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Recover Together, Recover Stronger, Building A Sustainable and Resilient Agriculture Food System

3rd ICTAFF
FACULTY OF AGRICULTURE
MULAWARMAN UNIVERSITY

Balikpapan, September 19th, 2023

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Building A Sustainable and Resilient Agriculture Food System "

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Prof. Dr. Ivan Galis (Institute of Plant Science and Resources, Okayama University, Japan)
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FOREWORD

This proceeding book is a collection of scientific thoughts presented by researchers at the 2023 International Conference on Tropical Agrifood, Feed, & Fuel (ICTAFF) Seminar. The theme of the seminar was: **"Recover Together, Recover Stronger, Building A Sustainable and Resilient Agriculture Food System".**

Agriculture in the broadest sense has become one of the cornerstone sectors for economic growth. The development of globalization still leaves unresolved problems in all aspects of agriculture, especially added to the problems in the period after the current pandemic, the rapid development of technology and the flow of globalization are increasingly putting pressure on various agricultural actors both in Indonesia and internationally, especially third world countries. The local potential in the agricultural sector in Indonesia has a huge opportunity both from social, cultural and technological aspects to provide a distinctive characterization. Local wisdom in the agricultural sector can have a positive impact.

Agricultural sustainability is also supported by aspects of local wisdom that have advantages in the quality of these products. These potentials can still be improved through the empowerment of local potentials so that they can be competitive and have high economic value. Increasing this potential can be done in terms of increasing the agricultural value of form utility, time utility, place utility, and possesion utility. Activities that can be carried out in the form of agricultural production that is capable of high productivity and quality, processing of agricultural products to increase added value, agricultural marketing so that agricultural products are of high selling value and can be available and affordable by the community, as well as supporting systems and agricultural institutions that support the smooth running of productive activities.

This International Seminar intends to produce various innovative and solutive thoughts related to the problems that become the theme. It takes an active role from various parties in order to contribute to the Indonesian economy. The publication of these proceedings is expected to be a picture and reference for improving agriculture to become high value-added and competitive in order to realize the welfare of farmers. We would like to thank all parties involved in the completion of these proceedings. Hopefully this book will be useful and open our insights into agriculture as a life support. Long live Indonesian Agriculture.

Samarinda, September 19th 2023

Editor

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FOREWORD BY THE CHAIRMAN

Assalammu'alaikum Warahmatullahi Wabarakatuh.
Good morning.
Whom I respect,
Rector of Mulawarman University Samarinda;
Dean of the Faculty of Agriculture, Mulawarman University, Samarinda;
Vice Dean of the Faculty of Agriculture, Mulawarman University, Samarinda;
Main Speaker, Speaker and moderator; Guests as well as:
We are proud of the seminar participants and attendees.

Thank God to Allah SWT who has given His grace, so that today we can attend the 3rd ICTAFF International Seminar, Faculty of Agriculture, Mulawarman University in good health. The ICTAFF activity is a biennial research results dissemination agenda that has been carried out by the Faculty of Agriculture, Mulawarman University since 2018. This 3rd ICTAFF activity carries the theme **Recover Together, Recover Stronger: Building a Sustainable and Resilient Agriculture Food System**.

It is believed that the agricultural sector can be a beacon of hope in maintaining national economic stability. The agricultural sector not only guarantees food availability, but also absorbs large numbers of workers, reduces poverty and improves people's welfare. Universities as centers for the development of science and innovation must be able to provide the best solutions to increase production and maintain the quality of food products. The use of science, innovation and technology is critical to meeting the global challenges of producing food more efficiently, improving nutrition and helping families who depend on agriculture for a living become more resilient.

In connection with this international seminar, we presented five resource persons as main speakers, namely Prof. Ivan Galis (Institute of Plant Science and Resources, Okayama University, Japan), Prof. Normaz Wana Ismail (Vice Dean of Research, Funding, Corporate and Community Linkages School of Business and Economics University Putra Malaysia), Prof. Worawan Panpipat (Dean of the Faculty of Agricultural Technology, Walailak University, Thailand), Prof. Md. Sazedul Hoque, Ph.D (Chair, Faculty of Fisheries, Putuakhali Science and Technology University, Bangladesh), Prof. Sahat M. Pasaribu, Ph.D. (BRIN Industrial, Services and Trade Economic Research Center, Indonesia), and Dr. Odit Ferry Kurniadinata, S.P., M.Sc. (Department of Agroecotechnology, Faculty of Agriculture, Mulawarman University, Indonesia). As well as people as accompanying resource persons from various domestic and foreign institutions and universities.

On this occasion, allow us to thank the Rector of Mulawarman University, the Dean of the Faculty of Agriculture, Mulawarman University, the sponsors who have participated in this seminar activity. As well as the highest appreciation to the entire committee who have worked wholeheartedly for the success of this seminar activity.

We realize that the implementation of this international seminar still has many shortcomings, for that we apologize profusely. Finally, I hope that all seminar participants who attended can get the maximum benefit from this seminar activity. Billahi taufiq wal hidayah Wassalammu'alaikum warahmatullahi wabarakatuh.

Balikpapan, September 19th 2023

Chief Executive,
Dr Syamad Ramayana

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FOREWORD BY THE DEAN

Ladies and gentlemen,

Distinguished guests, speakers, researchers, and fellow participants,

It is with immense pleasure and great enthusiasm that I extend a warm welcome to all of you at the opening of the third International Conference of Tropical Agrifood, Feed, and Fuel hosted by the Faculty of Agriculture. Today, we gather here to explore the horizon of agriculture, share knowledge, and envision a more sustainable and resilient agrifood system for the future. Our theme for this conference is, "Recover together, recover stronger: Building a Sustainable and Resilient Agriculture Food System."

Agriculture is the cornerstone of life, the backbone of our existence. It is an industry that touches every aspect of our lives, from the food we eat to the fuel that powers our world. In the tropical regions, agriculture plays an even more critical role, providing sustenance, employment, and economic development to countless communities. It is only fitting that we convene here today to discuss the challenges and opportunities that lie ahead in tropical agrifood production.

The past few years have brought unforeseen challenges to the global agricultural landscape. Climate change, the COVID-19 pandemic, and economic fluctuations have shown us the vulnerabilities in our current systems. However, we are resilient beings, and with every challenge come an opportunity to adapt and evolve. It is during times like these that our collective knowledge, expertise, and innovative spirit shine the brightest.

This conference aims to be a platform where experts from various fields, researchers, and policymakers come together to engage in fruitful discussions, share their research findings, and inspire one another with innovative solutions. We hope to explore sustainable agricultural practices, cutting-edge research in agrifood technology, and policies that promote resilience and inclusivity in the agricultural sector.

Together, we will examine the impact of emerging trends, such as precision agriculture, biotechnology, and sustainable resource management, on tropical agrifood production. Our goal is to foster a global understanding of the unique challenges and opportunities that tropical agriculture presents and to work collectively towards building a more sustainable and resilient agriculture food system.

As we embark on this intellectual journey over the next few days, I encourage all of you to actively participate, engage in thought-provoking discussions, and establish connections that may lead to collaborations and breakthroughs in the field of agriculture. We believe that through shared knowledge and collective efforts, we can indeed recover together and recover stronger.

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Ladies and gentlemen,

As we gather here today for the opening of this prestigious international conference, I would like to extend our heartfelt gratitude to our distinguished international speakers who have traveled from afar to share their invaluable insights and expertise with us.

We are honored to have with us Prof. Worawan Panpipat from Walailak University, Thailand, Prof. Dr. Ivan Galis from Okayama University, Japan, Prof. Normaz Wana Ismail from Universiti Putra Malaysia, Prof. Sahat M. Pasaribu from BRIN, and Dr. Odit Ferry Kurniadinata from Mulawarman University, Indonesia. Your dedication to advancing knowledge and your commitment to this conference are truly appreciated. Your contributions will undoubtedly enrich the discussions and inspire us all as we work towards building a more sustainable and resilient agricultural food system. Thank you for your presence and your dedication to the betterment of agriculture on a global scale.

I also want to express my heartfelt gratitude to all the participants, our distinguished the organizing committee, and our generous sponsors for their support and dedication in making this conference a reality.

With that, I officially declare the third International Conference of Tropical Agrifood, Feed, and Fuel open. Let us work together towards a more sustainable and resilient future in agriculture. Thank you, and I wish you all a successful and inspiring conference.

Balikpapan, September 19th 2023

Dean,

Prof. Dr.Ir. H. Rusdiansyah, M.Si

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Literature Review of The Potential of *Eleutherine americana* Merr and Its Application in Food Products

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ABSTRACT

Tiwai onions, also known as Dayak onions, are a variety of plants found in Indonesia, particularly in the Kalimantan region, where they are traditionally cultivated by the Dayak people. These onions are commonly used in ways similar to shallots, including pickles, sweets, culinary spices, and herbal drinks. Tiwai onions are rich in bioactive compounds, such as alkaloids, steroids, flavonoids, glycosides, tannins, and phenolics, which offer various health benefits. The extraction of these bioactive components from tiwai onions typically employs the maceration method, using various solvents such as ethanol, distilled water, n-hexane, ethyl acetate, and others. Different solvents yield varying amounts of bioactive components. Several studies have highlighted the numerous benefits of tiwai onions, which include the potential to reduce high blood pressure, high cholesterol, diabetes, constipation, kidney stones, cancer, and the risk of stroke. Currently, tiwai onions are being explored as a supplement or fortification ingredient in food products, including candies. Future research in this area is anticipated and should focus on innovative food fortification technologies that can effectively incorporate tiwai onion extracts. This approach can potentially enhance both the yield and economic viability of tiwai onion cultivation.

Keywords: tiwai onions, functional food, bioactive, bioactivity, extraction

INTRODUCTION

Sabrang onions or Dayak onions are a species of onion originating from the United States, which belongs to the Iridaceae family. Some people call the Latin name *Eleutherine americana*, *Eleutherine bulbosa, and Eleutherine palmifolia*. This plant is widely cultivated in South America, Africa and Southeast Asia, such as Indonesia (Kusuma et.al, 2010; Insanu et.al, 2014). Dayak onions are a plant that grows a lot on the island of Kalimantan, that's why people across Kalimantan call them "diamond onions or sabrang onions" because they have to 'nyabrang' or cross to Kalimantan Island if they want to pick them. Meanwhile, Dayak onions are obtained by the Dayak tribe in the forest, so they call them "forest onions or kambe onions" and tiwai onions. Because of its health benefits, Malays often call it the Mecca onion (Indrawati and Razimin, 2013). The Dayak tribe traditionally uses tiwai onions as a medicinal plant, food flavoring, pickle, or as a stamina enhancer and is now also being developed as a functional drink. Tiwai onion plants can be seen in Figure 1.

Figure 1. Tiwai onion plant (Personal documentation, 2023).

The extraction process is the initial stage that needs to be carried out to extract bioactive compounds from the sample matrix, such as bulbs, to facilitate the process of further analyzing phytochemical compounds. Extraction of materials is typically considered a separation process, where bioactive compounds are isolated from the food. Different parts of plants produce varying phytochemical contents due to the structure of the plant matrix. The choice of solvents for the extraction process depends on the bioactive compounds being analyzed (Sarajlija et al., 2012; Rehman et al., 2020). Solvents can be categorized based on their polarity, such as polar, semi-polar, and non-polar. Examples of polar solvents include water, acetonitrile, methanol, and ethanol, while non-polar solvents include acetone, chloroform, and ethyl ether. According to Abarca-Vargas et al. (2016), phytochemical compounds in plants or food have different polarities; therefore, bioactive compounds can be extracted using appropriate solvents. The choice of solvent for the extraction process is crucial in maximizing the extract yield and bioactivity of plant extracts, depending on the specific properties of the desired phytochemical content. Solvent polarity is an important factor in determining the desired bioactive compound (Waszkowiak et al., 2015; Altemimiet al., 2017). Each solvent has different qualities for separating phytochemical compounds.

The superiority and evaporation process of the solvent when extracting tiwai onions are determining factors in obtaining high bioactive compounds. The extraction process for Tiwai onions can be carried out using methods such as maceration, percolation, soxhletation, reflux, and steam distillation. Various types of solvents are used in the maceration of tiwai onions. For instance, Sulastri and Oktaviani (2015), Syamsul et al. (2015), Yuliandra et al. (2018), Asih and Suprapto (2018), Jannah et al. (2018), Kartikasari and Anggraini (2018), Christopher et al. (2017), Kuntorini et al. (2016), Kuntorini and Astuti (2010), Saleh (2010), Kuntorini (2013), Nurliani and Santoso (2012), and Sulastri and Oktaviani (2015) reported that the extraction process using maceration with 96% ethanol produces a thick tiwai onion extract. On the other hand, Chen et al. (2019) and Han et al. (2008) used only methanol in their research. HS and Sampepana (2007) and Rauf et al. (2018) employed methanol extract and Tiwai onion water, while Sa'adah and Nurhasnawati (2015) used ethanol extract and water. Furthermore, in the food sector, this extract has found widespread application in various food products as a food additive, functional drink ingredient, processed snacks, candy, natural coloring, and nutritional additive for animal feed.

MATERIALS AND METHODS

This review paper was created by conducting a comprehensive review of several relevant articles to assess the current status and development of tiwai onions. To achieve this objective, the author reviewed various sources, including journal articles, conference proceedings, books, book sections, dissertations, theses, and online resources related to the development of tiwai onions. After collecting and analyzing the data, the author summarized all the information. In the concluding discussion, essential findings and insights were synthesized, which can serve as additional knowledge, references, and recommendations forthe further development of this local plant.

RESULTS AND DISCUSSION

Phytochemistry and Quantification of Bioactive Compounds Tiwai Onion

Tiwai onion bulbs consist of three main groups of compounds: naphthalene, anthraquinone, and naphthoquinone (Wang et al., 2015). Meanwhile, compounds isolated from this herbaceous plant include eleutherin, isoeleutherin, eleutherol, isoeleutherol, hongconin, eleutherinol, elecanacin, eleutherinoside A and B, and eleuthraquinone A and B (Insanu et al., 2014). Kamarudin et al. (2019) conducted an HPLC analysis revealing eight bioactive compounds: eleutherine, gallic acid, chlorogenic acid, quercetin, kaempferol, rutin, epicatechin gallate, and myricetin. Nascimento et al. (2012) identified anthraquinones, triterpenoids, saponins, while research by Pratiwi et al. (2013) reports that tiwai leaves contain flavonoids, saponins, phenols, and tannins. According to Kuntorini and Nugroho (2010), the secondary metabolite content varies during the development process of tiwai onion plants in the bulbs, increasing significantly with bulb development, but the secondary metabolite content in the leaves is not significant.

Bioactivity of Tiwai Onion

Tiwai onion bulb extract is traditionally used by the Dayak Community for various health purposes,including treating diabetes, stroke, breast cancer, hypertension, increasing breast milk production, addressing fertility problems, alleviating menstrual pain, and promoting anti-inflammatory and wound healing effects (Ieyama et al., 2011; Saragih et al., 2014; Saragih et al., 2017; Han et al., 2008). This plantis often consumed in the form of tea and is well-known in phytotherapy in the Amazon for treating amoeba-induced diarrhea (Nascimento et al., 2012).

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Tiwai onion bulb extract is obtained through the extraction process of fresh or dried tiwai onion bulbs using various solvents. Tiwai onion bulb extract has demonstrated bioactive properties such as antibacterial, antioxidant, antihypertensive, antifungal, anti-inflammatory, antidiabetic, and anticancer effects. These bioactive properties of the extract will be discussed further in the following subsection.

Anti-bacterial

Tiwai onion bulb extract, especially ethanol extract, is rich in secondary metabolite compounds, some of which exhibit antibacterial properties by inhibiting the growth of bacteria, both gram-positive and gram-negative types. Secondary metabolite compounds with antibacterial functions include tannins, saponins, and flavonoids. Research by Munaeni et al. (2017) reported that the ethanol extract of tiwai onion bulbs significantly inhibited the growth of Vibrio harveyi in a dose-dependent manner compared to chloramphenicol. The inhibitory diameter increased with higher concentrations, and phytochemical analysis revealed the presence of flavonoids, alkaloids, quinones, and triterpenoids. Harlita and Oedjijono (2018) found that n-hexane, ethyl acetate, and 96% ethanol extracts of tiwai onion bulbs demonstrated effective microbial inhibition against pathogenic bacteria such as Bacillus cereus, MRSA, Shigella sp, and Pseudomonas aeruginosa using the disc diffusion agar method. Furthermore, Jiang et al. (2020) investigated the antimicrobial activity of active fractions extracted from tiwai onion bulbs against pathogenic bacteria like Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa. The results showed that the compounds eleubose A and B exhibited moderate inhibitory activity against E. coli with a minimum inhibitory concentration (MIC) value of 12.5 g/mL and mild inhibition against S. aureus and P. aeruginosa with an MIC value of 25 g/mL compared to the positive control (clarithromycin). Meanwhile, research conducted by Mahmudah et al. (2019) using a water extract of tiwai onion bulbs significantly inhibited the growth of E. coli, with an inhibitory diameter ranging from 6 mm at the lowest concentration of 10% to 30 mm at the highest concentration of 100% compared to the positive control, ceftriaxone (35 mm).

Antioxidant

Antioxidant activity is aimed at preventing the formation of free radicals, which are compounds or molecules containing one or more unpaired electrons in their outer orbital, making them highly reactive and prone to causing diseases (Sunarni et al., 2007). The parameter used to assess antioxidant activity is the efficient concentration (EC50) or Inhibition Concentration (IC50), representing the concentration required to inhibit 50% of radicals (Naspiah et al., 2013). Substances with high antioxidant activity have low IC50 values. A compound is considered a very strong antioxidant if its IC50 value is less than 50 ppm, strong if between 50-100 ppm, moderate if between 100-150 ppm, and weak if between 151-200 ppm (Mardawati et al., 2008). Munaeni et al. (2020) conducted research on the antioxidant activity of tiwai onion bulbs, demonstrating strong antioxidant activity with an IC50 value of 1.48 g/mL in DPPH testing, compared to the positive control ascorbic acid. Strong antioxidant activity can promote the growth of prebiotic bacteria, indicating the potential of tiwai onion bulb extract to act as both an antioxidant and a prebiotic. Kamaruddin et al. (2020) obtained similar results, with DPPH testing showing 75.2% and ABTS of 74.9% antioxidant activity under optimized extraction conditions compared to Trolox, indicating strong antioxidant activity in tiwai onion bulb extracts. Other research has shown that ethanol extracts of tiwai onion bulbs exhibit strong antioxidant activity against DPPH (1,1-diphenyl-2-picrylhydrazyl) with an IC50 value of 25.33 ppm (Kuntorini and Astuti, 2010). Additionally, Pratiwi et al. (2013) reported that ethanol extracts of tiwai leeks obtained through maceration had an IC50 value of 31.97 ppm.

Agustin et al. (2016) found that the most effective solvent for extracting polyphenols from tiwai onion bulbs is 70% methanol, resulting in a phenol content of 20 mg GAE/g DW and flavonoids of 15.03 mg QE/g DW compared to gallic acid and quercetin. It also showed an IC50 value of 39.06 g/mL in DPPHtesting. Shi et al. (2019) discovered that tiwai onion bulb extracts are rich in phenols and flavonoids, indicating strong antioxidants as evidenced by their high peroxyl radical scavenging capacity in HepG2 cells. Moreover, Morabandza et al. (2016) reported that ethanol solvent extracts of tiwai onion bulbs contained a total phenolic content of 27.12 mg GAW/g DW and flavonoids of 17.97 mg RE/g DW compared to water extracts. The ethanol extracts of tiwai onion bulbs also exhibited high polyphenol content, resulting in high antioxidant activity with an IC50 value of 0.595 mg/mL compared to water extracts of tiwai onion bulbs with an IC50 value of 1.251 mg/ML. In vivo research has demonstrated that tiwai onion bulb extract's antioxidant activity can improve sperm quality in mice. It was found that the extract significantly increased sperm concentration in rats induced by lead acetate (Jayanti et al., 2019). Meanwhile, Ernawati and Nurliani (2012) stated that the ethanol extract of tiwai onion bulbs, when administered to male rats exposed to cigarette smoke, increased free radical inhibition activity, leading to an increase in spermatid cell count from 3.00 to 3.36. This effect counteracted the decrease in cell count initially caused by free radicals from cigarette smoke. The variation in results from these studies can be attributed to different factors, such as the different regions

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from which onion bulbs were sourced, resulting in varying concentrations of active compounds. Additionally, differences in the solvents used and potentialerrors in the preparation of simplicia and tiwai onion bulb extracts could also contribute to variations in outcomes.

Antidiabetic

Diabetes mellitus is a genetic disease characterized by chronic metabolic disorders that result in various vascular complications and cardiac dysfunction due to elevated blood glucose levels (Sharma et al., 2020). Research on tiwai onion bulb extract as a functional bioactive agent has been conducted both in vitro and in vivo. In vitro research conducted by Ieyama et al. (2011) demonstrated that a compound isolated from the methanol extract of tiwai onion bulbs, namely eleutherinoside A, exhibited inhibitory activity against the ά-glucosidase enzyme with an IC50 value of 0.5 mM. Inhibition of this enzyme prevents the breakdown of carbohydrates into monosaccharides and their absorption in the intestine, thereby reducing blood glucose levels. This property attributes antidiabetic potential to tiwai onions by inhibiting the ά-glucosidase enzyme. Chen et al. (2018) found potential therapeutic effects of compounds isolated from tiwai onion bulbs (eleutherol A, B, and C; eleuthinone B and C) against hyperglycemia, providing a protective effect on human umbilical vein endothelial cells (HUVECs) exposed to high glucose levels. Furthermore, Lahrita et al. (2015) investigated traditional medicinal plants in Indonesia used to alleviate diabetes symptoms and found that tiwai onion bulbs exhibited activity in increasing glucose absorption induced by insulin at a concentration of 50 g/mL, similar to 12 other medicinal plants when compared to rosiglitazone. In vivo research conducted by Saleh (2010) examined the hypoglycemic effect of ethanol extract of tiwai onion tubers by orally administering the extract to male rats previously given glucose. The results indicated that the extract had a hypoglycemic effect on rats at a dose of 50 mg/kgBW. Additionally, Febrinda et al. (2014) reported that the consumption of water and ethanol extracts of tiwai onion bulbs inhibited the alpha-glucosidase enzyme, thereby reducing postprandial blood glucose levels.

Another study by Ahmad et al. (2018) found that methanol extract of tiwai onion bulbs, obtained using three different extraction methods, reduced glucose tolerance levels in Swiss albino mice. The results showed significant reductions with glucose levels reaching 62.2% and 74.6% 90 minutes after treatment for the reflux and maceration methods, respectively, compared to the positive control, glibenclamide, which showed a 55.2% reduction. According to Nurcahyawati et al. (2017), research on tiwai onion tuber extract at a dose of 400 mg/kg demonstrated kidney protection in Wistar rats induced by alloxan when compared to the positive control, metformin.

Anticancer

Cancer is a disease resulting from the failure to regulate cellular proliferation and other homeostatic functions in multicellular organisms. It is characterized by uncontrolled cell growth, invasiveness into surrounding tissues, and metastasis to other parts of the body (Sumardika et al., 2010). In vitro studies have shown that tiwai onion bulbs possess strong cytotoxic properties against various cancer cells. For instance, research by Lestari et al. (2019) demonstrated a potent cytotoxic effect on mouse lymphocytic leukemia cell lines, with a half IC50 inhibitory concentration of 9.56 ppm. Mutiah et al. (2019) reported a robust cytotoxic effect on cervical cancer cells (HeLa), particularly when tiwai onion extract was used in combination with doxorubicin, showing synergy compared to doxorubicin alone. This finding aligns with previous research by Mutiah et al. (2018) that investigated the synergistic effects of tiwai onion bulbs and Macrosolen cochinchinensis on HeLa cancer cells, revealing increased synergistic activity against cancer cells. Li et al. (2009) identified compounds eleutherinoside C and isoeleutherine from isolated tiwai onion tubers that exhibited selective cytotoxic properties against cancer cells and inhibited TCF/β-catenin transcription in SW480 cancer cells, surpassing the positive control, quercetin, in effectiveness. Furthermore, ethanol extracts of tiwai onion tubers were tested on LNCaP prostate cancer cells and were found to inhibit cell proliferation significantly with an IC50 value of 162.5 ppm (Abdulah et al., 2011).

Application of Tiwai Onion in the Food Sector

Tiwai onion bulbs have found wide-ranging applications in various fields, particularly in the food industry, healthy snacks, and feed additives. Extracts from tiwai onion bulbs have been utilized in the production of various food products, including effervescent tablets (Saragih, 2013), natural food coloring agents (Saragih et al., 2011), candies (Saragih, 2010), functional drinks, herbal dips (Saragih, 2011), and tiwai coffee (Saragih et al., 2022). Tiwai onion bulb extracts have also been employed as food additives (Suroto HS, 2007), functioning as natural preservatives and antioxidants. Suroto and Yustini (2015) reported on the microencapsulation of tiwai onion extract, making it easier to incorporate into food recipes, particularly pasta. This research emphasized that the composition of the coating material and temperature, as well as their interactions, significantly affect parameters such as phenol content, water content, solubility in water, diameter size, and ethanol content at a 5% confidence level.

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Phoem and Voravuthikunchai (2013) demonstrated that encapsulating tiwai onion bulb extract and oligosaccharide extract have the potential to act as a prebiotic, supporting the growth of infant intestinal microbiota and promoting the production of short fatty acids. Subsequent research by Phoem et al. (2015) showed that the microencapsulation technique of Bifidobacterium longum and tiwai onion bulb extract in fresh milk tofu and pineapple juice exhibited good resistance under refrigerated storage and heat treatment when compared to free cells. Encapsulated pineapple juice, in particular, maintained low acidity levels compared to free cells. Other researchers have reported that the addition of tiwai onion bulb extract at a concentration of 15% improved the organoleptic quality of taste, smell, tenderness, and texture while marginally affecting the color and overall acceptability of Arabic chicken nuggets compared to the control (Ismanto et al., 2014). The incorporation of tiwai onion tuber extract has also been shown to enhance the antioxidant activity of tempeh nuggets (fermented soybeans) when mixed at a 15% ratio (Damayanti et al., 2018). Moreover, the inclusion of tiwai onion tuber extract in homemade salad dressing demonstrated excellent anti-staphylococcal activity and remained stable under varying heat and pH conditions, ultimately enhancing the overall food quality (Ifesan et al., 2009).

Beyond its role as a food additive, tiwai onion bulb extract has potential as a snack ingredient, as observed by Lesmana and Parman (2019). They produced onion sticks from a combination of tiwai onion tubers and rice flour (50g of tubers in 100g of rice flour), which were favored by respondents due to their crunchy texture and delicious taste. Furthermore, tiwai onion bulb extract has been used as an additive in laying hen feed, as studied by Ooi et al. (2018). Their research demonstrated that diet supplementation with 1% bulb extract led to a significant reduction in the number of Enterobacteriaceae, lowered fecal pH, and increased fecal lactic acid bacteria compared to the control treatment. Similarly, Hardi and Handayani (2018) conducted research on striped catfish feed (Pangasianodon hypophthalmus) and found that supplementation with 30g/kg of tiwai onion bulb extract increased amylase activity, leukocyte count, growth rate, and phagocytosis rate in fish.

CONCLUSION

Tiwai onion bulb extract represents a valuable component of Indonesia's biodiversity, particularly on Kalimantan Island, characterized by its rich content of bioactive compounds and antioxidants. Various solvents, including ethanol, methanol, and water extracts, have been employed to extract and isolate phytochemicals from Tiwai onion bulbs, with the goal of achieving higher yields and improved quality. Tiwai onion bulb extract offers a wide range of health benefits, including antibacterial, antioxidant, antidiabetic, and anticancer properties, among others. In the food sector, this extract has found extensive applications as a food additive, a key ingredient in functional drinks, processed snacks, candies, natural food coloring agents, and nutritional additives for animal feed. Further exploration of its potential in various food sectors, particularly food fortification technology utilizing Tiwai onion bulb extract, holds promise for future research.

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