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Standardization and Quality Characterization of Moringa, Mung Bean, and Pumpkin Simplisia for Functional Food Development

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ABSTRACT

Childhood stunting and adolescent anaemia remain important nutrition challenges in Indonesia, requiring sustainable food-based approaches using locally available resources. The development of functional foods requires consistent and quality-controlled raw materials to ensure reproducible formulation processes. This study aimed to produce and characterize standardized simplisia from moringa leaf (Moringa oleifera), mung bean (Vigna radiata), and pumpkin (Cucurbita moschata) as preliminary raw materials for functional food development. This experimental descriptive-characterization study represented the first phase of the two-year "Keloreal Berani Sehat" program. Three plant materials obtained from local producers in Central Sulawesi and East Java were processed following national herbal-material preparation procedures. Quality evaluation included yield (rendemen), loss on drying, and descriptive organoleptic characterization. Each material was processed in a single production batch, and data were analyzed descriptively according to established quality criteria. The resulting simplisia showed low moisture content, with loss on drying values of 4.7% for moringa leaf, 4.4% for mung bean, and 5.4% for pumpkin, all below the 10% threshold specified for dried herbal materials. Yield varied according to the characteristics of the source materials, with mung bean showing the highest yield (97.3%), followed by moringa leaf (28.5%) and pumpkin (12.2%). All samples showed acceptable physical characteristics and absence of visible foreign matter. These findings establish a traceable and standardized raw material foundation for subsequent functional food formulation studies, including nutritional composition analysis, bioactive evaluation, processing optimization, and acceptability assessment.

INTRODUCTION

Childhood stunting and adolescent anaemia remain two of the most persistent nutrition-related public-health burdens in Indonesia. The 2023 Indonesian Health Survey placed the national prevalence of stunting in children under five at about one in five, while anaemia continues to affect a substantial share of adolescents, particularly girls.[1] Large national analyses confirm that stunting is driven by a complex web of maternal, dietary and environmental determinants, and that it is concentrated in the first 1000 days of life, when linear growth faltering is largely irreversible.[2–4] Adolescent anaemia, in turn, is closely linked to inadequate dietary iron and folate intake and, through its effect on future maternal iron status, forms part of the intergenerational cycle that perpetuates stunting.[4,5] Both conditions therefore share modifiable dietary roots, and food-based strategies that draw on locally available commodities offer a sustainable, scalable means of prevention.[6]

Three local commodities are especially promising for this purpose. Moringa leaf (*Moringa oleifera* Lam.) is a nutrient-dense source of iron, folate, protein, calcium and provitamin A, and intervention studies show that moringa leaf powder incorporated into complementary foods and biscuits can raise haemoglobin and improve child growth indicators, including height-for-age.[7–11] Mung bean (*Vigna radiata* L.) supplies high-quality plant protein, folate, magnesium and the C-glycosyl flavones vitexin and isovitexin, and is a well-established base for complementary and supplementary foods aimed at undernourished children.[6,12,13] Pumpkin (*Cucurbita moschata* Duchesne) is rich in β-carotene (provitamin A), vitamin E and soluble fibre, nutrients important for immunity and for correcting the vitamin A deficiency that frequently accompanies stunting.[14–16] Combined, the three materials provide a complementary profile of protein, iron, folate and provitamin A that maps directly onto the nutritional needs of stunted children and anaemic adolescents.

The principal barrier to translating this potential into an effective product is the limited bioavailability of the target nutrients and bioactives. Iron, polyphenols and carotenoids are sensitive to heat, oxygen and gastrointestinal pH and are readily degraded during processing and digestion, which diminishes their functional performance in conventional food matrices.[18] Although advanced processing technologies such as nanoencapsulation may enhance bioactive compound stability, these approaches require prior standardization of raw materials to ensure consistent physicochemical characteristics. Nanotechnology particularly nanoencapsulation and spray-drying of extracts with food-grade carriers such as maltodextrin has emerged as a robust means of protecting these compounds and improving their solubility, storage stability and intestinal absorption.[18–22] These approaches underpin the "Keloreal Berani Sehat" program, which aims to develop a nanotechnology-based, ready-to-brew functional flour integrating the three commodities to help address stunting and adolescent anaemia; an earlier pilot product (a moringa cereal) was exhibited at the 2024 BRIDA Expo in Central Sulawesi and provided the rationale for the present, more rigorous development pathway.

A frequently overlooked prerequisite of such nano-based development is the quality of the dried raw materials, or simplisia, that enter the process. The moisture content, purity and botanical authenticity of the feedstock directly govern its microbiological stability, the reproducibility of downstream extraction and encapsulation, and ultimately the retention of the very nutrients the product is designed to deliver.[22,25] Although moringa leaf powder has been used successfully as a food fortificant against child and maternal anaemia,[23,24] the integrated, standardized preparation of moringa leaf, mung bean and pumpkin as a coordinated raw-material set for a single functional food has rarely been reported.

Previous studies have investigated moringa, mung bean, and pumpkin individually as nutritional ingredients; however, limited information exists regarding the integrated standardization of these three locally available commodities as a coordinated raw-material platform for functional food development. Establishing quality-controlled simplisia is therefore an essential preliminary step before evaluating nutritional composition, bioavailability, sensory acceptance, and functional efficacy. The objective of this study the foundational first-year phase of the two-year program was therefore to produce and characterize standardized simplisia of the three commodities, quantifying their yield (rendemen) and loss on drying and describing their organoleptic quality, so as to establish a reproducible and quality-controlled raw material foundation for subsequent functional food formulation and sensory evaluation.

MATERIALS AND METHODS

This study followed an experimental, descriptive-characterization design and constitutes the first year (2026) of a two-year functional-food research and development program. Fresh moringa leaf, mung bean and pumpkin were obtained from local producers, with field coordination and material sourcing supported by the Provincial Health Office of Central Sulawesi and processing performed at the UPT Laboratorium Herbal Materia Medica Batu, Provincial Health Office of East Java a laboratory that routinely issues certified simplisia production and quality-testing reports. All batches were processed in July 2026.

Simplisia were prepared following standard national herbal-material procedures (Figure 1). Each fresh material was received and weighed, then wet-sorted to remove weeds and foreign matter. Materials were washed with well water under running water with triple rinsing. Size reduction was applied only to pumpkin, which was machine-sliced to a uniform thickness; moringa leaf and mung bean required no size reduction. All materials were oven-dried at 50 °C to constant weight, dry-sorted to remove any residual foreign matter, and ground and sieved into a homogeneous powder. Batch and certificate numbers were recorded for full traceability.

Three quality parameters were determined. Yield (rendemen) was calculated as the ratio of dried-simplisia weight to fresh-material weight, expressed as a percentage. Loss on drying, representing the residual moisture of the finished simplisia, was measured with a gravimetric moisture analyzer and expressed as a percentage. Organoleptic assessment was conducted descriptively by trained laboratory personnel based on macroscopic characteristics including colour, form, odour, and taste comparison with reference descriptions. Organoleptic characteristics form, colour, odour and taste were assessed against reference descriptions for each material. Data were analyzed descriptively and interpreted against established quality thresholds, notably the requirement that loss on drying of dried simplisia should not exceed 10%.[25]

Because this phase involved only plant-derived raw materials and did not enrol human or animal subjects, formal ethical clearance was not required for the work reported here. The subsequent, second-year phase which will include organoleptic (hedonic) evaluation with human panelists will obtain ethical approval from the institutional health research ethics committee prior to implementation. Because this study represented an initial product-development phase, each commodity was processed as one independent production batch. Therefore, the analysis was descriptive and intended for baseline characterization rather than hypothesis testing. The materials were selected based on availability from local producers. Information regarding cultivar variation and agricultural practices was not experimentally controlled and should be considered when interpreting yield differences.

RESULTS

The three materials were successfully processed into standardized simplisia, and their production and quality parameters are summarized in Table 1. Oven drying at 50 °C was completed within one to three days per batch. The finished simplisia weights were 0.88 kg for moringa leaf (from 3.09 kg fresh), 1.945 kg for mung bean (from 2.00 kg fresh) and 0.70 kg for pumpkin (from 5.74 kg fresh).

Table 1. Production, processing and quality parameters of the three standardized simplisia.

Parameter	Moringa leaf	Mung bean	Pumpkin
Botanical name	*Moringa oleifera Lam.*	*Vigna radiata (L.) R. Wilczek*	*Cucurbita moschata Duchesne*
Batch number	260714.KLR.F.BTU.922.477	260707.KHJ.C.MLG.818.448	260707.LBU.D.MLG.819.449
Certificate number	3252/102.20/2026	3088/102.20/2026	3089/102.20/2026
Reception date	14 Jul 2026	06 Jul 2026	06 Jul 2026
Fresh weight (kg)	3.09	2.00	5.74
Size reduction	None	None	Machine-sliced (uniform)

Parameter	Moringa leaf	Mung bean	Pumpkin
Drying method / temp.	Oven / 50 °C	Oven / 50 °C	Oven / 50 °C
Drying period	14–15 Jul 2026	07–09 Jul 2026	07–08 Jul 2026
Simplisia weight (kg)	0.88	1.945	0.70
Yield / rendemen (%)	28.5	97.3	12.2
Loss on drying (%)	4.7	4.4	5.4
Wet sortation	No foreign matter	No foreign matter	No foreign matter
Dry sortation	No foreign matter	No foreign matter	No foreign matter
Washing	Well water, running, 3×	Well water, running, 3×	Well water, running, 3×

Because each commodity was processed as a single batch, variability between independent production batches could not be statistically evaluated. Therefore, the results represent baseline characterization rather than population-level estimates. Yield differed markedly among the materials. Mung bean gave the highest yield at 97.3%, followed by moringa leaf at 28.5% and pumpkin at 12.2%. In contrast, loss on drying was low and comparable across all three materials—moringa leaf 4.7%, mung bean 4.4% and pumpkin 5.4% each well below the 10% threshold for dried simplisia.[25] Wet and dry sortation confirmed the absence of weeds or foreign matter in every batch, and all materials were washed with well water under running water with triple rinsing (Table 1).

Organoleptic characterization (Table 2) was consistent with the reference descriptions for each commodity. Moringa simplisia comprised green to brownish-green leaves that were odourless and tasteless; mung bean simplisia consisted of small ovoid green seeds with a characteristic clean, mildly sweet and slightly floury profile; and pumpkin simplisia formed thin, curved flakes ranging from dark yellow to yellowish-brown with a naturally sweet aroma and taste. No musty, rancid or off-odours were detected in any sample.

Table 2. Organoleptic characterization of the three standardized simplisia.

Parameter	Moringa leaf	Mung bean	Pumpkin
Form / shape	Round to elongate-ovate leaves; acute base, blunt-rounded tip; pinnate venation	Ovoid to short-round/oblong seeds, 3–5 mm; white hilum line	Thin, curved flakes

Parameter	Moringa leaf	Mung bean	Pumpkin
Colour	Green, yellowish-green to brownish-green	Dark to glossy light-green; golden pale-yellow cotyledon	Dark yellow, orange to yellowish-brown
Odour	Odourless	Weak, characteristic clean raw-legume note; no musty/rancid odour	Weak, characteristic sweet pumpkin; slight dried-fruit aroma
Taste	Tasteless	Bland, slightly sweet, mildly floury	Naturally sweet, characteristic pumpkin, mildly floury

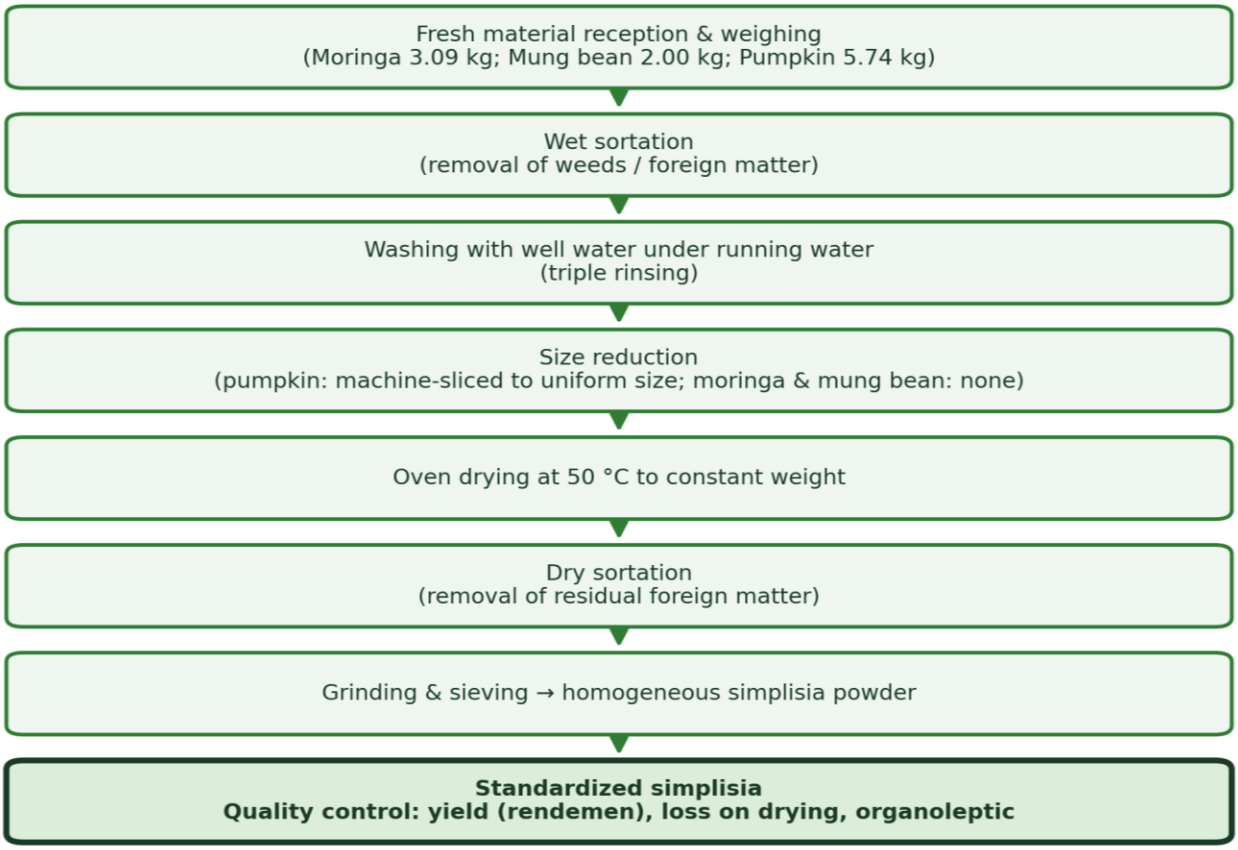

Figure 1. Standardized production workflow of moringa leaf, mung bean and pumpkin simplisia.

DISCUSSION

The central finding of this phase is that all three simplisia met the quality requirements expected of standardized herbal raw materials, with loss on drying values (4.4–5.4%) comfortably below the 10% pharmacopoeial threshold.[25] Low residual moisture is decisive for functional-food feedstock because it lowers water activity, suppresses microbial growth and enzymatic and oxidative deterioration, and thereby preserves both storage stability and the sensitive nutrients targeted by the product.[22,25] The moringa value of 4.7% obtained at 50 °C is closely comparable with published oven-drying results for moringa leaf (of the order of 4.5% at 55 °C) and reflects the falling-rate, diffusion-controlled drying behavior repeatedly reported for this material.[26,27] A drying temperature of 50 °C represents a sensible compromise: it is low enough to limit thermal degradation of heat-labile compounds such as vitamin C, provitamin A carotenoids and polyphenols, yet sufficient to achieve microbiologically safe moisture levels within a practical drying time.[26,27]

The pronounced differences in yield are explained by the water content of the source tissues rather than by any processing deficiency. Mung bean enters the process as mature, already-dry seeds, so little mass is lost, and the yield is very high (97.3%); here, drying chiefly standardizes residual moisture and assures microbial safety. Moringa leaf, with a fresh moisture content typically around three-quarters of its mass, gives an intermediate yield (28.5%), while pumpkin flesh among the most water-rich of the three loses close to nine-tenths of its mass on drying, yielding only 12.2%.[15,26] This has direct practical implications for the Keloreal formulation: a large fresh input of pumpkin is required per unit of powder, which affects sourcing logistics and cost, but the accompanying moisture loss also concentrates fat-soluble constituents such as β-carotene in the dried flakes, a recognized effect of dehydration in pumpkin.[15,16] Documenting these material-specific yields is therefore essential for reproducible formulation planning and scale-up.

The organoleptic profiles provide a first line of identity and integrity control. Their agreement with reference descriptions and the absence of musty or rancid notes indicates authentic, uncontaminated materials that have not undergone appreciable spoilage during processing.[25] For a multi-ingredient functional food aimed at children and adolescents, this consistency underpins batch-to-batch reproducibility of colour, aroma and flavour, which will strongly influence the acceptability of the final ready-to-brew product in these age groups.

Taken together, these results establish the raw-material foundation required before nano-scale processing can proceed. Uniform, low-moisture feedstock improves the reproducibility and encapsulation efficiency of spray-drying and related nano-formulation steps and minimizes pre-processing oxidation of carotenoids and polyphenols during storage.[19–22] These commodities are reported in previous studies as sources of iron, folate, protein and provitamin A; however, the retention of these nutrients after processing requires confirmation through direct compositional analysis of moringa, the protein and folate of mung bean, and the β-carotene of pumpkin, the standardized inputs retain precisely the nutrients implicated in linear growth and haemoglobin synthesis. This is directly relevant to the program's goals: moringa leaf powder incorporated into complementary foods and biscuits has been shown to raise haemoglobin and improve growth in children and to reduce anaemia in vulnerable groups,[7–11,23,24] mung bean is an established protein-rich base for supplementary foods against child undernutrition,[6,12,13] and pumpkin contributes provitamin A relevant to immunity and vitamin A status in stunting.[14–16] The intrinsic bioavailability of these constituents nonetheless remains limited, which is the rationale for the planned nano-encapsulation stage.[18] Finally, sourcing the materials from Central Sulawesi and East Java reinforces the program's alignment with local-commodity valorization and food security.

Several limitations should be acknowledged. This phase quantified physical yield, moisture and organoleptic quality but did not yet measure phytochemical or micronutrient content, particle size, or sensory acceptability, all of which are objectives of the second year. A single batch was processed per material, precluding replicate statistical analysis, and the yields reported are specific to the cultivars, maturity and geographic origin used here. These constraints define, rather than diminish, the contribution of the present work as a raw-material standardization baseline.

CONCLUSION

Standardized simplisia from moringa leaf, mung bean, and pumpkin were successfully produced with acceptable preliminary quality characteristics, including low loss on drying, absence of visible foreign matter, and consistent organoleptic profiles. Differences in yield reflected the physical characteristics of each raw material, particularly variation in moisture content. This study provides a baseline raw-material standardization framework for subsequent functional food development. Further studies should prioritize nutritional composition analysis, bioactive compound evaluation, microbiological safety testing, formulation optimization, sensory assessment, and efficacy evaluation before determining potential nutritional benefits.

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Surabaya in 2026. The funding body had no role in the design of the study; in the collection, analysis, or interpretation of the data; or in the writing of the manuscript.

AUTHOR CONTRIBUTIONS

Mujayanto conceived and designed the study, supervised the simplisia production and quality assessment, and drafted the manuscript. Taufiqurrahman contributed to data collection, laboratory coordination and data analysis. Amsal coordinated material sourcing and field implementation. Fahmi Hafid contributed to the study conception, critical revision of the manuscript for important intellectual content, and correspondence. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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