga, C., Ferreira, I. C. F. R., Pereira, C., & Barros, L. (2022). Natural Food Colorants and Preservatives: A Review, a Demand, and a Challenge. Journal of Agricultural and Food Chemistry, 70(9), 2789–2805. https://doi.org/10.1021/ACS.JAFC.1C07533/ASSET/IMAGES

/LARGE/JF1C07533_0003.JPEG

Piyathissa, S. D. S., Kahandage, P. D., Namgay, Zhang, H., Noguchi, R., & Ahamed, T. (2023). Introducing a Novel Rice Husk Combustion Technology for Maximizing Energy and Amorphous Silica Production Using a Prototype Hybrid Rice Husk Burner to Minimize Environmental Impacts and Health Risk. Energies 2023, Vol. 16, Page 1120, 16(3), 1120. https://doi.org/10.3390/EN16031120

Prakoso, A., Rizka, M., & Nur, K. L. (2023). Kajian Keamanan Pangan Pada Industri Pengolahan Susu Di Jawa Tengah Dengan Menggunakan Metode Good Manufacturing Practices (GMP). Jurnal Teknologi Industri Pertanian, 33(3), 305–316. https://doi.org/10.24961/j.tek.ind.pert.2023.33.3.305

Rodriguez-Amaya, D. B. (2016). Natural food pigments and colorants. Current Opinion in Food Science, 7, 20–26. https://doi.org/10.1016/j.cofs.2015.08.004

Sardans, J., Montes, F., & Peñuelas, J. (2010). Determination of As, Cd, Cu, Hg and Pb in biological samples by modern electrothermal atomic absorption spectrometry. Spectrochimica Acta Part B: Atomic Spectroscopy, 65(2), 97–112. https://doi.org/10.1016/J.SAB.2009.11.009

Sigurdson, G. T., Tang, P., & Giusti, M. M. (2017). Natural Colorants: Food Colorants from Natural Sources. Annual Review of Food Science and Technology, 8(1), 261–280. https://doi.org/10.1146/annurev-food-030216-025923

Susanto, D. A., Suef, M., & Karningsih, P. D. (2023). Level of Implementation of GMP and SSOP in SMEs Wet Noodle Production Process with Gap Analysis Tools. Evergreen, 10(1), 510–518. https://doi.org/10.5109/6782155

Vega, E. N., Ciudad-Mulero, M., Fernández-Ruiz, V., Barros, L., & Morales, P. (2023). Natural Sources of Food Colorants as Potential Substitutes for Artificial Additives. Foods 2023, Vol. 12, Page 4102, 12(22), 4102. https://doi.org/10.3390/FOODS12224102

Vera Zambrano, M., Dutta, B., Mercer, D. G., MacLean, H. L., & Touchie, M. F. (2019). Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. Trends in Food Science & Technology, 88, 484–496. https://doi.org/10.1016/J.TIFS.2019.04.006

Wang, Z., Chen, H., Xu, L., Xu, S. Q., Gao, C. F., Oliphant, A. J., Liu, J., Lu, Y., Wang, W., & Sun, L. (2015). Synthesis and colour prediction of stable pigments from rice husk biomass. Green Materials, 3(1), 10–14. https://doi.org/10.1680/GMAT.14.00007

Zhang, H., Nagy, A., Bowman, C., Peladeau-Pigeon, M., Hu, A., Lovell, J., Steele, C. M., & Xia, J. (2022). Food-Grade Activated Charcoal for Contrast-Enhanced Photoacoustic Imaging of Aspiration: A Phantom Study. Dysphagia, 37(6), 1651. https://doi.org/10.1007/S00455-022-10422-8