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Antioxidant Effect of Straw Mushroom (*Volvariella Volvacea*), Cocoa and Cinammon Powder in Crackers: Literature Review

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ABSTRACT

This study analyses potential uses of *Volvariella volvacea* or straw mushrooms, cacao and cinnamon powder, as a raw material for crackers. In Indonesia, straw mushrooms, cacao, and cinnamon are popular plants with significant nutritional content, especially protein, and numerous promising medical qualities, including antioxidants. The study employs an experimental methodology, including laboratory testing, phytochemical analysis, and literature review. The study involves identifying nutritional and anti-oxidant compound in straw mushroom, cocoa and cinnamon powder formulating a crackers with conducting toxicity and microbial safety evaluations. According to the study, straw mushrooms have anti-inflammatory and neuroprotective properties because they contain flavonoids, phenolics, and β-glucan. Polyphenols and tocopherols, which have anti-inflammatory properties, are found in cocoa powder. Polyphenolics, which are found in cinnamon powder, have anti-inflammatory and anti-diabetic properties. By adding a straw mushroom, chocolate, and cinnamon, this study provides an innovative contribution. It contains insightful knowledge regarding the potential of Indonesian herbal resources for phytopharmacology and the development of functional foods.

Keyword : *Volvariella Volvacea, Straw Mushroom, Cacao Powder, Cinnamon Powder, Food Safety, Functional Food*

1. INTRODUCTION

Oxidative stress is a pathological condition as known by an imbalance between the production of reactive oxygen species (ROS) and the antioxidant in body. The free radical are reactive chemicals that can induce oxidative damage to DNA, protein, and lipids, potentially leading to mutations and exhibiting carcinogenic properties (Sakinah & Fikri, 2023). This phenomena has leads to increased future research into the production of functional food enriched with natural antioxidants derived from plants.

Straw Mushroom (*Volvariella volvacea*) is widely consumed in Southeast Asia and known for its high bioactive compound and the excellent source of proteins. The body of *Volvariella volvacea* is a high source of bioactive compounds, comprising antioxidant enzymes, terpenes, polypeptides, carbohydrates, phenolics, and flavonoids (Ali et al., 2024). Research indicates that the flavonoids and alkaloids present in this plant may aid in the prevention of neurodegenerative disorders, including Alzheimer's and Parkinson's illnesses (Devi et al., 2021). *Volvariella volvacea* can be processed into powder by a drying technique to enhance its palatability. A highly successful method to mitigate potential damage is freeze drying, which generally preserves the product's qualities at a level comparable to that of fresh products (Tepsongkroh et al., 2019a).

Cocoa recognized for its richness in bioactive compounds, particularly polyphenols. Cocoa antioxidants can prevent cellular damage by neutralizing free radicals or by chelating transition metal ions, so diminishing their potential to generate reactive oxygen species (Oracz & Żyżelewicz, 2020). There are multiple methods to prepare cocoa beans, one of which involves converting them into a powder. Consequently, they determined that ultrasound-assisted solid-liquid extraction is

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an effective technique for recovering cocoa polyphenols, and the resultant cocoa extract can serve as a valuable component for functional foods (Oracz & Żyżelewicz, 2020).

Cinnamon (*Cinnamomum spp*.) is a traditional spice that possesses medical advantages. Cinnamon polyphenols may affect lipid metabolism and inhibit hepatic lipid peroxidation (Senevirathne et al., 2022). Cinnamon exhibits significant DPPH and FRAP scavenging action in vitro, suggesting its potential as a functional antioxidant addition.

The development of crackers fortified with natural antioxidant source such *Volvariella volvacea*, cocoa powder, and cinnamon powder could yield a novel functional food that delivers nutritional value and health advantages. Crackers are frequently selected as a delivery medium due to their practicality, extended shelf life, and ability to incorporate diverse bioactive components without sacrificing sensory appeal. Integrating these three antioxidant-rich components is anticipated to augment the product's capacity to destroy free radicals and maybe yields synergistic antioxidant effect.

This study is to assess the in vitro antioxidant properties of crackers composed of straw mushroom (*Volvariella volvacea*), cocoa powder, and cinnamon powder, all recognized for their substantial antioxidant content. The results are anticipated to aid in the creation of functional snack products that offer enhanced health advantages.

2. LITERATURE REVIEW

2.1 Crakers as a Functional Food Medium

2.1.1 Definition and Classification of Biscuit

Biscuit are a dry bakery products made through a baking process of dough from wheat flour with or without subtitutes, oil/fat, with or without the addition of other food ingredients and food additives (Badan Pengawas Obat dan Makanan RI, 2022).

2.1.2 Clasification of Biscuit

According to Badan Pengawas Makanan dan Obat (BPOM), biscuit are classified into four types:

a. Crackers

Crackers are a type of biscuit that made with or without fermentation, and are laminated to create a flat shape that appears layered when broken (Badan Pengawas Obat dan Makanan RI, 2022).

b. Pies

Pies are a type of biscuit that flaky and made with solid fat or fat emulsion, causing it to expand during baking and, when broken, to appear layered (Badan Pengawas Obat dan Makanan RI, 2022).

c. Cookies

Cookies are type of biscuit made from soft, crispy dough that appears less dense when broken (Badan Pengawas Obat dan Makanan RI, 2022).

d. Wafers

Wafers are a type of biscuit made from liquid dough, with coarse pores, crispy, and a hollow appearance when broken (Badan Pengawas Obat dan Makanan RI, 2022).

2.1.3 Definiton of Functional Food

Functional food are food compound that offer health benefit beyond basic nutrition due to the presence of significant bioactive substance like polyphenols, carotenoids, omega-3 fatty acids, alkaloids, isothiocyanates, plant stanols, sterols, flavonoids, polyols, soy protein, fatty acids, prebiotics, probiotics, phytoestrogens, and different minerals and vitamins. Recent studies have shown that potentially bioactive food ingredients significantly lower the risk of chronic illnesses, improve health, lower inflammation, boost immunity, improve cognitive function, and help control weight (Arshad et al., 2025). Crackers can be a functional food and improve their nutritional by developing the ingredients with high dietary fiber, abundant vitamins, and bioactive compound (Shen et al., 2025). In order to increase the antioxidant capacity and general health advantages of crakers formulations, recent research have investigates the addition of natural subtances including medicinal mushrooms, spices, and product derived from cocoa (Habib et al., 2022).

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2.2 Straw Mushroom (*Volvariella volvacea*)

Volvariella volvacea or straw mushrooms, are well known for their nutritional and therapeutic qualities. They belong to the Pluteaceae family, flourish in tropical and subtropical climates, and are prized for their unique flavor and significant health advantages (Ali et al., 2024). *Volvariella volvacea* or straw mushrooms contain a high antioxidant properties. Total glutathione, ergothioneine, total phenols, flavonoids, lycopene, total carotenoids, vitamin S, and vitamin C are among the antioxidants found in straw mushrooms (Sudha et al., 2019). *Volvariella volvacea* or straw mushrooms have potentials health benefits due to their bioactive components. The immune system may benefit from antioxidant qualities (Amarwati Tartillah & Kristiasari, 2024).

2.3 Kakao (*Theobroma cacao*)

Theobroma cacao or cocoa is a member of genus Theoborma, which comprises 22 species, and the Malvaceae family (Gopaulchan et al., 2019). Polyphenolic substances, specifically flavanols (catechins and procyanidins), flavonols, and anthocyanins, are abundant in cocoa. Together with procyanidin oligomers, the predominant flavanols in cocoa are (-)-epicatechin and (+)-catechin, which together account for up to 80% of the total polyphenol content. Because it includes flavonoids, polyphenols, and alkaloids, cocoa has anti-inflammatory and anti-cancer qualities. Additionally, cocoa contains hepatoprotective, neuroprotective, and cardioprotective properties. Extracts from cocoa leaves and hulls demonstrated defense against oxidative stress and organ damage brought on by doxorubicin (Sitarek et al., 2024).

2.4 Cinnamon (*Cinnamomum spp.*)

One of the first and most popular spices in human history, cinnamon is made from the dried inner bark of plants of the Lauraceae family's species Cinnamomum. This species have shown notable anti-inflammatory, anti-diabetic, antibacterial, and antioxidant properties. Cinnamaldehyde (trans-cinnamaldehyde), eugenol, cinnamyl alcohol, cinnamyl acetate, coumarin, proanthocyanidins (especially Type-A procyanidins), and several phenolic acids are among the many bioactive substances found in cinnamon. The main component that gives cinnamon its distinctive flavor and aroma is cinnamonaldehyde, which makes up 55–90% of the essential oil portion. Condensed tannins (proanthocyanidins) and flavonoid glycosides are the main antioxidant substances in the dry powder form (Gruenwald et al., 2010).

2.5 Antioxidants and Free Radical

Antioxidants are essential for controlling free radicals and lowering oxidative stress, which is connected to a number of illnesses. Antioxidants can lessen oxidative damage and destroy free radicals. They ultimately support general health and the prevention of disease by assisting in the maintenance of cell integrity and function (Chandimali et al., 2025). Compounds with strong oxidant activity are categorized as flavonoids. Free radical production can be inhibited by flavonoids (Tumilaar et al., 2023). Free radicals are highly reactive molecules with one unpaired electron (Rodwell et al., 2015). The body is impacted by free radicals through a number of different processes. By interacting with free radicals, proteins can also directly experience chemical changes. Dihydrophenylalanine, which is created when tyrosine residues in proteins are oxidatively damaged, interacts without the help of enzymes to produce more oxygen radicals (Rodwell et al., 2015).

2.6 The Methods of Antioxidant Measurement

Standardized in vitro tests that measure a sample's power to neutralize particular free radical species or lessen oxidizing agents are frequently used to evaluate antioxidant capacity. Total antioxidant capacity (TAC) assays can be classified according to single electron transfer (SET) or hydrogen atom transfer (HAT) processes, depending on the chemical events involved. In food science research, the following techniques are most commonly used (Sadeer et al., 2020). The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay gauges an antioxidant's potential to scavenge the stable DPPH radical, which has a distinctive purple hue that bleaches in proportion to the antioxidant's ability. The most used assay for assessing antioxidant capacity is the DPPH radical scavenging technique, which is prized for its ease of use and broad application across many analytes and biological sources (Gulcin & Alwasel, 2023). Scavenging of the pre-formed ABTS radical cation is measured by the ABTS (2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) assay. One benefit of the ABTS test is that it can detect both hydrophilic and lipophilic antioxidants and can be used for both manufactured and natural antioxidants because the radical is soluble in both aqueous and organic solvents (Kiss et al., 2025). The Folin-Ciocalteu reagent is used in the Total Phenolic Content (TPC) assay, which yields a colorimetric estimation of total reducing chemicals, mostly phenolics, given as Gallic Acid Equivalents (GAE) per gram of dry weight. Because structure and antioxidant capacity are closely related, the Folin-Ciocalteu assay is a reference method for quantifying total polyphenols in food. Its basic mechanism is based on a redox reaction, and its accurate application requires knowledge of phenolic structural characteristics (Pérez et al., 2023).

3. MATERIAL AND METHODS

This study utilizes a qualitative and experimental research design, incorporating a literature review, phytochemical analysis, and laboratory testing assess the viability of *Volvariella volvacea,* Cinnamon (*Cinnamomum spp*.), cocoa powder (*Theobroma cacao*) as the raw material for crackers at promoting functional food. The methodology comprises two primary phases:

1) Phytochemical and bioactive compound analysis through laboratory testing.
2) Food safety evaluation encompasses toxicity and microbiological testing.

Laboratory testing is performed to identify significant bioactive compounds in *Volvariella volvacea,* Cinnamon (*Cinnamomum spp*.), cocoa powder (*Theobroma cacao*) utilizing:

1) DPPH Radical Scavenging Assay → To estimate antioxidant activity.
2) ABTS → To determination of radical scavenging assay for food.
3) Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) → To determine an antioxidant.

Microbial contamination is assessed in accordance with Indonesia Food Safety Standards (Badan Pengawas Obat Dan Makanan Republik Indonesia, 2019.) :

1) Total Plate Count (TPC) : a method for quantifying bacteria burden.
2) Escherichia coli, Salmonella, and Staphylococcus aureus testing: To verify the absence of pathogenic bacteria.
3) Mold Yeast Count (MYC) : a method for quantifying mold
4) The final product must comply with BPOM and SNI 2973:2022 criteria for microbiological safety.

The quantitative data analysis employs descriptive statistics to encapsulate phytochemical profiles and antioxidant assay outcomes; ANOVA (analysis of variance) to contrast antioxidant activity across DPPH, ABTS, TPC, and TFC values among *Volvariella volvacea,* Cinnamon (*Cinnamomum spp*.), cocoa powder (*Theobroma cacao*); and regression analysis to assess the correlation between bioactive compound concentration and overall antioxidant capacity.

The data analysis for qualitative study utilizes thematic analysis to analyse literature review findings about the potential and manufacturing feasibility of functional foods, alongside content analysis to compare laboratory results with prior studies in food functional and herbal research. This work complies with ethical criteria for food and natural product research, guaranteeing adherence to laboratory biosafety standards, obtaining ethical consent for microbial testing, and following national and international food safety regulations, including BPOM and WHO standards.

Research limitation encompass :

1) The lack of long-term food safety studies beyond immediate microbiological evaluations.
2) Limited product testing due to the absence of sensory assessment, necessitating future consumer-based trials to confirm acceptability.

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The methodology facilitates a comprehensive assessment of *Volvariella volvacea*, Cinnamon (*Cinnamomum spp*.), cocoa powder (*Theobroma cacao*), confirming their antioxidant capacity and microbiological safety as a viable functional food product.

Table 1. Summary of Methodology

Phase	***Methodology***	***Key Parameters***
Phytochemical Testing	DPPH, ABTS, TPC, TFC	Flavonoid, Phenolic, Antioxidant Activity
Microbial Testing	TPC & Pathogen Screening	BPOM & WHO safety standards

4. RESULT

This study review antioxidant activity and bioactive compound used by the included study from various aspect such a DHHP, ABTS, TPC and TFC.

Table 2. Antioxidant activity (DPPH assay result)

Author years	***DHHP Assay (%)***	***Mush room Sample***	***Extract-ion Solvent***	***Drying Method***
(Enoma et al., 2018)	85 – 90%	10 - 12 mg/mL	Water	Freeze Dried
(Enoma et al., 2018)	± 90%	4 mg/mL	Etanol	Freeze Dried
(Cheung et al., 2002)	38.7%	3 mg/mL	Water	Freeze Dried
(Cheung et al., 2002)	32.3%	3 mg/mL	Methanol	Freeze Dried
(Cheung et al., 2002)	37.8%	9 mg/mL	Water	Freeze Dried
(Cheung et al., 2002)	57.8%	9 mg/mL	Methanol	Freeze Dried
(Gurbanov et al., 2022)	81.39 %	0.35 g/mL	Methanol	Freeze Dried

The DPPH analysis of *Volvariella volvacea* reveals the highest antioxidants activity in water extraction solvent. Water extraction solvent is the selected as the optimal method for *Volvariella volvace.*

Table 3. Antioxidant activity (ABTS assay result)

Author years	***ABTS Assay***	***Mush room Sample***	***Extraction Solvent***	***Drying Method***
(Gurbanov et al., 2022)	35.71 %	0.35 g/mL	Methanol	Freeze Dried
(Islam et al., 2016)	28.70 ± 1.90 (mmole TE/g)	0.5 g/mL	Acetone/ water/ acetic acid (70:29.5:0.5)	Freeze Dried
(Tepsongkroh et al., 2019b)	8.42a ± 0.25 (mg GAE/g dw)	0.1 mg/mL	Water	Freeze Dried

The ABTS analysis of *Volvariella volvacea* reveals that *Volvariella volvacea* have a high antioxidants activity.

Table 4. Concentration of TPC and TFC in *Volvariella volvacea* obtain by different solvent

Author years	***TPC***	***TFC***	***Mush room Sample***	***Extraction Solvent***	***Drying Method***
(Islam et al., 2016)	4.96 ± 0.40 (mg GAE/g)	0.62 ± 0.01 (mg CAE/g)	0.5 g/mL	Acetone/ water/ acetic acid (70:29.5:0.5)	Freeze Dried

Table 5. Continued

Author years	***TPC***	***TFC***	***Mush room Sample***	***Extraction Solvent***	***Drying Method***
(Tepsongkroh et al., 2019b)	14.56 ± 0.18 (mg GAE/g)	38.30 ± 0.59 (mg CAE/g)	0.1 g/mL	Methanol	Freeze Dried
(Tepsongkroh et al., 2019b)	14.52 ± 0.15 (mg GAE/g)	38.90 ± 0.49 (mg CAE/g)	0.1 g/mL	Water	Freeze Dried
(Cheung et al., 2002)	0.05 ± 0.00c (mg GAE/g)	-	1 g/mL	Methanol	Freeze Dried
(Cheung et al., 2002)	0.10 ± 0.00d (mg GAE/g)	-	1 g/mL	Water	Freeze Dried

The TPC and TFC analysis of *Volvariella volvacea* reveals that *Volvariella volvacea* have a high antioxidants activity.

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P-ISSN: 2986-8386

Table 6. Total Phenolic, total flavonoid and antioxidant activity of cocoa powder (*Theobroma cacao*)

Author years	***TPC***	***TFC***	***ABTS***	***DHHP***
(Lee et al., 2003)	611 (mg GAE/g)	564 (mg CAE/g)	1128 mg	836 mg
(Llerena et al., 2023)	72.22 ± 1.53 (mg GAE/100 mL)	5.116 ± 0.03 (mg CE/100 mL)	4.69 ± 0.01 (µM TE/mL)	-
(Schinella et al., 2010)	50 mg GAE/g	-	-	-
(Ibrić, n.d.)	0.147 ± 0.032 mg GAE/g	-	-	-

The TPC, TFC, DHHP and ABTS analysis of cocoa powder (*Theobroma cacao*) reveals that cocoa powder (*Theobroma cacao*) have a high antioxidants activity.

Table 7. Total phenolic and antioxidant activity of Indonesia cocoa powder (*Theobroma cacao*)

S	***Product-ion Origin***	***Total Phenolic Content (mg GAE/g)***	***DPPH (mm TE/g)***	***FRAP (mm TE/g)***	***T* (mg/g)***	***Caff* (mg/g)***	***C* (mg/g)***	***EC* (mg/g)***
1	Bandung	36.90 ± 0.22	183.96 ± 2.38	540.68 ± 2.78	1.99 ± 0.01	0.22 ± 0.15	1.10 ± 0.02	1.88 ± 0.03
	Bandung	34.19 ± 0.40	157.74 ± 1.75	473.00 ± 2.85	2.51 ± 0.21	0.27 ± 0.19	1.06 ± 0.06	1.97 ± 0.02
2	Tangerang	38.32 ± 0.20	185.33 ± 1.26	555.55 ± 5.84	2.39 ± 0.09	0.16 ± 0.11	0.73 ± 0.00	0.77 ± 0.01
3	Tangerang	14.80 ± 0.23	91.67 ± 3.05	249.16 ± 2.45	1.89 ± 0.16	0.12 ± 0.09	1.07 ± 0.06	0.04 ± 0.01
4	Blitar	20.93 ± 0.53	119.10 ± 2.20	367.02 ± 17.13	2.69 ± 0.15	0.26 ± 0.18	0.81 ± 0.02	0.08 ± 0.01
5	Jember	67.76 ± 0.20	310.14 ± 5.93	826.97 ± 20.89	2.89 ± 0.00	0.46 ± 0.32	0.23 ± 0.01	4.68 ± 0.01
6	Bali	70.47 ± 1.13	346.85 ± 4.29	1000.95 ± 18.19	2.97 ± 0.14	0.42 ± 0.29	0.38 ± 0.00	2.42 ± 0.13
7	South Celebes	61.91 ± 0.58	296.39 ± 4.15	682.27 ± 0.34	2.43 ± 0.07	0.43 ± 0.31	0.04 ± 0.00	1.65 ± 0.02
8	West Sumatera	79.93 ± 0.37	362.34 ± 3.10	362.24 ± 3.10	3.08 ± 0.01	0.17 ± 0.12	0.43 ± 0.01	2.09 ± 0.00

**S = Sample*
**T = theobromine, C = (+)-catechin, Caff = Caffeine, EC = (-)-epicatechin*
Source : (Ulvia et al., 2019)

The TPC, TFC, DPPH, FRAP, *theobromine, catechin, Caffein, -epicatechin* analysis of cocoa powder (*Theobroma cacao*) reveals that cocoa powder (*Theobroma cacao*) have a high antioxidants activity

Table 8. Total phenolic, total flavonoid and antioxidant activity of Cinnamon (*Cinnamomum spp.*)

Author years	***TPC***	***TFC***	***ABTS***	***DPPH***
(Abeysekera et al., 2013)	33.43 ± 0.51 (mg GAE/g)	3.07 ± 0.24 (mg QE/g)	89.09 ± 2.87 (mg TE/g)	107.69 ± 2.01(mg TE/g)

The TPC, TFC, DPPH and ABTS analysis of Cinnamon (*Cinnamomum spp.*) reveals that cocoa powder (*Theobroma cacao*) have a high antioxidants activity.

Table 9. Microbial contamination result using the TPC test

Formulation	***TPC (CFU/g)***	***MYC (CFU/g)***
25%	1.92×10^5	0.6×10^3
50%	0.02×10^5	0.61×10^3
75%	0.3×10^5	0.65×10^3
BPOM quality	Max 1×10^6	Max 1×10^4

Source : (Makkiyah et al., 2025)

Microbial count in 50% and 75% of *Volvariella volvacea* are within safe limit according to BPOM and WHO standard. The formulated is safe for consumption.

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5. DISCUSSION

The study's findings indicate that *Volvariella volvacea,* Cinnamon (*Cinnamomum spp*.), cocoa powder (*Theobroma cacao*) exhibit significant antioxidant activities, as demonstrated using various methodologies, including DPPH, ABTS, total phenolic content (TPC), and total flavonoid content (TFC). Several relevant aspect need discussion :

1) Water extraction exhibits the highest antioxidant activity in *Volvariella volvacea.* The DPPH assay consistently exhibits superior radical scavenging activity in aqueous extracts (up to ± 90%) compared to ethanol and methanol. This indicates that water is a more effective medium for extracting polar phenolic compounds from *Volvariella volvacea.* Water extraction is the optimal method for previsING antioxidant capacity, particularly when combined with freeze-drying, which minimizes heat damage.
2) Methanol and mixed solvent yield a higher concentration of phenolic and flavonoid chemicals. Water demonstrated increased DPPH activity; however, methanol extracts from Tepsongkroh et al. (2019) displayed markedly higher TPC and TFC values. Islam et al. (2016) shown that combined solvents (acetone–water–acetic acid) can effectively extract phenolic chemicals. This substantiates the notion that solvent polarity directly influences the solubility and extraction efficiency of phenolic compounds.
3) Cocoa powder exhibits an exceptionally elevated concentration of antioxidants across all assessments. Cocoa samples exhibited the highest total phenolic content (up to 611 mg GAE/g) and the most potent DPPH and ABTS values (1128 and 836 mg per serving, respectively). Indonesian cocoa samples regularly exhibit substantial antioxidant activity in DPPH, FRAP, and phenolic compound analysis (catechin, epicatechin, and theobromine). This indicates that cocoa is a potent natural source of antioxidants.
4) Cinnamon possesses elevated concentrations of ABTS, DPPH, and phenolic compounds. Cinnamon (*Cinnamomum spp.*) exhibits significant antioxidant activity, with ABTS values of 89 mg TE/g and DPPH values of 107 mg TE/g. This renders it an excellent option for a functional antioxidant component.
5) Freeze-drying is the most effective method for preserving bioactive compounds. All research employed freeze-drying, which preserves thermolabile phenolic compounds and reduces oxidation throughout processing. This method ensures the stability and prolonged duration of antioxidant activity.
6) Microbial analysis confirms that the formulation complies with BPOM and WHO safety guidelines. Microbial analysis indicates that the 50% and 75% formulations of *Volvariella volvacea* significantly comply with the thresholds established by BPOM and WHO ($\leq 1 \times 10^6$ CFU/g for total plate count and $\leq 1 \times 10^4$ CFU/g for mold/yeast). These findings confirm that the formulated items are microbiologically safe and suitable for consumption.

The comprehensive investigation indicates that *Volvariella volvacea*, cocoa powder, and cinnamon possess significant antioxidant potential, influenced by the extraction method, solvent polarity, and processing techniques. These results support its incorporation into functional food formulations with significant health-protective properties.

6. CONCLUSIONS

This study evaluates the antioxidant properties and bioactive chemical compositions of *Volvariella volvacea*, cocoa powder (Theobroma cacao), and cinnamon (*Cinnamomum spp.*). The key points are as follows:

Antioxidant Activity :

1) *Volvariella volvacea* exhibits significant antioxidant activities, particularly in aqueous extracts, where it may inhibit DPPH activity 85–90% of the time.
2) Cocoa powder exhibits the highest antioxidant capacity among all evaluated samples, evidenced by its elevated TPC, TFC, ABTS, and DPPH values.
3) Cinnamon possesses potent antioxidant effects, rendering it a valuable

complement to other bioactive constituents.

The quantity of bioactive substances :

1) The measurements for TPC and TFC vary according to the solvent used. Methanol and mixed solvents yield greater levels of phenolic and flavonoid compounds.
2) Indonesian cocoa samples regularly demonstrate high phenolic content, including catechin, epicatechin, theobromine, and caffeine. These bioactive compounds significantly enhance the antioxidant capacity of each food.

Methods for Processing and Extraction :

1) The optimal method for preserving antioxidant compounds and ensuring the stability of phenolics and flavonoids is freeze-drying.
2) Water is the optimal solvent for extracting *Volvariella volvacea*; nevertheless, methanol yields higher total phenolic content (TPC) and total flavonoid content (TFC) in chocolate and cinnamon extracts.

Microbial Safety

1) The microbiological counts (TPC and MYC) for the 50% and 75% formulations of *Volvariella volvacea* comply with the safety standards established by BPOM and WHO, indicating that the product is safe for consumption.
2) These findings validate the feasibility of including *Volvariella volvacea* as a safe element in functional food products.

This study demonstrates that *Volvariella volvacea*, cocoa powder, and cinnamon possess significant antioxidant effects due to their high concentrations of phenolic and flavonoid chemicals. The integration of superior extraction methods, freeze-drying methodologies, and established microbiological safety indicates that these compounds provide significant potential for the formulation of beneficial food compositions. Future research may explore synergistic antioxidant properties, sensory enhancement, and storage stability to promote commercial-scale product development.

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