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The Circular Economy of Herbal Beverage Products and Their Physicochemical Characteristics

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ABSTRACT

The circular economy seeks to maximize resource utility while enhancing waste materials' added value. Herbal beverages are derived from biopharmaceutical plants, commonly using ginger, cardamom, turmeric, aromatic ginger or lesser galangal, and curcuma. This study had two primary objectives: (1) to analyze the physicochemical characteristics of instant ginger, instant turmeric, and instant ginger beverages, and (2) to enhance the economic value of production waste by converting it into liquid organic fertilizer (POC). The research was conducted at the small and medium enterprise "AIG Bunda Nisa" in Semarang Regency, Indonesia. Physicochemical characteristics were assessed through proximate analysis, and the quality of the POC was evaluated based on the standards set by the Indonesian Ministry of Agriculture (No.216/KPTS/SR.310/M/4/2019). The findings revealed that waste from the production of instant herbal drinks can be effectively repurposed as POC. The analysis showed that instant ginger beverages have higher ash and carbohydrate content than fresh ginger but lower total fat and protein content. Additionally, instant ginger beverages' caloric value and carbohydrate content are higher than fresh ginger. Conversely, instant ginger's protein content is lower than fresh ginger's. In the case of turmeric, the ash, total fat, moisture, and protein content in fresh turmeric were lower than in instant turmeric beverages.

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1. Introduction

Herbal medicine offers a natural alternative that people can use to enhance immunity and help prevent the spread of diseases. Indonesia, home to the second-largest biodiversity in the world, boasts a rich variety of native medicinal plants (Yulianti & Bintoro, 2021). Among the plants used for natural health remedies are ginger, turmeric, and other biopharmaceutical crops. Compared to the synthetic pharmaceutical and biotechnology industries, Indonesia's herbal medicine sector is recognized as a robust industry, supported by abundant medicinal plants that are part of the country's vast biodiversity, totaling thousands of species (Sharma et al., 2021).

Modern research has demonstrated that many biopharmaceutical plants can help treat chronic diseases due to their antioxidant, anti-inflammatory (Hayu, 2019), anti-tumor, anti-acidogenic, and neuroprotective properties (Hermawan, 2020). Furthermore, several biopharmaceutical products' antioxidant and anti-aging agents show potential for use in the cosmetic industry (Kusumawati et al., 2018), with properties that can even lighten the skin (Li et al., 2019).

In line with this, Indonesia's agricultural development policies encourage the growth of off-farm systems aimed at producing high-quality, competitive products. However, for product diversification to succeed, support is needed through technological adoption and product innovation—areas where Biopharmaca SMEs in Indonesia have often faced challenges. The role of production technology is crucial, specifically in improving efficiency, productivity, and processes while enhancing product quality and added value.

Biopharmaceutical crops are a leading commodity in Semarang Regency, Indonesia. In 2018, the main biopharmaceutical plant productions were ginger (8,793.9 tons), followed by cardamom (2,042.7 tons), turmeric (1,241.5 tons), galangal (467.2 tons), and curcuma (208.3 tons) (Badan Pusat Statistik Kabupaten Semarang, 2019). Although production declined in 2019, the ginger commodity in Semarang remained one of the major contributors in Central Java, accounting for 20.06% of the total 27,071.1 tons produced (Badan Pusat Statistik Provinsi Jawa Tengah, 2020). Small and medium-sized enterprises (SMEs) in Semarang Regency have leveraged the vast potential of biopharmaceutical plants to produce a variety of post-harvest processed products, including simplicia, powders, herbal ingredients, and instant powdered drinks. SMEs such as "AIG Bunda Nisa" in Semarang Regency have produced six variants of instant powder drink products, including ginger, red ginger, turmeric, white turmeric, curcuma, and Javanese spice blends.

However, SMEs processing herbal beverage products face several challenges: (1) The production process remains traditional, resulting in significant food losses and requiring up to 12 hours per production cycle, leading to high fuel consumption. This traditional method also risks the loss and degradation of nutrients and other bioactive compounds; (2) The production waste amounts to 180 kg of dregs and 10 kg of starch per month, which has not yet been effectively utilized.

Therefore, this research aims to (1) identify the physicochemical characteristics of instant herbal beverage products and (2) enhance the economic value of production waste by converting it into organic fertilizer. Additionally, this research emphasizes the importance of

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utilizing local resources as functional food, reducing waste production, adding value, and fostering a circular economy.

2. Literature

Indonesians have long utilized traditional wisdom by incorporating ginger, curcuma, and turmeric into various herbal remedies, such as using ginger to treat colds, turmeric to address diarrhea, and curcuma to reduce body odor (Novianti, 2017). Modern research has revealed that these biopharmaceutical plants can treat chronic diseases due to their antioxidant, anti-inflammatory (Ghosh et al., 2015), anti-tumor, anti-acidogenic, and neuroprotective properties (Amalraj et al., 2017). These biopharmaceuticalplants' benefits attract people for personal use and trade. Ginger (183.52 thousand tons), turmeric (193.58 thousand tons), and curcuma (27 thousand tons) are key biopharmaceutical products that play a significant role in Indonesia's sustainable production efforts (Badan Pusat Statistik, 2021). Indonesia is also a major player in the rhizome trade under the Harmonized System (HS) 0910 group, which includes ginger, turmeric, curcuma, and other spices (Munadi, 2017).

Previous research on the diversification of herbal drink products and the utilization of waste has been widely explored. However, comprehensive studies integrating activities from upstream to downstream in the herbal drink industry remain limited, particularly concerning using production waste as raw material for liquid organic fertilizer. Most prior research has been fragmented. For example, a study in India focused on post-harvest management and value-added products of ginger (*Zingiber officinale Roscoe*) by improving technology and diversifying processed ginger into food products (Kaushal et al., 2017). Yet, herbal drink processing also produces significant amounts of waste that could be transformed into products with economic value (Santana et al., 2017).

In a circular economy, the dregs from processed herbal drink production can be repurposed as liquid organic fertilizer. Organic fertilizers offer several advantages: nitrogen (N) in the form of organic compounds that plants easily absorb, no inorganic acid residue left in the soil, and high levels of organic carbon (C) compounds. Liquid organic fertilizer (POC) improves soil structure, allows nutrients to be absorbed more rapidly by plants, enhances soil biological activity, contains beneficial microorganisms, is easier to apply, and can help address nutrient deficiencies (Siboro et al., 2013). Organic liquid fertilizer derived from biopharmaceutical production waste has been shown to contain N, P, and K following standards (Rusmilan & Putra, 2017). Furthermore, adding fish waste to the fertilizer introduces elements like Fe, Mg, and Ca, meeting quality standards as per SNI-19-7030-2004 (Jumirah et al., 2018).

Fertilizers are essential for plant growth and development. Commonly used fertilizers include organic varieties, such as compost and liquid organic fertilizers, and inorganic fertilizers, such as chemical fertilizers. Although many Indonesian farmers favor chemical fertilizers for quick results, prolonged use can reduce soil productivity, damage soil structure, and pose risks to human health. This highlights the need for liquid organic fertilizers (POC) that improve soil structure, offer quick nutrient absorption, enhance biological activity, and are easier to apply (Siboro et al., 2013).

A circular economy is a system that maximizes the usefulness and value of raw materials, components, and products while minimizing waste and preventing materials from ending up in landfills. The circular economy also promotes environmentally friendly economic growth, unlike the traditional "business as usual" approach. In the context of herbal medicine production, the circular economy goes beyond waste management; it involves designing raw materials, products, and processes to extend the lifecycle of materials and products. This model

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reduces waste, generates additional income, creates new jobs, and empowers women with better opportunities.

The circular economy is an alternative to the traditional linear economy (produce, use, dispose), aiming to conserve resources by keeping them in use for as long as possible, extracting maximum value from them, and then recovering and recycling products and materials at the end of their lifecycle. A circular economy is based on three core principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. In a circular economy, waste is eliminated as resources are continually cycled, allowing for more efficient and sustainable use of natural resources.

The shift toward a circular economy requires more than simply mitigating the negative impacts of the linear economy. It involves fundamental changes that build long-term resilience, generate business opportunities, and provide environmental and social benefits. Activities within a circular economy include collecting, sharing, maintaining, redistributing, remanufacturing, and recycling using new technologies and business models. Maintaining outdated linear technologies and business models is no longer viable for countries aiming to achieve a genuine circular economy.

Indonesia has incorporated the concept of a circular economy into its development vision and plans, promoting rapid economic change, particularly in fostering a green economy. Indonesia's Vision 2045 includes circular economy concepts as part of future policy. The circular economy is growing, with many businesses proactively adopting it to address sustainable development goals. The literature shows that collaborative interactions between supply chain partners support circular economy practices. In a circular economy, economic activities build and enhance systems at all levels, involving organizations and individuals and addressing global and local aspects. Adopting a circular economy in five key industrial sectors could contribute an additional GDP of Rp593 trillion and Rp642 trillion, according to a recent report by the Ministry of National Development Planning in partnership with the United Nations Development Program (UNDP). These sectors include food and beverage, textiles, wholesale and retail trade (focusing on plastic packaging), construction, and electronics. The report also estimates that by 2030, the circular economy concept could create around 4.4 million new job opportunities.

Resource utilization is the primary difference between the circular economy and other concepts. A circular economy recycles raw materials from various products, minimizing waste, emissions, and wasted energy. Key reasons for embracing the circular economy include waste reduction, increased productivity, addressing future resource shortages, and minimizing the negative environmental impacts of production and consumption.

Indonesia has integrated the circular economy concept into its development vision, accelerating economic transformation and supporting a green economy. Indonesia's Vision 2045 has laid out the circular economy as a future policy. As an initial step toward implementation, the Indonesian government, in collaboration with the UNDP, focuses on five key industrial sectors: food and beverage, construction, electronics, textiles, and plastics. The National Action Plan for 2025-2029 incorporates the circular economy into the RPJMN (Indonesia's national development plan). In practice, the Ministry of Industry has established five main principles of the circular economy: Reduce, Reuse, Recycle, Recovery, and Repair.

3. Research Methodology

This research is an exploratory study conducted in several stages: (1) determining the chemical characteristics of instant ginger, turmeric, and ginger drink products, as well as ginger

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and ginger extract residues, including proximate compound and mineral content (ash, protein, fat, carbohydrate, and water content); and (2) testing the phytochemical content of Plant Organic Compost (POC) following the Ministry of Agriculture's Standard No. 216/KPTS/SR.310/M/4/2019 regarding the Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Conditioners, with parameters including C-Organic, N-Total, P2O5, K2O, Fe, Mn, Zn, Cu, and B.

The research was conducted at the "AIG Bunda Nisa" small and medium enterprise (SME) in Semarang Regency, Indonesia. Purposive sampling was employed in this study, focusing on instant ginger, instant turmeric, and instant ginger herbal drinks. Data were collected through interviews, experiments, and laboratory testing techniques.

4. Results

The proximate analysis of instant herbal beverage products reveals the following for instant turmeric: ash content of 0.62%, energy from fat at 2.97 Kcal/100g, total fat content of 0.33%, the water content of 0.65%, the total energy of 396.57 Kcal/100g, the carbohydrate content of 97.36%, protein content of 1.04%, total plate count of 5.7 x 10^2 colony/g, and yeast mold count of 1.0 x 10^2 colony/g. In comparison to fresh turmeric per 100 grams, several differences were observed. Fresh turmeric had an ash content of 1.14%, total fat content of 9.1%, water content of 11.8%, and protein content of 5.7%, all higher than the corresponding values in instant turmeric. The total energy of fresh turmeric was 349.0 Kcal with a carbohydrate content of 59.4%, both of which were lower than the total energy and carbohydrate content in instant turmeric.

Table 1. Proximate Analysis of Instant Herbal Drink Products

No	Parameter	Unit	Instant Ginger	Instant Turmeric	Instant Curcuma	Method
1	Ash content	%	0.65	0.62	0.45	SNI 01-2891-1992 point 6.1
2	Energy from fat	Kcal/100g	0	2.97	0	Calculation
3	Total fat content	%	<0.02	0.33	<0.02	18-8-5/MU/SMM-SIG point 3.2.2 (Weibull)
4	Water content	%	0.83	0.65	0.61	SNI 01-2891-1992, point 5.1
5	Total energy	Kcal/100g	394.08	396.57	395.76	Calculation
6	Carbohydrates (By Difference)	%	97.66	97.36	98.23	18-8-9/MU/SMM-SIG (Calculation)
7	Protein content	%	0.86	1.04	0.71	18-8-31/MU/SMM-SIG (Titrimetry)
8	Total plate count (TPC)	colony/g	7.6 x 10^2	5.7 x 10^3	1.3 x 10^2	SNI ISO 4833-1:2015
9	Yeast mold	colony/g	<10	1.0 x 10^2	<10	SNI ISO 21527-2:2012

Source: Data Processed (2023)

5. Discussion

The proximate analysis results show that the instant curcuma herbal drink product from AIG Bunda Nisa contains 0.45% ash, less than 0.02% total fat, 0.61% water, 395.76 Kcal total

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energy, 98.23% carbohydrates, 0.71% protein, a total plate count (TPC) of 1.3 x 10^2 colony/g, and less than ten colony/g yeast. Instant ginger has higher ash and carbohydrate content but lower total fat and protein content than fresh ginger. Previous studies report that the proximate composition of fresh ginger includes 0.37% ash, 1.52% protein, 1.35% fat, 0.80% crude fiber, and 79.96% carbohydrates (Putri, 2013). The microbial levels in instant ginger meet the 2019 Indonesian Food and Drug Authority (BPOM) requirements, which specify TPC ≤ 5 × 10^7 colony/g and yeast and mold ≤ 5 × 10^5 colony/g (Badan Pengawas Obat dan Makanan, 2020).

Similarly, the proximate analysis of the instant ginger drink revealed 0.65% ash, 0 Kcal/gram energy from fat, less than 0.02% total fat, 0.83% water, 394.08 Kcal total energy, 97.66% carbohydrates, 0.86% protein, a TPC of 7.6 x 10^2, and less than ten colony/g yeast and molds. Fresh ginger contains 79 Kcal of energy, 17.86% carbohydrates, and 3.57% protein per 100 g (Sari & Nasuha, 2021). Instant ginger has higher carbohydrate and caloric value but lower protein content than fresh ginger. The microbial levels in instant ginger also comply with the 2019 BPOM requirements.

The proximate analysis of instant turmeric shows an ash content of 0.62%, energy from fat of 2.97 Kcal/100g, 0.33% total fat, 0.65% water, 396.57 Kcal total energy, 97.36% carbohydrates, 1.04% protein, a TPC of 5.7 x 10^2, and 1.0 x 10^2 colony/g yeast and molds. Instant turmeric shows higher values than fresh turmeric, which contains 1.14% ash, 9.1% fat, 11.8% water, and 5.7% protein. Fresh turmeric's total energy is 349.0 Kcal with 59.4% carbohydrates, lower than instant turmeric. The microbial levels in instant turmeric also meet the 2019 BPOM standards. Turmeric, a plant from the ginger family (*Zingiberaceae*), is commonly used as a spice. Previous research has shown that turmeric can improve the quality of foods like duck meatballs (Murti et al., 2013).

The nutritional content of instant products differs significantly from that of fresh ingredients. In all three samples, the carbohydrate content of instant products is higher than that of fresh ingredients. Carbohydrate levels in plants are influenced by photosynthesis and are stored in roots, tubers, or seeds (Nurcahyani et al., 2019). The higher carbohydrate content in instant products may be due to adding ingredients like sugar to crystallize the ginger powder. In protein analysis, instant turmeric and curcuma had higher protein levels than fresh ginger and turmeric, while instant ginger had lower protein content than fresh ginger. These differences could be attributed to the processing of instant products. Proper processing can enhance the nutritional content and protein digestibility, but improper techniques, such as excessive heat, can denature proteins (Sundari et al., 2015).

Regarding water content, the instant product samples have lower water content than fresh ingredients. Moisture content directly affects the stability and quality of food; higher water content increases the risk of spoilage due to internal biological activity and microbial growth (Hammond et al., 2015). Regarding ash content, instant ginger has a higher ash content than fresh ginger, while instant turmeric has a lower ash content than fresh turmeric. Ash is the inorganic residue left after the combustion of organic material and is related to the mineral content of food. The ash content of food is determined by the type of material and the ashing method.

The total plate count (TPC) is a test that measures the number of bacteria in a sample. A higher TPC indicates more bacterial colonies, suggesting that the product's manufacturing process may not be hygienic or sterile (Mursalim, 2018). However, the TPCs of instant curcuma, turmeric, and ginger meet BPOM standards, ensuring product quality. The yeast and mold levels in these products also comply with BPOM standards. Mold is a multicellular organism that typically grows on food and is easily observable as a fungus. Several factors can influence

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mold growth, including moisture content, storage temperature, storage duration, product drying, and external air contamination (Muchtar et al., 2011). In this case, the production and storage processes were appropriately managed, preventing mold and yeast growth from exceeding BPOM standards.

The test results for ginger powder (SJ), turmeric powder (SK), and curcuma powder (ST), as well as dregs products including ginger dregs (AJ), turmeric dregs (AK), and curcuma dregs (AT) for metal As and Hg, are presented in **Table 2**.

Table 2. As and Hg Content in Tested Samples

Sample	Dissolved Arsenic (As) (mg/L)	Dissolved Mercury (Hg) (mg/L)
Ginger Powder (SJ)	0.0027	0.0003 x 10^-1
Turmeric Powder (SK)	0.0016	<0.0003 x 10^-1
Curcuma Powder (ST)	0.0034	<0.0003 x 10^-1
Turmeric Dregs (AK)	0.0057	<0.0003 x 10^-1
Ginger Dregs (AJ)	0.0065	<0.0003 x 10^-1
Curcuma Dregs (AT)	0.0091	<0.0003 x 10^-1
Quality Standards	**≤ 5.0**	**≤ 0.5**

Source: Data Processed (2023)

Laboratory tests were conducted to assess the presence of Hg and As metal contaminants in instant herbal medicine powder samples, specifically turmeric powder (SK) and ginger powder (SJ and ST). The Hg content in SK and ST samples was <0.0003 x 10^-1 mg/L, while SJ showed 0.0003 x 10^-1 mg/L. These Hg levels meet the BPOM (2019) regulatory threshold of ≤ 0.5 mg/L. For dissolved As content, the ST, SJ, and SK samples showed levels of 0.0034 mg/L, 0.0027 mg/L, and 0.0016 mg/L, respectively, all within the BPOM guideline of ≤ 5 mg/L.

A prior study by Pulung reported that heavy metal As in ginger powder was below the detection limit, which may differ due to the raw ginger material used (Pulung, 2018). A different study by Husna on Hg contamination in herbal medicines in Pekanbaru found that 4 out of 6 samples exceeded BPOM thresholds, possibly due to contamination from raw materials (Husna et al., 2015). Heavy metal contamination in rhizome plants can be influenced by soil fertility, organic material, and environmental pollution (Yuan et al., 2009).

The curcuma dregs (AT) results showed dissolved As at 0.0091 mg/L and Hg at <0.0003 x 10^-1 mg/L, below BPOM standards. Similar results were observed for ginger dregs (AJ) and turmeric dregs (AK), with Hg content below detection limits and As levels well within regulatory standards. These findings suggest that the plants used for these herbal products were grown in areas with low heavy metal contamination, making them relatively safe for herbal medicine production.

Herbal beverage waste can be repurposed to produce organic liquid fertilizer (POC). POC has several advantages, such as improving soil structure, enhancing nutrient absorption, and supporting soil biological life. The waste from the herbal drink production by AIG Bunda Nisa is being engineered into POC (approximately 10 liters in volume), using additional ingredients such as 200 grams each of moringa leaves and neem leaves, 1 kg of bamboo shoots, 1 kg of banana stem, and other components, including coconut water, rice washing water, and rabbit urine.

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The development and refinement of products are crucial for increasing competitiveness and maximizing profits (Rifkowaty & Martanto, 2016). From laboratory tests, the POC produced from herbal drink waste does not yet meet Indonesian National Standard (SNI) requirements in several parameters (see **Table 3**).

Table 3. Results of Liquid Organic Fertilizer Testing

No	Parameter	Unit	Results POC-73/VI/2022	Quality Standards*
1	pH.H20	-	5.73	-
2	C-Organic	%	1.15	Minimum 10%
3	N-Total	%	0.17	Minimum 0.5%
4	C/N Ratio	-	6.71	-
5	P2O5	%	0.04	2-6%
6	K2O	%	0.48	2-6%
7	Na	%	0.06	Maximum 2000 ppm
8	Ca	%	0.10	-
9	Mg	%	0.03	-
10	Fe	ppm	75.04	90-900 ppm
11	Mn	ppm	17.21	25-500 ppm
12	Zn	ppm	5.65	25-500 ppm
13	Cu	ppm	1.62	25-500 ppm
14	B	ppm	10.82	12-250 ppm
15	S	%	0.11	-

Note: Ministry of Agriculture No.216/KPTS/SR.310/M/4/2019 regarding Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvers

Several POC parameters, including C-Organic, N-Total, P2O5, K2O, Fe, Mn, Zn, Cu, and B, fall below the Ministry of Agriculture's quality standards. For instance, the C-Organic content is significantly lower than the minimum standard, requiring an additional 8.85% to meet quality requirements. Similarly, the N-Total content requires an additional 0.33%, and P2O5 and K2O need increases of 1.96% and 1.52%, respectively, to meet standards. Other elements, such as Fe, Mn, and B, are closer to meeting the standards.

In the herbal medicine industry, waste should be utilized to create value-added products through technological processes, enhancing economic value and sustainability. The value-addition process transforms raw materials into more valuable products due to processing, transportation, or storage.

Several patents related to POC production, such as Patent IDS000002008, filed on November 7, 2018, and Patent P00201910175, granted on November 8, 2019, involve processes and formulations for creating liquid organic fertilizers. However, these patents are limited by the availability of specific raw materials, which may not be readily available in all locations. In contrast, the herbal waste from turmeric and curcuma pulp is abundant. Its high C-Organic and N-Total content shows potential as a raw material for POC despite low P2O5 and K2O levels.

The POC formulation can be improved using the ingredients listed in **Table 4**.

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Table 4. Composition of Raw Materials for POC Production (40 liters)

No.	Raw Materials	Volume/Amount	Unit	Percentage
1	Curcuma dregs	2	Kg	4.22 – 4.30
2	Turmeric dregs	2	Kg	4.22 – 4.30
3	Maringa leaves	0.2	Kg	0.42 – 0.50
4	Neem leaves	0.2	Kg	0.42 – 0.50
5	Bamboo shoots	1	Kg	2.11 – 2.20
6	Young banana trunk	1	Kg	2.11 – 2.20
7	Betel leaves	0.2	Kg	0.42 – 0.50
8	Tobacco leaves	0.1	Kg	0.21 – 0.30
9	Red onion	0.25	Kg	0.53 – 0.60
10	Garlic	0.25	Kg	0.53 – 0.60
11	Lime betel	0.02	Kg	0.04 – 0.06
12	Cooked shrimp paste	0.02	Kg	0.04 – 0.06
13	Flavoring	0.05	Kg	0.11 – 0.20
14	Coconut water	3	Liter	6.33 – 6.40
15	Rice washing water	3	Liter	6.33 – 6.40
16	Rabbit urine	3	Liter	6.33 – 6.40
17	Aloe vera	0.2	Kg	0.42 – 0.50
18	Soursop leaves	0.5	Kg	1.06 – 1.10
19	Swamp moss	0.2	Kg	0.42 – 0.50
20	EM4	0.1	Liter	0.21 – 0.25
21	Cane molasses	0.1	Liter	0.21 – 0.25
22	Water	30	Liter	63.30 – 63.40

Numerous methods and compositions for liquid organic fertilizer (POC) have been patented, such as the process described in Patent Number IDS000002008, dated November 7, 2018, titled "Liquid Organic Fertilizer Manufacturing Process." This process involves mixing coconut water with molasses in a 3:1 ratio to form the media material, adding decomposer microbes, and then incorporating 500 liters of the material over 30 days, stirring every ten days until the POC is formed.

Another invention, registered under Application Number P00201910175 and granted on November 8, 2019, is titled "Liquid Organic Fertilizer Formulation and Its Use." This formulation consists of 10% fish waste, 10% potatoes, and 80% water, which are boiled for 40 minutes, cooled, mixed with a microbial starter, and then fermented for one month. However, these inventions have limitations related to the availability of raw materials. While some ingredients may be difficult to find, herbal medicine waste, such as turmeric and ginger pulp, is abundant at the invention's location, which has not been widely utilized as a raw material for POC. Test results indicate that turmeric and Curcuma pulp have high levels of organic carbon (C-Organic) and total nitrogen (N-Total), making them promising candidates for POC production despite lower levels of phosphorus (P2O5) and potassium (K2O).

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Table 5. Chemical Content Test Results of POC from Turmeric and Curcuma Dregs

No.	Parameter	Unit	Results
1.	pH.H2O	-	5.73
2.	C-Organic	%	1.15
3.	N-Total	%	0.17
4.	C/N Ratio	-	6.71
5.	P2O5	%	0.04
6.	K2O	%	0.48
7.	Na	%	0.06
8.	Ca	%	0.10
9.	Mg	%	0.03
10.	Fe	ppm	75.04
11.	Mn	ppm	17.21
12.	Zn	ppm	5.65
13.	Cu	ppm	1.62
14.	B	ppm	10.82
15.	S	%	0.11

The composition of the mixture, which includes ingredients such as ginger pulp (4.22%), turmeric pulp (4.22%), moringa leaves (0.42%), neem leaves (0.42%), young banana stems (2.11%), bamboo shoots (2.11%), betel leaves (0.42%), tobacco leaves (0.21%), shallots (0.53%), garlic (0.53%), lime betel (0.04%), cooked shrimp paste (0.04%), flavoring agents (0.11%), coconut water (6.33%), rice washing water (6.33%), rabbit urine (6.33%), aloe vera (0.42%), soursop leaves (1.06%), swamp moss (0.42%), EM4 (0.21%), and cane molasses (0.21%), complies with the regulations set by the Ministry of Agriculture. POC made from ginger and turmeric waste from herbal medicine production can be used to fertilize plants. The application involves diluting one bottle cap of POC in 2-3 liters of clean water, stirring, and letting it stand for 10 minutes before spraying it on the plants' stems, branches, and leaves. Spraying should be done weekly until the plants mature.

6. Conclusion

Instant herbal drink waste can be effectively used as liquid organic fertilizer (POC) for biopharmaceutical plants. Instant ginger drink powder has a higher ash and carbohydrate content than fresh ginger but lower total fat and protein content. The carbohydrate content and caloric value of instant ginger drinks are higher than those of fresh ginger, while the protein content is lower. Similarly, fresh turmeric's ash, total fat, water content, and protein content are lower than in instant turmeric drinks, while the energy and carbohydrate content are also lower. Test results indicate that turmeric and ginger dregs contain high levels of organic carbon (C-Organic) and total nitrogen (N-Total), making them suitable raw materials for POC production. However, since the levels of P2O5 and K2O are low, these elements may need to be supplemented from other organic sources.

The circular economy approach is key to maximizing the use and added value of raw materials, components, and products. In the context of herbal medicine production, this model involves waste management and considers the design of raw materials, product development, and production processes to ensure that raw materials and products can be recycled and have a

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longer life cycle. This model has the potential to generate additional income, reduce waste, and create new job opportunities, particularly empowering women with better economic prospects.

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8. Declaration of Conflicting Interests

The authors have declared no potential conflicts of interest concerning this article's research, authorship, and/or publication.

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