I. INTRODUCTION

1.1 Background

Indonesia possesses a wealth of indigenous medicinal plants, leading to the widespread consumption of traditional herbal medicine known as *jamu*, particularly most valued in rural areas of the country as these remedies are favored for their perceived minimal health risks compared to synthetic medicines. *Jamu* is a term rooted in the Javanese tribal language, denoting traditional plant-based medicine. Nowadays, there is an innovative effort to advance the industrialization of *jamu* production (Marcellinus, 2012; Woerdenbag & Kayser, 2014). The practice of *jamu* consumption aligns with the World Health Organization's definition of traditional medicine, which encompasses knowledge, skills, and practices rooted in indigenous beliefs and experiences. These traditions are applied in healthcare, spanning prevention, diagnosis, and treatment of physical and mental ailments. Within the category of medicinal herbs, *Zingiberaceae*, such as *Curcuma*, are well-recognized. They are used to treat dermatological conditions and gastrointestinal issues, with *Curcuma* being a prominent genus within *Zingiberaceae* utilized in *jamu* for enhancing stamina (Fathir et al., 2021; Sumarni et al., 2019). Notably, the ingredients used in herbal remedies are sourced from nature and free of synthetic chemicals, resulting in regular consumption with relatively few side effects. Various types of herbal medicines exist, including *jamu beras kencur, jamu kunir asem*, *jamu paitan*, *jamu temulawak,* and *jamu godong kate*s (Sumarni et al., 2019).

The production of traditional *jamu* typically involves water extraction of local rhizomes, such as black turmeric (*Curcuma aeruginosa*), white turmeric (*Curcuma zedoaria*), and aromatic ginger (*Kaempferia galanga L.*). Unfortunately, this process generates by-products called rhizomes pomace (RP), which become waste and are often discarded. The improper disposal of RP in landfills contributes to environmental pollution, specifically air pollution and land pollution (Amir & Lestari, 2013). A study by Huc-Mathis et al. (2019) has reported that micronized apple pomace exhibits the capability to function as stabilizers in oil-in-water emulsions. This efficacy is attributed to the complementary attributes of both soluble and insoluble components within these raw powders. The insoluble particles operate through the Pickering mechanism (Huc-Mathis et al., 2021). Given that RP is rich in antioxidants, the production of finely ground RP powder could prove advantageous as a viable Pickering agent in emulsions for various food products whilst being a sustainable approach to make use of the by-product (Speroni et al., 2020).

Drying plays a pivotal role in the production of powders and is a crucial method for the preservation of a wide variety of products. This method reduces moisture content and water activity of RP effectively as it limits the growth of spoilage bacteria, making it one of the most widely utilized methods for other food preservations (Aryal, 2022). There are several drying methods available, including traditional sun drying and conventional cabinet drying. While open sun drying is the most cost-effective and straightforward approach, it comes with numerous limitations, such as susceptibility to the growth of microorganisms and loss of essential vitamins, color, and texture in drying material due to its unpredictable temperature and weather conditions. In contrast, the utilization of a cabinet dryer significantly improves drying efficiency, reducing drying time by approximately 20% and yielding higher-quality dried products when compared to open sun drying (Naing & Soe, 2021).

In addition, taking into account and understanding the physical properties of powdered products, including the moisture content, water activity, hygroscopicity, solubility, and flowability is essential for the efficacy of various processes within the food industry, such as handling, processing, mixing, packing, and storage (Camacho et al., 2022; Sapariya et al., 2023; Singh et al., 2018). These attributes are also important for the improvement of the overall quality and stability of the powdered product including the visual appearance and the transport properties of the powder (Szulc & Lenart, 2016). The stability and storage conditions of a powder is usually highly dependent on its moisture content and water activity. A high water activity signifies more free water present within the sample which affects a shorter shelf life for the product. The storage and stability of powdered products are also affected by their hygroscopicity. Furthermore, the flowability and solubility of the powder is important for the handling and applications in food products (Wang et al., 2020).

Therefore in this study, the valorization of RP from *jamu* by-products will be conducted by different drying temperatures and durations (high temperature with short duration; 80^{o}C for 18 hours, and low temperature with longer duration; 50^{o}C for 48 hours) utilizing conventional cabinet drying, towards the changes in the physical properties, including moisture content, water activity, color, hygroscopicity, solubility, and flowability of the dried RP powder will be observed.

1.2 Objective

To observe and compare the effect of different drying temperatures, particularly high-temperature at 80^{o}C for 18 hours and low-temperature at 50^{o}C for 48 hours towards the physical properties (moisture content, water activity, hygroscopicity, solubility, flowability, and color) between rhizomes pomace (RP) powder obtained from black turmeric (*Curcuma aeruginosa*), white turmeric (*Curcuma zedoaria*), and aromatic ginger (*Kaempferia galanga L.*).

1.3 Hypotheses

- H0 (null hypothesis): There is no significant difference on the physical properties including moisture content, water activity, hygroscopicity, flowability, solubility, and color between rhizome pomace powder produced from black turmeric, white turmeric, and aromatic ginger treated with high-temperature drying at 80^{o}C for 18 hours, and low-temperature drying treatment at 50^{o}C for 48 hours.
- H1 (alternative hypothesis): There is no significant difference on the physical properties including moisture content, water activity, hygroscopicity, flowability, solubility, and color between rhizome pomace powder produced from black turmeric, white turmeric, and aromatic ginger treated with high-temperature drying at 80^{o}C for 18 hours, and low-temperature drying treatment at 50^{o}C for 48 hours.

1.4 Scope of the research

The scope of this research consists of several key steps in the utilization of Rhizome Pomace (RP). Initially, the process involves the peeling and water extraction that is carried out to collect the pomace resulting from this process. Following the pomace collection, the research moves on to RP powder production. This employs a cabinet drying procedure, involving both high and low-temperature methods, along with micronization. To acquire a thorough understanding of the physical characteristics of the RP powder, various analyses are performed, including measurements of hygroscopicity and solubility, determining moisture content, evaluating flowability, assessing water activity, and measuring color. These methods contribute to the thorough study of the properties and potential applications of RP.