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Utilization of Coconut Water for In Vitro Shoots Multiplication of *Pogostemon cablin* Benth. 'Sidikalang' and Essential Oil Profile

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Abstract. *Pogostemon cablin* Benth. cv. Sidikalang (Acehnese patchouli) is one of the essential oil-producing plants which has therapeutic properties and fixative materials for perfume, so the demand for patchouli oil is relatively high. However, this advantage of patchouli is in contrast with the low quality of patchouli oil and its fluctuating prices in the international market. Therefore, patchouli's plant tissue culture technique is developed to obtain oil with a similar and a better quality one, which is characterized by the high level of patchouli alcohol in patchouli oil. This study aims to determine the effect of coconut water and BAP (6-Benzyl Amino Purine) of in vitro shoots multiplication of *Pogostemon cablin* Benth. 'Sidikalang' and to compare the in vitro essential oil profile to the native plant. Hence, in vitro shoots multiplication of patchouli in this study was done by using solid and liquid MS (Murashige-Skoog) medium with the treatment of 10% coconut water, 15% coconut water, 10% coconut water + 0.5 mg/L BAP, 15% coconut water + 0.5 mg/L BAP, and 0.5 mg/L BAP. Patchouli leaves hydrodistillation was done for six-weeks-old shoots derived from liquid MS medium with the giving of 0.5 mg/L BAP, which had the best growth index (24.94 ± 3.38). Morphologically, the growth of patchouli in the solid medium was not as good as in the liquid medium because more rosette shoots were found. The analysis results of UV-Vis spectrophotometry and gas chromatography showed that in vitro essential oil profile were the same as the native plant (ex vitro) and its commercial patchouli oil.

INTRODUCTION

Nowadays, the highest consumption level of essential oil is patchouli oil from Aceh patchouli (*Pogostemon cablin* Benth. 'Sidikalang') leaves. Patchouli oil has an important role in the cosmetics and perfume industry because it has fixative properties (scent binders) hence it is used as the main raw material for these products [1,2]. The increasing consumption of essential oils as industrial raw materials has resulted in more patchouli oil production from patchouli plants by developing or producing better quality patchouli oil. Therefore, the need for patchouli oil in the world market will grow in cosmetic and perfume products. Moreover, the excellent quality of patchouli oil depends on the extraction method the properties of patchouli oil so that the resulting patchouli oil is of good quality. The extraction method in this case, is using plant tissue culture techniques in order to obtain uniformed patchouli leaves for commercial purposes [3,4].

In vitro shoots multiplication of Aceh patchouli using tissue culture method is initiated with cytokinin as a growth regulator, by adding various concentrations of coconut water as an alternative cytokinin to synthetic cytokinins such as BAP in solid and liquid Murashige & Skoog (MS) medium to get the best growth index. Coconut water can replace

synthetic cytokinin because coconut water contains natural growth regulators, which are included in the cytokinin group and are organic compounds. In addition, coconut water contains glucose, fructose, and sucrose, so it is often used in tissue culture engineering applications [5]. Similarly, Surachman [6] reported that patchouli shoot multiplication in MS medium + 10% coconut water was the best because it produced the highest and highest shoots and the highest number of leaves. In contrast, MS + BAP 0.5 mg/L, the growth of the culture was more towards the formation of shoots with a small number of leaves but many, and green. According to Swamy [7], BAP concentration of 0.5 mg/L also produced the best yield because it showed the highest average number, length, and fresh weight of shoots. Based on these studies, not only coconut water and BAP were compared, but also the consistency of the medium. There was a solid and a liquid medium. The consistency of the medium affected the growth of shoots. Vyas et al. [8] stated the growth of shoots was better in liquid medium than in solid medium. Shoots multiplication in liquid medium reached a much higher rate (about 4.75 to 7-fold) than the control one.

The study was continued by looking at the profile of essential oils from the medium with the best shoot multiplication to determine the components contained in the oil. The best quality of patchouli oil based on Indonesian national standards is with a minimum PA content of 31% [9]. PA can bind and prevent aroma evaporation because it is fixative to retain the aroma longer. In order to get good quality patchouli oil, extraction methods are also needed in accordance with the nature of patchouli oil. Ermaya et al. [10], suggested that patchouli oil extracted from Aceh patchouli leaves is composed of several main constituents, but patchouli alcohol (PA) (42,75%) is the highest. The techniques used to qualitative and quantitative analysis were Ultraviolet-Visible Spectrophotometry and Gas Chromatography.

MATERIALS AND METHODS

In Vitro Shoots Multiplication

In vitro patchouli shoot explants that have been cultured in MS₀ medium, without plant growth regulator (PGR), were then planted in various of treatment medium, both solid and liquid medium, with 10% coconut water, 15% coconut water, coconut water 10% + BAP 0.5 mg/L, coconut water 15% + BAP 0.5 mg/L, and BAP 0.5 mg/L. In each treatment medium, three replications were carried out with each culture bottle containing two explants, and each explant contained three nodes.

Growth Curve

The shoot growth curve was obtained from the fresh weight of the late shoots divided by the fresh weight of the initial shoots. The initial fresh weight data was obtained by weighting the shoots just before being cultured on the treatment medium. In contrast, the final fresh weight data was obtained by weighing the shoots every week for seven weeks to obtain growth index data for each week. The determination of the value of the growth index can be made with the following formula:

Growth Index =
$$\frac{\text{shoot fresh weight}_1(mg)}{\text{shoot fresh wight}_0(mg)}$$

Hydrodistillation of Leaves of Patchouli

Patchouli leaf explants from the original plant (ex vitro) and in vitro shoots were first dried by aerating. After that, the dried leaves and shoots were made into powder. Then, the step was followed by the water distillation method. After that, the distillate (oil and water) obtained was added with anhydrous Na₂SO₄ to absorb the water that was still present in the essential oil [11–13]. The yield of patchouli oil can be calculated by the following formula [14]: $Yield = \frac{extract\ weight}{sample\ dry\ weight} \times 100\%$

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Ultraviolet-Visible Spectrophotometry

Each patchouli oil sample from commercial patchouli oil, plant origin, and in vitro culture of 10 L was dissolved in 3 mL of n-hexane and put into a different quartz cuvette. Then a qualitative analysis was carried out with a UV-Vis spectrophotometer for the three samples to obtain the maximum wavelength possessed by each oil sample.

Gas Chromatography Analysis

A total of 1 μ l of essential oil was analyzed using a Gas Chromatography (GC) tool to determine the chemical components that made up essential oils in the database program on the GC device. The results of the analysis with GC would obtain chromatograms derived from the results of GC analysis [15]

Data Statistics Analysis

Data analysis with the Two-Way Anova Test and Duncan's Multiple Range Test was carried out on growth index data at six weeks of explants at the stationary point on the growth curve. The various analyzes were carried out with IBM SPSS Statistics 20 Software with $\alpha = 0.05$.

RESULTS

Shoot Multiplication and Growth Index

Table 1 showed the best results on MS medium supplemented with coconut water 10% + BAP~0.5~mg/L because it had the highest average growth index value (31.07 ± 5.84) and was significantly different compared to other treatments which was indicated by a different notation. Unfortunately, the growth of shoots at sixth week on liquid MS medium supplemented with coconut water 10% + BAP~0.5~mg/L increased to many shoots, rosettes, and calli. Therefore, based on the type of medium, treatment using 0.5~mg/L~BAP on liquid medium was the best because morphologically the shoots were normal and not rosettes-shaped.

TABLE 1. The Average of Growth Index of Interaction between Type of Medium and Plant Growth Regulator of Patchouli Shoots in 6 Weeks

Type of Medium	Plant Growth Regulator	Average of Growth Index±SD
	MS_0	6.91 ± 1.62^{a}
	BAP 0.5 mg/L	$24.94 \pm 3.38^{\text{d}}$
T :t d	CW 10%	6.63 ± 1.49^{a}
Liquid	CW 10% + BAP 0,5 mg/L	$31.07 \pm 5.84^{\text{e}}$
	CW 15%	$13.32 \pm 2.33^{\text{b}}$
	CW 15% + BAP 0,5 mg/L	$19.06 \pm 2.27^{\circ}$
	MS_0	$13.46 \pm 1.52^{\text{b}}$
	BAP 0.5 mg/L	$25.48 \pm 4.52^{ ext{d}}$
Solid	CW 10%	9.36 ± 1.17^{ab}
Solid	CW 10% + BAP 0,5 mg/L	10.91 ± 2.25^{ab}
	CW 15%	11.40 ± 1.72^{ab}
	CW 15% + BAP 0,5 mg/L	$23.99 \pm 2.47^{\text{d}}$

- CW: coconut water
- Different letter notations indicate that the data is significantly different at p<0.05 based on Duncan's Multiple Range Test (DMRT)

Based on Table 2, regardless of the type of medium used, the data obtained shows different results from **Table 1**, where the BAP 0.5 mg/L treatment gave the best results (25.21 ± 3.58) and was significantly different from other treatments indicated by different notations. On the other hand, **Table 3** proves that the type of medium used has no difference.

TABLE 2. The Average of Growth Index from Type of Plant Growth Regulator of Patchouli Shoots in 6 weeks

Plant Growth Regulator	Average of Growth Index±SD
MS_0	10.18 ± 3.85^{ab}
BAP 0,5 mg/L	$25.21 \pm 3.58^{\mathbf{d}}$
CW 10%	7.99 ± 1.91^{a}
CW 10% + BAP 0,5 mg/L	20.99 ± 11.,73 ^c
CW 15%	12.36 ± 2.11^{b}
CW 15% + BAP 0,5 mg/L	$21.52 \pm 3.43^{\circ}$

- CW: coconut water
- Different letter notations indicate that the data is significantly different at p<0.05 based on Duncan's Multiple Range Test (DMRT

TABLE 3. The Average of Growth Index from Type of Medium of Patchouli Shoots in 6 weeks

Type of Medium	Average of Growth Index±SD
Solid	16.99 ± 9.66
Liquid	15.76 ± 6.99

Hydrodistillation of Leaves of Patchouli

Distillate from hydrodistillation obtained patchouli oil from plant origin (ex vitro) as much as 0.4 mL and in vitro 0.2 mL from 10 grams of dry weight of simplicia plant leaves ex vitro and shoots in vitro, respectively. Hence, the ex vitro patchouli oil yield was 4% ($^{v}_{dw}$) and the yield of patchouli oil in vitro was 2% ($^{v}_{dw}$).

Ultraviolet-Visible Spectrophotometry Analysis

Scanning results of commercial patchouli oil samples, plant origins (ex vitro), and in vitro cultures yielded qualitatively the same spectrum profile. The similar spectral profiles shows that the chemical compounds contained in the ex vitro and in vitro oil samples are not different from commercial patchouli oil, with the maximum wavelength (λ max) of the three samples being 251 nm.

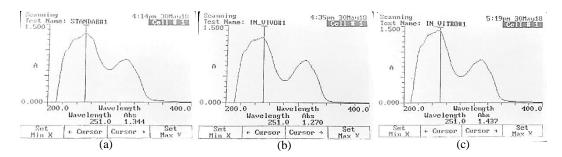


FIGURE 1. Spectrum of Patchouli Oil Samples (a) Commercial; (b) Ex Vitro; (c) In Vitro at λ = 200-400 nm with n-Hexane Eluent using UV-Vis Spectrophotometry

Gas Chromatography Analysis

Based on the results of patchouli oil profile with GC (**Figure 2**), it was found that in the content of patchouli oil from commercial patchouli oil, ex vitro, and in vitro plants there are several constituents including patchouli alcohol (PA) which is the main constituent of patchouli oil. PA was found at a retention time of around 26.5 minutes and produced the highest peak compared to other compounds in all samples. PA levels of commercial patchouli oil ranged between 37.58 - 45.35% ($^{\vee}_{v}$), PA levels of ex vitro patchouli oil were between 23.39 - 26.36% ($^{\vee}_{v}$), and PA levels of in vitro patchouli oil were between 23.71 - 26.84% ($^{\vee}_{v}$).

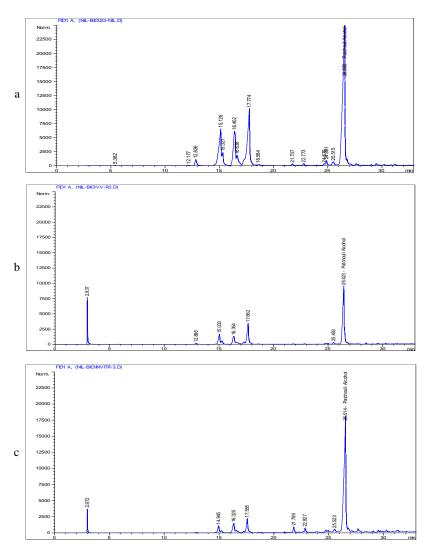


FIGURE 2. Chromatogram of Patchouli Oil Samples (a) Commercial; (b) Ex Vitro; (c) In Vitro using Gas Chromatography with *HP-INNOWax* Coloumn

TABLE 4. Retention Time and PA Level of Patchouli Oil Samples using Gas Chromatography Analysis

Sample	Replication	Retention Time	PA Levels	Average of PA Levels \pm SD	Yield
Sample	Replication	(min)	$[\%(^{v}/_{v})]$	$[\%(^{\mathrm{v}}/_{\mathrm{v}})]$	$[\%(^{v}/_{v})]$
	1	26.61	37.58		
Commercial	2	26.44	39.14	- - 40.69±4.11 ^b	
	3	26.56	45.35	40.09±4.11°	-
	1	26.42	24.18		
Ex Vitro	2	26.42	23.39	- 24.64±1.54 ^a	4
	3	26.44	26.36	24.64±1.54**	4
	1	26.45	26.84		
In Vitro	2	26.51	23.71	25.46.1.608	2.
	3	26.51	25.84	-25.46 ± 1.60^{a}	2

[•] Different letter notations indicate that the data is significantly different at p<0.05 based on Duncan's Multiple Range Test (DMRT)

DISCUSSION

Shoots Multiplication and Growth Index

Based on the results of this study, liquid MS medium was the best for patchouli shoot multiplication, and its growth index was also good (**Table 1**). This was supported by data from Table 3 which shows that there was no difference between solid and liquid MS medium types. Commercially, liquid MS medium was chosen because the required operational costs would be less than solid MS medium because it did not require a gelling agent (agar or phytagel). The use of the gelling agent in a solid medium requires about 80% of the cost of the medium, and eliminating the gelling agent from the medium can reduces the cost by up to 5.2 –fold of the total cost [16]. Moreover, De Klerk & Brugge [17] proved that growth of *Dahlia hybrida* shoots in vitro in liquid MS medium was four times faster than in solid MS medium. Similarly, Pati et al. [16] reported that shoot growth, poliferation, diameter, number of leaves and shoots, fresh and dry weight of *Catharanthus roseus* (L.) G. Don in liquid MS medium supplemented with 5 μM of BA was better than in solid medium. In contrast, Pancaningtyas [18] also proved that using liquid MS medium supplemented with 0.025 mg/L of adenine hormone can produced somatic embryo of *Theobroma cacao* higher (74%) than in solid medium (43%). Hence, liquid medium can be selected to produce better cultures and faster multiplication rates, as well as higher commercial profit.

Based on **Table 1**, there was no difference in growth index between treatments only with coconut water and without PGR. This was probably due to the insufficient cytokinin content of coconut water to increase shoot growth. Coconut water also contains cytokinins for shoot growth which is lower than BAP, hence BAP is a better ZPT than coconut water [19]. In contrast with Surachman [6] research that used coconut water singly with concentrations of 5%, 10%, 15%, 20%, and 25% stated that coconut water 10% was the best concentration for patchouli shoot multiplication when viewed from the percentage of shoots that grew, number of shoots, shoot height, and number of leaves

Hydrodistillation of Leaves of Patchouli

The hydrodistillation of patchouli leaves ex vitro produced higher patchouli oil $[4\% (v'_{dw})]$ than patchouli leaves in vitro $[2\% (v'_{dw})]$. The results obtained for ex vitro patchouli oil were following the literature and research conducted by Schaduw et al. [20] who also obtained patchouli oil $3.93\% (v'_{dw})$. Meanwhile, the level of in vitro patchouli oil ought can reach about $2.5 - 5\% (v'_{dw})$, which means that patchouli oil in vitro in this study has not reached that number. This result could be due to the small leaf size of the in vitro shoots, so the number of glandular trichomes on the leaf surface was estimated to be small, hence oil productivity was also low [21]. The use of in vitro shoots on the leaves and stems was also influential, because the stems had fewer glandular trichomes than the leaves. In addition, in vitro shoot culture was not in contact with other subjected to external pressure, so it was suspected that the shoots did not produce large amounts of glandular trichomes on the leaf surface. If glandular trichomes are produced in small quantities, the essential oil produced is also small, because glandular trichomes are the site of biosynthesis and accumulation of patchouli essential oil. Moreover, on the leaves surface there is not only glandular trichomes, but also non-glandular trichomes that do not produce essential oils. Therefore, high value of growth index does not necessarily guarantee the number of glandular trichomes present [22].

Ultraviolet-Visible Spectrophotometry Analysis

The patchouli oil profile can be seen from the wavelength spectrum produced by the three samples (commercial, ex vitro, and in vitro). The results obtained were that the three types of samples had the same spectrum profile with the same maximum wavelength (λ max), which was 251 nm, so it could be confirmed that the three patchouli oil samples contain similar chemical constituents (**Figure 1**). Moreover, the maximum wavelength scanning results were not in accordance with the theory, where the max of patchouli alcohol was in the range of 254 – 366 nm. This could be due to differences in the sample preparation carried out, and also diluted samples would show better spectral results [23].

Gas Chromatography Analysis

Based on the **Table 4**, PA levels of ex vitro oil were significantly different from commercial patchouli oil, as well as in vitro oil to commercial patchouli oil. Ex vitro patchouli oil was obtained from small and early leaves were assumed to be still in the lag or log growth stage, so that the synthesis of secondary metabolites had not yet reached the optimum point or stationary point [24]. PA levels from in vitro patchouli oils were relatively higher than ex vitro although they were not significantly different. The reason was because in the in vitro culture system, the nutritional requirements were already available so that the environmental conditions were more controlled [25]. Ermaya et al. [10], explained that the highest PA levels were found in the leaves compared to the roots and stems of patchouli. In this study, in vitro shoots were used, not only from the leaves, but also from the stems. Therefore, the PA levels of in vitro patchouli oil obtained were slightly higher than ex vitro and were still below commercial patchouli oil. Bunrathep et al. [15], also stated an increase in secondary metabolites of PA (alcohol sesquiterpenes) can be done by giving a precursor such as cis-farnesol.

The GC profiles for all samples were the same (**Figure 2**), with the retention time for the PA around 26.5 minutes. Meanwhile, the research conducted by Hu et al. [26], shows that the retention time of PA was 29.21 minutes, while the research conducted by Paul et al. [27], shows a retention time of 23.46 minutes. PA has a high boiling point, which is $150 - 160^{\circ}$ C at a pressure of 8 mmHg. The higher the boiling point of the compound, the longer the retention time. Therefore, the retention time of PA is longer than other compounds in patchouli oil [28].

In this study, patchouli oil of in vitro culture was derived from several patchouli shoots consisting of stem nodes and leaves, while the ex vitro patchouli only used the leaves. Hence, this research can only confirm the presence or absence of PA contained and its levels in these samples. Further research is needed to compare ex vitro and in vitro patchouli only in the leaves.

CONCLUSION

The addition of natural plant growth regulator such as coconut water was not good enough for in vitro shoot multiplication and growth. The most suitable medium for in vitro shoot explant multiplication was liquid MS medium supplemented with BAP 0.5 mg/L. The essential oil profiles were qualitatively and quantitatively the same for in vitro and ex vitro essential oils.

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By Peng Zhang and Tri Agus Siswoyo

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Viral diseases of sugarcane in Indonesia: Occurren notes, pathogenic characteristics and management strategies ≒	
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The soil available-potassium enrichment by several potential tropical weeds Abdul Kadir Salam; N. Sriyani; S. K. Dewi; M. Utomo AIP Conference Proceedings 2583, 020040 (2023) doi: https://doi.org/10.106	
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Response of 16 rice varieties (<i>Oryza sativa</i> L.) to hi temperature at vegetative stage 낮 Prita Sari Dewi; Ida Widiyawati; Kartika Ferrawati; Aldakris Afifa	
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BIOTECHNOLOGY AND BIOMOLECULE

Effect of lignocellulolytic fungi to biodegradation of different type of organic waste derived from cocoa production ₩

Intan Nirmalasari; Erwin Prastowo; Anisa Aulia Rahma; Gracia Melsiana Aldini

AIP Conference Proceedings 2583, 040001 (2023) doi: https://doi.org/10.1063/5.0119710

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Morphological performance of rambutan (*Nephelium lappaceum* L.) for biodiesel raw materials ₩

Triyas Vinandita; Endang Yuniastuti; Samanhudi

AIP Conference Proceedings 2583, 040002 (2023) doi: https://doi.org/10.1063/5.0116458

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Free radical study of Papua's candy as consumption culture of Papuans ≒

Livy Febria Tedjamulia; Ivana Josephin Purnama; Jasmine Veldina Gegono; Achmad Ridwan Ariyantoro

AIP Conference Proceedings 2583, 040003 (2023) doi: https://doi.org/10.1063/5.0115806

Abstract ✓ View article	Abstract ✓ View article

Utilization of coconut water for in vitro shoots multiplication of *Pogostemon cablin* Benth. 'Sidikalang' and essential oil profile ≒

Natasha Florenika; Go Gaby Eliazar; Wina Dian Savitri; Didik Pudji Restanto; Popy Hartatie Hardjo

AIP Conference Proceedings 2583, 040004 (2023) doi: https://doi.org/10.1063/5.0118813

Characterization and evaluation of lipase inhibitory activity of Raja Sereh (*Musa sapientum*) banana kombucha enriched with lactic acid bacteria ≒

Yati Maryati; Agustine Susilowati; Hani Mulyani; Euis Filaila; Hakiki Melanie; Setyani Budiari; Aspiyanto

AIP Conference Proceedings 2583, 040005 (2023) doi: https://doi.org/10.1063/5.0115824

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AGRICULTURAL ENGINEERING AND TECHNOLOGY

Soil structures engineered with the addition of soil stabilizing agents and exopolysaccharide-producing bacteria ≒

Arthur F. C. Regar

AIP Conference Proceedings 2583, 060001 (2023) doi: https://doi.org/10.1063/5.0124178

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Using Landsat to track land use and land cover (LULC) change from 1970 to 2020 in Mayang watershed, East Jawa

Mohamad Wawan Sujarwo; Farid Lukman Hakim; Indarto Indarto

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Performance of ultrafiltration membrane in separating valuable components from hydrolyzed corn (*Zea mays var. indentata*) for fortificant of natural folic acid ≒

Bioactivities and organoleptic analysis of dark chocolate probiotic as a functional beverage ≒

Hani Mulyani, Andini Sundowo, Euis Filailla, Minarti

AIP Conference Proceedings 2583, 090001 (2023) doi: https://doi.org/10.1063/5.0115842

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Machine learning and thin layer drying model of gembili (Dioscorea sp.) ₩ Tri Hadi Jatmiko; Yuniar Khasanah AIP Conference Proceedings 2583, 090002 (2023) doi: https://doi.org/10.1063/5.0116387 Abstract ∨ View article PDF Analysis of physical resistance of black grape (vitis vinivera) exposed to extremely low frequency (ELF) magnetic field with intensity of 300µT and 500µT ₩ Sudarti; Enik Wasiah Niati; Sherly Nur Laili AIP Conference Proceedings 2583, 090003 (2023) doi: https://doi.org/10.1063/5.0124188 Abstract ✓ View article 🔁 PDF Analysis active compounds of Carica papaya, Averrhoa bilimbi, and Chromolaena odorata leaves from geothermal area 😾 Tahara Dilla Santi; Radhiah Zakaria; Aditya Candra; M. Dharma Nauval AIP Conference Proceedings 2583, 090004 (2023) doi: https://doi.org/10.1063/5.0116236 Abstract ∨ View article PDF Antioxidant, anti-microbial, and physical properties improvement of turmeric (Curcuma domestica Val.) effervescent tablets with stevia (Stevia rebaudiana) leaf powder \₩ Maria Belgis; Ardiyan Dwi Masahid; Fitri Aulia Rahmawati; Nur Fathonah Sadek AIP Conference Proceedings 2583, 090005 (2023) doi: https://doi.org/10.1063/5.0116410 Abstract ✓ View article 🔁 PDF Notes on edible poaceae collected at Eka Karya Bali Botanic Garden 🖫 Arrohmatus Syafaqoh Li'aini; Farid Kuswantoro AIP Conference Proceedings 2583, 090006 (2023) doi: https://doi.org/10.1063/5.0117202 Abstract ✓ View article PDF Antibacterial activity of fermented katuk leaves (Sauropus androgynus (L.) Merr.) against gram positive bacteria and its free radical inhibitory ∖ Hani Mulyani; Yati Maryati; Euis Filailla; Hakiki Melanie; Setyani Budiari AIP Conference Proceedings 2583, 090007 (2023) doi: https://doi.org/10.1063/5.0115839 Abstract ✓ View article 🛚 PDF Separation and concentration of phycocyanin from Spirulina sp. using microfiltration membrane for natural pigment \ Hakiki Melanie; Aspiyanto; Hani Mulyani; Euis Filailla; Nina Artanti; Agustine Susilowati; Syelvira Febrianelly; Awalina Satya AIP Conference Proceedings 2583, 090008 (2023) doi: https://doi.org/10.1063/5.0115837 Abstract ✓ View article PDF

Gracilaria verrucose flour as a nutraceutical source: A study of various treatments on the stability of nutritional content

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Abstract ✓

and antioxidants #

The effect of satisfaction and competitive advantage on the SMEs sustainability of local coffee shops: A case in Yogyakarta, Indonesia 🖼 Nanda Rusti; Irham AIP Conference Proceedings 2583, 090017 (2023) doi: https://doi.org/10.1063/5.0116148 View article 🔁 PDF Abstract ∨ Impact of virgin coconut oil (VCO) on probiotic Lactobacillus delbrueckii subsp. bulgaricus ≒ Miksusanti; Herlina; Budi Untari; Dasril Basir; Indah Solehah; Ulfi AIP Conference Proceedings 2583, 090018 (2023) doi: https://doi.org/10.1063/5.0124216 View article Abstract ∨ 🖪 PDF Physical and milling quality of local rice variety and new superior varieties in Indonesia ≒ Siti Dewi Indrasari; Heni Purwaningsih; Titiek Farianti Djaafar; Purwaningsih; Mahargono Kobarsih; Kristamtini AIP Conference Proceedings 2583, 090019 (2023) doi: https://doi.org/10.1063/5.0116336 Abstract ∨ View article 🔼 PDF Production of black garlic from local garlic varieties of Lumbu Hijau at various aging ₩ Herlina; Siswoyo Soekarno; Johan Alif Ivansyah AIP Conference Proceedings 2583, 090020 (2023) doi: https://doi.org/10.1063/5.0119650 Abstract ✓ View article 🛚 PDF Effect of packaging and storage temperature to quality and shelf-life of corn egg-roll 3 Nur Aini; Hidayah Dwiyanti; Retno Setyawati; Budi Sustriawan; Abdullah Syukur AIP Conference Proceedings 2583, 090021 (2023) doi: https://doi.org/10.1063/5.0115873 View article 🖟 PDF Abstract ∨ Concentration index of feed production based on harvested area of rice plants in the farmers groups, Siparappe village, Sawitto district, Pinrang Regency as one of the ruminant livestock feed bases in fulfilling animal foods ₩ Surya, R. Rahman AIP Conference Proceedings 2583, 090022 (2023) doi: https://doi.org/10.1063/5.0117106 Abstract ∨ View article 🔁 PDF Antioxidant study of the gambier leaves by-products into tea with red ginger powder addition (Zingiber officinale var. Rubrum) ∵ I. Ketut Budaraga; Dian Pramana Putra AIP Conference Proceedings 2583, 090023 (2023) doi: https://doi.org/10.1063/5.0117233 Abstract ✓ View article 🔁 PDF

Detection of pesticide residue in forages for dairy farms in Jember district, East Java ≒

Listya Purnamasari; Melinda Erdya Krismaputri; Desy Cahya

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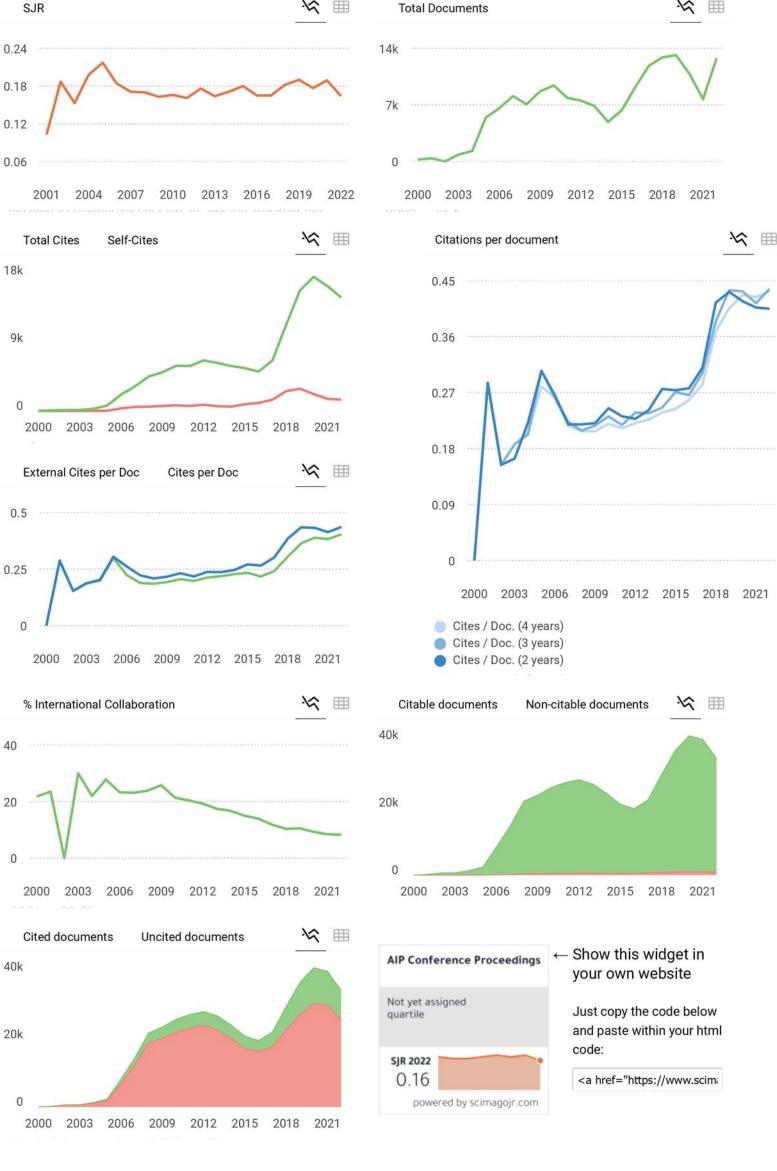
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