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Effect of Drying Temperature and *Wedang Uwuh* Extract Concentration on the Physical, Antioxidant, and Microbiological Properties of Yogurt Drink Powder

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Abstract

Increasing interest in healthy lifestyles has driven the demand for functional foods. Yogurt enriched with bioactive-rich *wedang uwuh* may provide additional antioxidant and probiotic benefits, while foam mat drying offers a practical method for producing a stable powdered product. This study was conducted to evaluate the effects of *wedang uwuh* extract concentration and drying temperature on the physical characteristics, antioxidant activity, and microbiological properties of yogurt drink powder. A randomized block design (RBD) with 2 factors was applied, consisting of *wedang uwuh* extract concentrations of 0%, 3%, 6%, 9%, and 12% and drying temperatures of 50, 60, and 70 °C. A coating agent of 15% egg white and 20% maltodextrin was used. Data were analyzed using analysis of variance (ANOVA) at a 95% confidence level and further tested using Duncan's multiple range test (DMRT). The results showed that *wedang uwuh* concentration and drying temperature significantly affected yield, color, total soluble solid (TSS), antioxidant activity, and lactic acid bacteria (LAB), but had no significant effect on dissolution time. The optimal treatment was 12% *wedang uwuh* extract dried at 60 °C, producing a yield of 26.62%, L* value of 92.37, a* value of 4.16, b* value of 22.73, dissolution time of 29.69 seconds at 25 °C and 10.10 seconds at 40 °C, TSS of 9.77°Brix, antioxidant activity of 86%, and total LAB count of 3.15×10^{11} CFU g^{-1}. These findings demonstrate the potential for developing a fortified *wedang uwuh* yogurt drink powder as a functional food product with antioxidant and probiotic properties.

Keywords: antioxidant; bioactive compound; probiotic; *wedang uwuh*; yogurt powder

INTRODUCTION

Public awareness of the importance of maintaining good health through healthier dietary habits continues to grow. These changing dietary habits are encouraging people to choose foods that not only serve as a source of nutrition but also provide additional health benefits. Food products with these characteristics are known as functional foods, which, in addition to meeting basic nutritional needs, contain bioactive components capable of producing positive physiological effects on health (Karelakis et al., 2020; Setiawan et al., 2024). Growing interest in functional foods has also driven the development of various food products that offer additional health benefits.

One of the most widely consumed functional foods is yogurt. Yogurt is a fermented milk product produced through fermentation by lactic acid bacteria (LAB). It is known to provide various health benefits, particularly by helping maintain the balance of the gut microbiota.

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In addition, yogurt contains various bioactive compounds that may contribute to antioxidant activity and support the immune system (Krisnaningsih et al., 2020). The high level of public interest in yogurt is reflected in the increasing consumption of this product in Indonesia, which accounted for approximately 28% of total dairy product consumption in 2022 (Wisnawa, 2022). This trend has encouraged the development of various yogurt innovations with different forms and flavors, as well as enhanced functional benefits (Lebdoyono et al., 2025).

One emerging innovation in the yogurt market is yogurt drinks, yogurt-based beverages with a thinner consistency that makes them easier to consume. These products have great potential for further development through fortification with natural ingredients rich in bioactive compounds to enhance their functional benefits. Various studies have shown that the addition of fruit extracts, herbs, or spices to yogurt can increase antioxidant activity and provide additional health benefits (Dhawi et al., 2020; Melia et al., 2022; Sibuea and Siantar, 2022). One natural ingredient with potential as a source of bioactive compounds is *wedang uwuh*.

Wedang uwuh is a traditional herbal beverage originating from Yogyakarta and prepared using various spices, such as ginger, lemongrass, cinnamon, cardamom, sappanwood, clove buds, nutmeg leaves, and cinnamon leaves (Lau et al., 2022). This combination of spices is known to contain various bioactive compounds, including flavonoids, alkaloids, saponins, tannins, and triterpenoids, which have antioxidant properties (Widanti et al., 2019; Harijono et al., 2021; Dewatisari and Hariyadi, 2024). Furthermore, *wedang uwuh* has also been reported to exhibit immunomodulatory effects and may help reduce blood glucose levels (Widyaningsih et al., 2020). Previous research has shown that the addition of 3% *wedang uwuh* extract to yogurt can enhance antioxidant activity without compromising the physical, chemical, or sensory quality of the product (Anjani et al., 2024).

However, yogurt drinks have a limited shelf life because their high-water content makes them susceptible to spoilage. Liquid yogurt products generally last less than 1 day at room temperature, approximately 14 days under refrigeration, and up to 21 days at 4 to 5 °C (Kasmiyetti et al., 2022). These conditions pose challenges for storage and distribution because they require a cold chain. One possible solution is to turn yogurt drinks into powder through a drying process.

One drying method that can be used is foam mat drying, a technique for liquid materials that are first converted into foam using a foaming agent, thereby increasing the surface area of the material and accelerating the rate of the drying process (Amini et al., 2023). Foam mat drying is considered relatively simple, cost-effective, and capable of operating at moderate drying temperatures, thereby helping to preserve the sensory quality and nutritional content of the product (de Carvalho et al., 2017; Adipratama et al., 2024).

Foaming agents that can be used in the foam mat drying method include egg white, while maltodextrin functions as an encapsulating and stabilizing agent. The combination of egg white and maltodextrin can form and maintain foam stability, thereby increasing the surface area of the material and accelerating the drying process (Abidin et al., 2019). In addition, maltodextrin can form a film layer that protects the active components of the material from heat-induced degradation, helps prevent browning, and inhibits crystallization (Ihsani et al., 2024). Meanwhile, egg white plays a role in foam formation and stability by increasing the surface area of the material, reducing surface tension, and forming a porous structure that facilitates water evaporation. This structure also helps to maintain product quality, including color, flavor, nutrient content, and the viability of LAB during the drying process (Haryanto, 2007; Miskiyah et al., 2019).

However, the drying process has the potential to affect the chemical characteristics and stability of the bioactive compounds present in the product. Excessively high drying temperatures can cause the degradation of antioxidant compounds. At the same time, variations in *wedang uwuh* extract concentration can affect the bioactive compound content and antioxidant activity of the final product. Research on the combined effects of *wedang uwuh* concentration and drying temperature on the physical characteristics, antioxidant activity, and microbiological properties of yogurt drink powder remains limited. Therefore, this research was conducted to investigate the effects of different *wedang uwuh* concentrations and drying temperatures on the yield, color, dissolution time, total soluble solids, antioxidant activity, and total LAB count of

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yogurt drink powder, thereby identifying the optimal treatment combination for producing a practical powdered functional beverage with potential health benefits.

MATERIALS AND METHOD

Materials and equipment

The materials used in this research included fresh cow milk obtained from a dairy farm in Baturaden, Purwokerto, Central Java, and skim milk (Indoprima). The yogurt starter culture used was Lactina, which contains *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Other ingredients consisted of ginger, lemongrass, cinnamon, cardamom, sappanwood, clove buds, nutmeg leaves, and cinnamon leaves obtained from Pasar Wage, Purwokerto, Central Java, as well as sugar (Gulaku), carboxymethyl cellulose/CMC (Koepoe-Koepoe), maltodextrin, eggs, soy lecithin, de Man Rogosa and Sharpe Agar (MRSA) medium (Merck), 2,2-diphenyl-1-picrylhydrazyl (Sigma Aldrich), and methanol. The equipment included a fermenter, mixer, cabinet dryer, color reader, refractometer, UV-Vis spectrophotometer, autoclave, oven, laminar air flow cabinet, incubator, and laboratory glassware.

Experimental design

This research applied a randomized block design (RBD) with 2 factors. The first factor was *wedang uwuh* extract concentration: 0%, 3%, 6%, 9%, and 12%. The concentration levels were selected based on previous research (Anjani et al., 2024). The second factor was drying temperature: 50, 60, and 70 °C. These temperatures were selected based on the foam mat drying temperature range of 50 to 80 °C (de Carvalho et al., 2017; Adipratama et al., 2024). Overall, 15 treatment combinations were obtained, with each treatment replicated 3 times.

Preparation of *wedang uwuh* extract

Wedang uwuh was prepared by drying the spices, followed by weighing 4 g of ginger, 1 g of lemongrass, 1 g of cinnamon, 1 g of cardamom, 1 g of sappanwood, 0.5 g of clove buds, 0.2 g of nutmeg leaves, and 0.3 g of cinnamon leaves. The ingredients were then mixed with 170 ml of mineral water (Lau et al., 2022; Winasih et al., 2023). The spice mixture was macerated for 48 hours and subsequently extracted using Microwave-Assisted Extraction (MAE) for 15 minutes before being filtered.

Preparation of yogurt drink powder

Yogurt was prepared by pasteurizing fresh cow's milk containing 10% (w/v) skim milk at 70 to 80 °C for 15 minutes. After cooling, 5% (v/v) yogurt starter was added, and the mixture was incubated for 24 hours (Latifasari et al., 2023). Yogurt drink was prepared by mixing plain yogurt with a 25% (w/v) sugar solution at a 1:2 ratio and 0.5% (w/v) CMC (Latifasari et al., 2024). The *wedang uwuh* extract was then added at concentrations according to the treatment. Foam was prepared by whipping 15% (w/w) egg white, 20% (w/w) maltodextrin, and 0.25% (w/w) soy lecithin for 7 minutes (Malik and Sharma, 2019; Miskiyah et al., 2019). The mixture was homogenized and dried for 6 hours, then blended and sieved through a 60-mesh sieve.

Analysis

The analyses conducted on the samples included yield (AOAC, 2016), color using a color reader (Setyawardani et al., 2021), dissolution time measured using a stopwatch until the sample completely dissolved (Husni et al., 2020), total soluble solids (TSS) using a handheld refractometer (Safitri et al., 2024), and antioxidant activity using the DPPH method (Kamoda et al., 2021). Total LAB in the yogurt before drying and in the resulting yogurt powder samples were determined using the total plate count (TPC) method on MRS Agar (Ragab et al., 2023).

Statistical analysis

The data were statistically analyzed using two-way analysis of variance (ANOVA) at a 95% confidence level. When significant differences were observed, the analysis was followed by Duncan's multiple range test (DMRT). The optimal treatment was determined using Zeleny's multiple attribute method.

RESULTS AND DISCUSSION

Yield

Yield refers to the proportion of dry weight obtained after drying compared to the initial wet weight before the drying process. The yield of the yogurt drink powder fortified with *wedang uwuh* extract ranged from 25.08 to 28.37% (Figure 1). The ANOVA results demonstrated that variations in drying temperature and *wedang uwuh* concentration significantly affected the yield of the final product ($p < 0.05$). Although the differences among treatments were relatively

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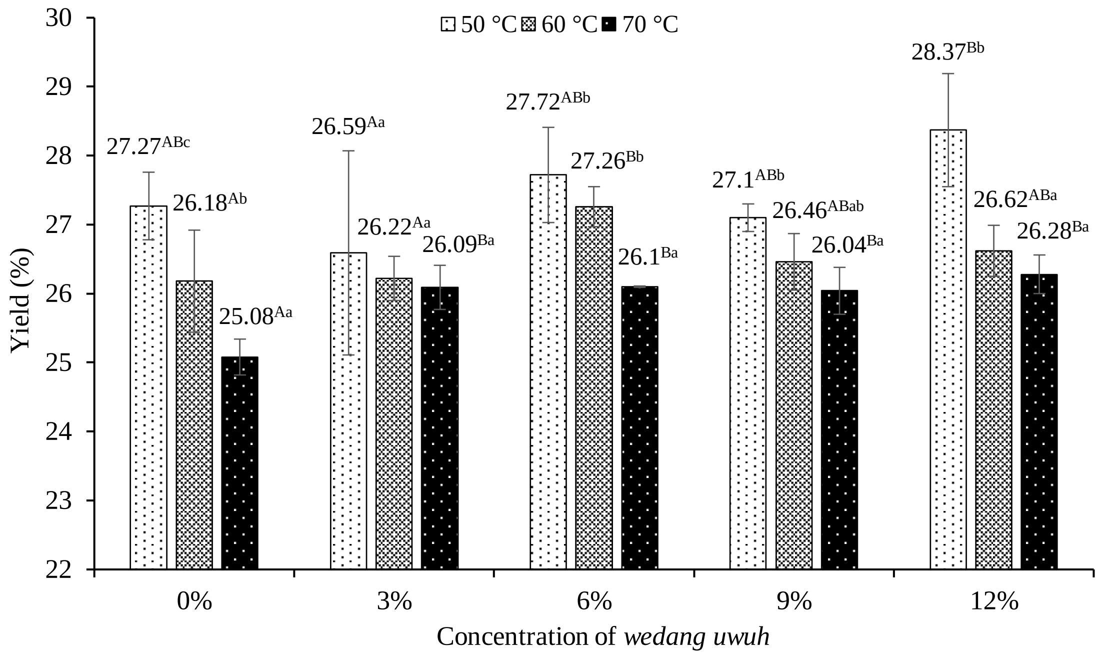

Figure 1. Yield analysis of *wedang uwuh* yogurt drink powder

Note: Different superscript letters indicate significant differences ($p < 0.05$). Uppercase letters are used for concentrations and lowercase letters for temperature

slight, the yield tended to decrease as drying temperature increased. Higher temperatures resulted in greater water evaporation, leading to lower moisture content in the product and ultimately decreasing yield (Santi et al., 2021). Yield tended to increase with increasing concentration of added *wedang uwuh*. This occurred because a higher concentration of the extract increased the solid-to-water ratio in the product, resulting in a higher yield. The increase in yield was consistent with an increase in the product's moisture content, as yield and moisture content are known to increase consistently together (Prabaningrum et al., 2022).

Color

Color is an important physical quality parameter that can indicate changes during processing. The L* value (0 to 100) represents lightness, with a lower value indicating a darker color. Drying temperature did not significantly affect the L* value ($p > 0.05$). The absence of significant differences in L* values among drying temperature treatments may be attributed to the drying temperatures being below 80 °C, resulting in relatively minor color changes and limited thermal degradation of the natural pigments (Ramanda et al., 2026). In contrast, *wedang uwuh* extract concentration significantly affected the L* value ($p < 0.05$), with higher concentrations producing darker colors due to greater pigment intensity. The color measurement results are presented in Table 1.

Variations in drying temperature and *wedang uwuh* extract concentration significantly affected the a* (red-green) and b* (yellow-blue) values ($p < 0.05$). The a* values ranged from 0.72 to 4.16, indicating a reddish tendency, which was mainly attributed to the presence of *brazilein* pigment from sappanwood (Fadhilah et al., 2023). Meanwhile, the b* values ranged from 15.90 to 22.73, indicating a yellowish tendency.

This color characteristic may be associated with pigment changes in sappanwood under acidic conditions, which can cause the red pigment to shift toward orange (Saraswati, 2016). Increasing the *wedang uwuh* extract concentration increased the a* and b* values due to the greater pigment content. In contrast, increasing drying temperature decreased both values, likely due to heat-induced pigment degradation (Sari, 2018). Overall, the yogurt powder exhibited a yellowish-white color, consistent with findings for yogurt powder containing *kecombrang* extract produced using the same foam mat drying method and foaming agent (Naufalin et al., 2024). Similarly, soybean milk yogurt powder produced using the foam mat drying method exhibited a yellowish-white color (Hayati et al., 2024).

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Dissolution time

Yogurt powder fortified with *wedang uwuh* extract had a dissolution time ranging from 29.58 to 29.85 seconds when brewed with water at 25 °C and from 10.00 to 10.15 seconds when brewed with water at 40 °C (Table 2). The effects of drying temperature and *wedang uwuh* extract concentration did not significantly influence ($p > 0.05$) the product's dissolution time. This indicates that variations in drying temperature and *wedang uwuh* extract concentration did not cause significant changes in dissolution time. Consistent with the research by Apriyan et al. (2025), the temperature applied during the production of the functional beverage *wedang pokak* did not show a significant effect on dissolution time.

Generally, dissolution time is affected by several factors, including particle size and particle morphology, surface properties, and storage conditions of the instant beverage powder (Suhag et al., 2024). Liquid temperature is known to influence the rehydration process of instant powder. Higher temperatures can increase molecular mobility, reduce surface tension and viscosity, and weaken intermolecular forces, thereby accelerating the dissolution process (Jiang et al., 2025). The dissolution time measurement results are presented in Table 2.

Total soluble solids (TSS)

The TSS content of yogurt is the soluble components of the product, consisting of total

Table 1. Color of the *wedang uwuh* yogurt drink powder

Drying temperature (°C)	Concentration of *wedang uwuh* (%)	Color		
		L*	a*	b*
50	0	97.10±0.00^{E}	0.72±0.07^{Aa}	15.90±0.72^{Aa}
	3	95.17±0.06^{D}	2.31±0.02^{Bb}	18.31±0.48^{Ba}
	6	94.13±0.23^{C}	2.70±0.61^{Ba}	18.17±0.30^{Ba}
	9	93.00±0.00^{B}	3.41±0.33^{Ca}	19.70±1.05^{Ca}
	12	92.33±0.15^{A}	3.47±0.07^{Cb}	19.71±0.35^{Cb}
60	0	95.93±0.06^{E}	1.73±0.29^{Ab}	17.64±0.12^{Ab}
	3	95.10±0.26^{D}	2.06±0.05^{ABb}	18.22±0.78^{Aa}
	6	94.30±0.20^{C}	2.30±0.26^{Ba}	18.55±0.17^{Aa}
	9	93.30±0.10^{B}	3.03±0.38^{Ca}	20.74±0.87^{Ba}
	12	92.37±0.15^{A}	4.16±0.05^{Dc}	22.73±0.28^{Cc}
70	0	95.87±0.49^{D}	1.43±0.51^{Ab}	18.03±0.85^{ABb}
	3	95.37±0.20^{CD}	1.70±0.29^{ABc}	17.54±0.29^{Aa}
	6	94.53±0.15^{C}	2.10±0.27^{Bb}	17.98±0.86^{ABa}
	9	93.61±0.28^{B}	2.83±0.12^{Ca}	19.49±0.17^{Ca}
	12	92.30±0.79^{A}	3.10±0.17^{Ca}	18.86±0.19^{BCa}

Note: Different superscript letters indicate significant differences ($p < 0.05$). Uppercase letters are used for concentrations and lowercase letters for temperature

Table 2. Dissolution time of *wedang uwuh* yogurt drink powder

Water temperature	Concentration of *wedang uwuh* (%)	Dissolution time (seconds)		
		50 °C	60 °C	70 °C
Cold water (25 °C)	0	29.64±0.08	29.85±0.16	29.71±0.19
	3	29.75±0.12	29.67±0.15	29.68±0.11
	6	29.77±0.16	29.72±0.13	29.78±0.07
	9	29.83±0.11	29.58±0.12	29.76±0.30
	12	29.65±0.17	29.69±0.19	29.78±0.15
Warm water (40 °C)	0	10.06±0.03	10.06±0.05	10.13±0.08
	3	10.13±0.04	10.07±0.05	10.00±0.06
	6	10.11±0.15	10.15±0.05	10.04±0.10
	9	10.14±0.07	10.06±0.15	10.02±0.12
	12	10.07±0.01	10.10±0.12	10.02±0.09

Note: No significant differences were observed among treatments ($p > 0.05$)

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residual sugar, lactic acid, and other organic acids (Tacazily et al., 2024). The TSS of the yogurt drink powder fortified with *wedang uwuh* extract ranged from 9.02 to 10.70°Brix (Figure 2). Drying temperature significantly affected the product's TSS content ($p < 0.05$). Increasing temperature enhances moisture removal during the drying process. The reduced moisture level results in dissolved solids becoming more concentrated, leading to a higher measured TSS value. These findings are consistent with previous studies reporting that increasing drying temperature can increase TSS (Degwale et al., 2022; Yudhistira et al., 2025).

Differences in the concentration of *wedang uwuh* extract showed no significant influence on the product's TSS content ($p > 0.05$). This occurred because the addition of *wedang uwuh* extract at concentrations up to 12% did not contribute significantly to an increase in the amount of total dissolved solids in the product. Similar findings were reported in a study where the addition of fruit juice with a relatively high water content had no significant effect on the TSS of yogurt (Zulaikhah and Karseno, 2024). Furthermore, the lack of significance in the analysis results was also attributed to the relatively narrow or small concentration range of the juice, resulting in no significant differences in the solid components of the product (Zulaikhah and Fitria, 2020; Tacazily et al., 2024).

Antioxidant activity

Antioxidants help counteract free radicals in biological systems that may adversely affect living organisms (Munteanu and Apetrei, 2021). Antioxidant activity was evaluated based on the percentage inhibition of DPPH radicals using a UV-Vis spectrophotometric method. The analysis was performed on yogurt powder samples dissolved in methanol at a ratio of 1:10 (10% w/v). The antioxidant activity results are presented in Figure 3.

The addition of *wedang uwuh* extract and drying temperature significantly affected the antioxidant activity of the yogurt drink powder ($p < 0.05$). Antioxidant activity increased with increasing concentration of *wedang uwuh* extract. Before the addition of *wedang uwuh* extract, antioxidant activity ranged from 21 to 45%, whereas after its addition, it increased to 49 to 90%. This increase may be attributed to bioactive compounds present in *wedang uwuh*, including phenolics, flavonoids, and alkaloids, along with other bioactive compounds (Shakty and Anggreini, 2023). Antioxidant activity is closely related to the levels of phenolic and flavonoid compounds, which can contribute to free radical scavenging (Felicia et al., 2023). The yogurt drink powder without added *wedang uwuh* extract had a high antioxidant content of 45%. This is because the fermentation process can increase antioxidant activity by forming bioactive

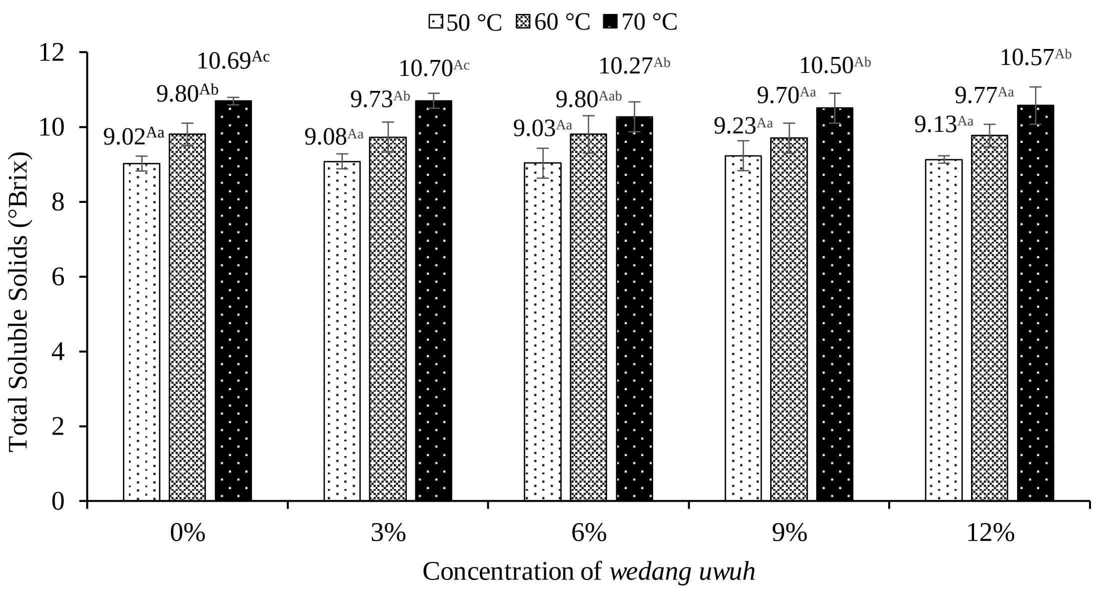

Figure 2. TSS of *wedang uwuh* yogurt drink powder

Note: Different superscript letters indicate significant differences ($p < 0.05$). Uppercase letters are used for concentrations and lowercase letters for temperature

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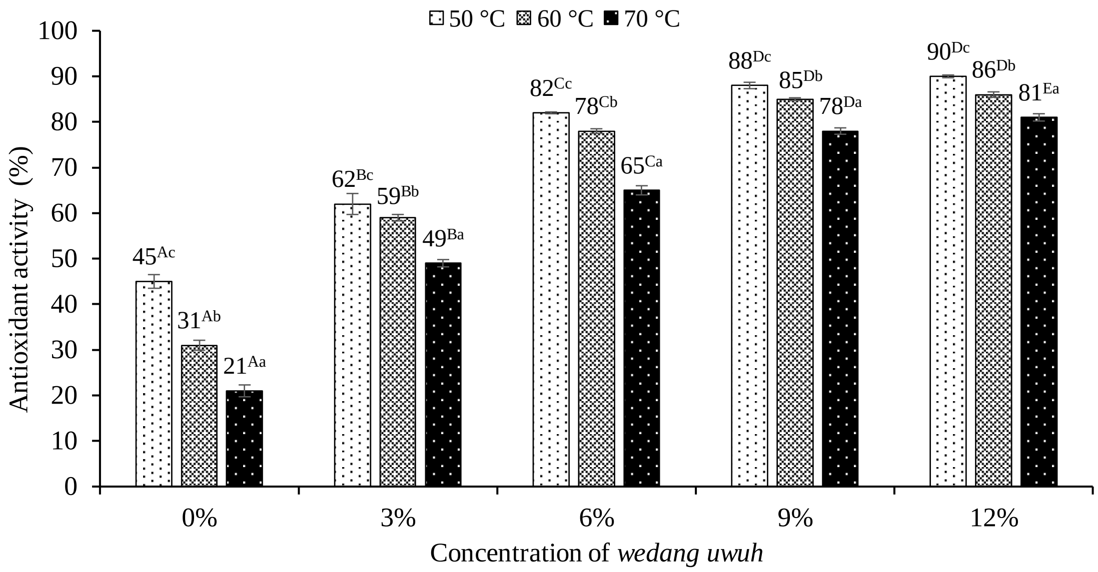

Figure 3. Antioxidant activity of *wedang uwuh* yogurt drink powder

Note: Different superscript letters indicate significant differences ($p < 0.05$). Uppercase letters are used for concentrations and lowercase letters for temperature

compounds through metabolism (Sibuea and Siantar, 2022).

Antioxidant activity generally decreased with increasing drying temperature. This may be attributed to the heat sensitivity of bioactive compounds such as phenols and flavonoids, which are secondary metabolites that can undergo degradation during high-temperature drying (Hradaya and Husni, 2021; Paiva et al., 2023). Exposure to high temperature during the drying of *wedang uwuh* has also been reported to reduce its antioxidant activity (Septiyani and Rahmawati, 2019). However, the antioxidant activity in this study was still partially retained because bioactive compounds do not exhibit the same degree of thermal sensitivity. For example, gingerol in ginger can be converted into shogaol and zingerone, which retain antioxidant activity (Jung et al., 2018; Sueishi et al., 2019). Therefore, these transformation products may contribute to the antioxidant activity remaining after the drying process.

Total lactic acid bacteria (LAB)

The LAB count in the yogurt drink before drying ranged from 2.48×10^{22} to 2.77×10^{22} CFU g^{-1}. Following the drying process, the LAB count decreased to 2.45×10^{10} to 3.52×10^{11} CFU g^{-1}. The total LAB is presented in Table 3. The yogurt was fermented with *L. bulgaricus* and *S. thermophilus*, which are the characteristic starter cultures used in yogurt production. During fermentation, these bacteria exhibit a symbiotic interaction that facilitates lactose metabolism and lactic acid production, contributing to the acidification and development of the characteristic properties of yogurt. The incorporation of *wedang uwuh* extract did not significantly affect the total LAB count ($p > 0.05$). LAB can adapt to environments containing phenolic compounds, allowing their viability in the product to be maintained without significant changes. Similar findings have been reported for yogurt supplemented with butterfly pea flower extract and spice extract, which did not significantly affect the LAB viability, and the resulting product remained within the Indonesian National Standard (SNI) requirements (Chosyatillah and Saidi, 2023; Cahyanti et al., 2024).

In contrast, drying temperature significantly affected the total LAB count ($p < 0.05$). The results indicated that increasing the drying temperature tended to reduce LAB viability in the product (Table 3). During drying, water evaporation induces thermal and dehydration stress, which can reduce LAB viability. Thermal stress causes macromolecular denaturation and cell damage, while dehydration disrupts membrane integrity and protein/enzyme functions, thereby impairing metabolic activity and reducing cell viability (Van Engeland et al., 2025).

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Table 3. Total LAB in yogurt drink powder and *wedang uwuh*

Concentration of *wedang uwuh* (%)	Drying temperature			
	Yogurt drink LAB (CFU g^{-1})	50 °C LAB (CFU g^{-1})	60 °C LAB (CFU g^{-1})	70 °C LAB (CFU g^{-1})
0	2.77×10^{22}	3.24×10^{11Ab}	2.80×10^{11Ab}	3.28×10^{10Aa}
3	2.55×10^{22}	3.45×10^{11Ab}	2.37×10^{11Ab}	3.17×10^{10Aa}
6	2.48×10^{22}	3.27×10^{11Ac}	2.50×10^{11Ab}	2.47×10^{10Aa}
9	2.59×10^{22}	3.42×10^{11Ab}	2.38×10^{11Ab}	2.45×10^{10Aa}
12	2.54×10^{22}	3.52×10^{11Ac}	3.15×10^{11Ab}	3.40×10^{10Aa}

Note: Different superscript letters indicate significant differences ($p < 0.05$). Uppercase letters are used for concentrations and lowercase letters for temperature

The LAB count obtained in the present study was also relatively close to that reported in yogurt powder made from legumes and *salak*, which ranged from 10^8 to 10^{10} CFU g^{-1} (Nuraeni et al., 2025). The use of 20% maltodextrin in yogurt powder production resulted in higher encapsulation efficiency and was able to maintain LAB viability (Eris et al., 2023). The use of egg white as a foaming agent resulted in higher viability, ranging from 1.5×10^9 to 1.8×10^{10} CFU g^{-1}, compared with Tween 80, which resulted in LAB viability ranging from 2.2×10^7 to 6.5×10^5 CFU g^{-1} (Ramanda et al., 2026). This result is in line with a previous study on instant red bean yogurt powder produced using the foam mat drying method, with egg white as the foaming agent and maltodextrin as the carrier, which reported LAB counts ranging from 12.55 to 15.59 log CFU ml^{-1} (Sihombing et al., 2026). The combination of egg white and maltodextrin may provide a protective matrix that helps maintain LAB viability during drying. Although there was a decrease in the number of LAB due to the drying process, the LAB count in the product met the yogurt quality standards set by SNI 2981:2009, requiring at least 10^7 CFU ml^{-1}.

CONCLUSIONS

The addition of *wedang uwuh* extract and drying temperature influenced the physicochemical, antioxidant, and microbiological characteristics of yogurt drink powder, while dissolution time remained unaffected. Higher *wedang uwuh* concentrations enhanced the antioxidant activity and color intensity, whereas higher drying temperatures tended to reduce antioxidant activity and LAB viability. The combination of 12% *wedang uwuh* extract and a drying temperature at 60 °C provided the most favorable balance among product quality, antioxidant activity, and LAB viability. These findings demonstrate the potential of *wedang uwuh*-fortified yogurt drink powder as a convenient functional beverage and provide an approach for adding value to traditional herbal ingredients.

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In the preparation of this manuscript, the authors used ChatGPT solely to assist with paraphrasing and grammar correction. The use of AI was limited to language editing and did not involve data generation, data analysis, interpretation of results, or scientific decision-making. The authors remain fully responsible for the content and scientific integrity of the manuscript.

REFERENCES

Abidin, A. F., Yuwono, S. S., & Maligan, J. M. (2019). The effect of maltodextrin and egg white on characteristic of white oyster mushroom broth powder. *Jurnal Pangan dan Agroindustri*, *7*(4), 53–61. https://doi.org/10.21776/ub.jpa.2019.007.04.6

Adipratama, T., Widyasanti, A., & Shah, N. N. A. K. (2024). Pembuatan bubuk jus tomat beef

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dengan metode foam mat drying. *Seminar Nasional Pariwisata dan Kewirausahaan (SNPK)*, *3*, 718–722. https://doi.org/10.36441/snpk.vol3.2024.293

Amini, K., Susanto, E., & Suharto, S. (2023). Karakteristik fisikokimia flavor bubuk kepala udang vanamei (*Litopenaeus vannamei*) dengan perbedaan konsentrasi maltodekstrin pada metode foam mat drying. *Jurnal Ilmu dan Teknologi Perikanan*, *5*(2), 99–110. https://doi.org/10.14710/jitpi.2023.16546

Anjani, T., Hutami, R., & Pertiwi, S. R. R. (2024). Penggunaan ekstrak wedang uwuh pada inovasi yoghurt fungsional. *Karimah Tauhid*, *3*(3), 3200–3209. https://doi.org/10.30997/karimahtauhid.v3i3.12488

AOAC. (2016). *Appendix F: Guideline for standard method performance requirement*. AOAC Official Method of Analysis. Association of Official Agricultural Chemists International. Retrieved from https://www.aoac.org/resources/?topic=Methods+%26+Standards&type=&key=

Apriyan, I. D., Supriyanto, & Asfan, D. F. (2025). Karakteristik fisikokimia dan aktivitas antioksidan minuman fungsional wedang pokak instan khas Madura. *AGRITEKNO : Jurnal Teknologi Pertanian*, *14*(1), 18–29. https://doi.org/10.30598/jagritekno.2025.14.1.18

Cahyanti, A. N., Nofiyanto, E., Sampurno, A., Sudjatinah, S., & Iswoyo, I. (2024). Total bakteri asam laktat, pH, aktivitas antioksidan dan kesukaan soygurt nangka dengan penambahan ekstrak rempah. *Prosiding Seminar Nasional Biologi*, *12*, 104–112. Retrieved from https://proceedings.unnes.ac.id/semnasbiologi/article/view/3942

Chosyatillah, A. A., & Saidi, I. A. (2023). The effect of various concentrations of telang flower (*Clitoria ternatea* L.) extract on cow milk yogurt characteristic. *Procedia of Engineering and Life Science*, *4*, 1–12. https://doi.org/https://doi.org/10.21070/ups.1592

de Carvalho, T. I. M., Nogueira, T. Y. K., Mauro, M. A., Gómez-Alonso, S., Gomes, E., Da-Silva, R., ... & Lago-Vanzela, E. S. (2017). Dehydration of jambolan [*Syzygium cumini* (L.)] juice during foam mat drying: Quantitative and qualitative changes of the phenolic compounds. *Food Research International*, *102*, 32–42. https://doi.org/10.1016/j.foodres.2017.09.068

Degwale, A., Asrat, F., Eniyew, K., Asres, D., Tesfa, T., & Ayalew, A. (2022). Influence of dehydration temperature and time on physicochemical properties of tomato (*Solanum lycopersicum* L.) powder. *Frontiers in Sustainable Food Systems*, *6*, 839385. https://doi.org/10.3389/fsufs.2022.839385

Dewatisari, W. F., & Hariyadi, H. (2024). Potensi antibakteri minuman fungsional tradisional jawa (wedang uwuh) berdasarkan variasi waktu rebusan. *Jurnal Teknologi dan Industri Pangan*, *35*(1), 10–26. https://doi.org/10.6066/jtip.2024.35.1.10

Dhawi, F., El-Beltagi, H. S., Aly, E., & Hamed, A. M. (2020). Antioxidant, antibacterial activities and mineral content of buffalo yoghurt fortified with fenugreek and *Moringa oleifera* seed flours. *Foods*, *9*(9), 1157. https://doi.org/https://doi.org/10.3390/foods9091157

Eris, F. R., Kusumasari, S., Pamela, V. Y., Febriansah, M. R., & Riyanto, R. A. (2023). Dextrose equivalent (DE) variation and maltodextrin concentration effects in yoghurt powder characteristics using foam-mat drying. *Indonesian Food Science and Technology Journal*, *7*(1), 36–42. https://doi.org/10.22437/ifstj.v7i1.30152

Fadhilah, D. N., Hutauruk, D., & Nurbaya, S. (2023). Karakterisasi simplisia dan skrining fitokimia ekstrak etanol kayu secang (*Caesalpinia sappan* L). *Jurnal Ilmu Kesehatan dan Gizi*, *1*(1), 207–217. https://doi.org/10.55606/jikg.v1i1.961

Felicia, N., Widarta, I. W. R., & Yusasrini, N. L. A. (2016). Pengaruh ketuaan daun dan metode pengolahan terhadap aktivitas antioksidan serta karakteristik sensoris teh herbal bubuk daun alpukat (*Persea americana* Mill.). *Jurnal ITEPA*, *5*(2), 85–94. Retrieved from https://www.scribd.com/document/525265840/27503-1-53714-1-10-20170125

Harijono, M. L., Estiasih, T., Narsito Wulan, S., & Sisca, P. H. (2021). The potential of

Copyright © 2026 Universitas Sebelas Maret

functional drink's wedang uwuh as body weight control and blood glucose level. *Jurnal Pangan dan Agroindustri*, *9*(3), 155–164. https://doi.org/10.21776/ub.jpa.2021.009.03.3

Haryanto, B. (2007). Fisik, kadar antosianin dan aktivitas antioksidan bubuk instan ekstrak kulit manggis (*Garcinia mangostana* L.) dengan metode foam mat drying. *Jurnal Kesehatan*, *7*(1), 2. https://doi.org/10.26630/jk.v7i1.112

Hayati, R. N., Rohmah, I. A., Sa'adah, K., Hikmawati, S. N., & Muflihati, I. (2024). Pembuatan yoghurt bubuk susu kedelai (*Glycine max* L. Meriil) menggunakan metode foam mat drying dengan penambahan maltodekstrin sebagai bahan penyalut. *METANA*, *20*(1), 27–39. https://doi.org/10.14710/metana.v20i1.58805

Hradaya, K. P. T., & Husni, A. (2021). Pengaruh suhu ekstraksi terhadap aktivitas antioksidan ekstrak metanolik *Eucheuma spinosum*. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *24*(1), 1–10. https://doi.org/10.17844/jphpi.v24i1.34193

Husni, P., Fadhiilah, M. L., & Hasanah, U. (2020). Formulasi dan uji stabilitas fisik granul instan serbuk kering tangkai genjer (*Limnocharis flava* (L.) Buchenau.) sebagai suplemen penambah serat. *Jurnal Ilmiah Farmasi Farmasyifa*, *3*(1), 1–8. https://doi.org/10.29313/jiff.v3i1.5163

Ihsani, Y. Y., Widyasanti, A., & Shah, N. N. A. K. (2024). Penerapan metode pengeringan busa (foam mat drying) pada proses pembuatan serbuk ampas tomat beef. *Seminar Nasional Pariwisata dan Kewirausahaan (SNPK)*, *3*, 690–698. https://doi.org/10.36441/snpk.vol3.2024.290

Jiang, H., Zhang, N., Xie, L., Li, G., Chen, L., & Liao, Z. (2025). A comprehensive review of the rehydration of instant powders: Mechanisms, influencing factors, and improvement strategies. *Foods*, *14*(16), 2883. https://doi.org/10.3390/foods14162883

Jung, M. Y., Lee, M. K., Park, H. J., Oh, E. B., Shin, J. Y., Park, J. S., ... & Choi, D. S. (2018). Heat-induced conversion of gingerols to shogaols in ginger as affected by heat type (dry or moist heat), sample type (fresh or dried), temperature and time. *Food Science and Biotechnology*, *27*(3), 687–693. https://doi.org/10.1007/s10068-017-0301-1

Kamoda, A. P., Nindatu, M., Kusadhiani, I., Astuty, E., Rahawarin, H., & Asmin, E. (2021). Uji aktivitas antioksidan alga cokelat *Saragassum* sp. dengan metode 1,1-difenil-2-pikrihidrasil (DPPH). *Patimura Medical Review*, *3*(1), 60–72. https://doi.org/10.31539/bioedusains.v7i2.11507

Karelakis, C., Zevgitis, P., Galanopoulos, K., & Mattas, K. (2020). Consumer trends and attitudes to functional foods. *Journal of International Food & Agribusiness Marketing*, *32*(3), 266–294. https://doi.org/10.1080/08974438.2019.1599760

Kasmiyetti, K., Amri, Z., Hasneli, H., Rahmayeni, S., & Mushollini, F. (2022). Pengaruh lama penyimpanan terhadap pH dan total bakteri asam laktat yoghurt dengan penambahan sari buah naga merah sebagai minuman fungsional bagi penderita hiperkolesterolemia. *Jurnal Teknologi Pangan dan Gizi*, *21*(2), 87–93. https://doi.org/10.33508/jtpg.v21i2.2986

Krisnaningsih, A. T. N., Kustyorini, T. I. W., & Selviana, R. (2020). Evaluasi sineresis dan sensori yogurt dengan penambahan stabilizer pati talas lokal (*Colocasia esculenta*) pada masa inkubasi 18 jam suhu ruang. *REKASATWA: Jurnal Ilmiah Peternakan*, *2*(2), 106–114. https://doi.org/10.33474/rekasatwa.v2i2.9056

Latifasari, N., Kurniawati, A. D., Naufalin, R., & Raharditya, C. (2024). Effect of adding hydrocolloid as a stabilizer on the rheological properties and total lactic acid bacteria of yogurt drinks during cold storage. *Jurnal Ilmu-Ilmu Peternakan*, *34*(3), 391–398. https://doi.org/10.21776/ub.jiip.2024.034.03.10

Latifasari, N., Naufalin, R., Supriyanti, R., Nuraeni, I., & Hartono, E. F. (2023). The evaluation of physicochemical and sensory properties of Sehati yogurt drink flavors with a combination of spice extract. *AgriHealth: Journal of Agri-Food, Nutrition and Public Health*, *4*(1), 23–32. https://doi.org/10.20961/agrihealth.v4i1.70515

Lau, M. A., Suseno, B. K., & Sudradjat, S. E. (2022). Wedang uwuh: Minuman herbal kaya antioksidan dari Yogyakarta. *Jurnal*

Copyright © 2026 Universitas Sebelas Maret

MedScientiae, *1*(1), 10–14. https://doi.org/10.36452/jmedscie.v1i1.2443

Lebdoyono, R., Azzahrya, A. B., & Prayitno, S. A. (2025). Nutritional and sensory evaluation of yogurt drinks based on pure milk and low-lactose milk with probiotic fermentation. *Journal of Tropical Food and Agroindustrial Technology*, *6*(1), 26–32. https://doi.org/10.21070/jtfat.v6i01.1645

Malik, M., & Sharma, A. (2019). Optimisation of foam-mat drying of yoghurt and properties of powdered yoghurt. *International Journal of Dairy Technology*, *72*(3), 381–387. https://doi.org/10.1111/1471-0307.12594

Melia, S., Juliyarsi, I., & Kurnia, Y. F. (2022). Physicochemical properties, sensory characteristics, and antioxidant activity of the goat milk yogurt probiotic *Pediococcus acidilactici* BK01 on the addition of red ginger (*Zingiber officinale* var. *rubrum rhizoma*). *Veterinary World*, *15*(3), 757–764. https://doi.org/10.14202/vetworld.2022.757-764

Miskiyah, Juniawati, Ayu, K., & Mulyati, A. H. (2019). Study on yoghurt powder probiotic quality using foam-mat drying method. *IOP Conference Series: Earth and Environmental Science*, *309*(1), 012048. https://doi.org/10.1088/1755-1315/309/1/012048

Munteanu, I. G., & Apetrei, C. (2021). Analytical methods used in determining antioxidant activity: A review. *International Journal of Molecular Sciences*, *22*(7), 3380. https://doi.org/10.3390/ijms22073380

Naufalin, R., Wijonarko, G., Wicaksono, R., & Bawono, I. R. (2024). Sensory characteristics of yoghurt powder with the addition of kecombrang extract (*Etlingera elatior*). *Proceeding International Conference on Multidisciplinary Approaches for Sustainable Rural Development*, 15–20. Retrieved from https://jos.unsoed.ac.id/index.php/eprocicma/article/download/10315/4995

Nuraeni, I., Sumarto, S., & Radiati, A. (2025). Microbiological properties, dietary fiber, and nutritional content of fluidized bed-dried local legumes and salak yogurt powder. *Amerta Nutrition*, *9*(3), 506–513. https://doi.org/10.20473/amnt.v9i3.2025.506-513

Paiva, Y. F., Figueirêdo, R. M. F. D., Queiroz, A. J. D. M., Amadeu, L. T. S., Reis, C. G. D., Santos, F. S. D., ... & Lima, T. L. B. D. (2023). Tropical red fruit blend foam mat drying: Effect of combination of additives and drying temperatures. *Foods*, *12*(13), 2508. https://doi.org/10.3390/foods12132508

Prabaningrum, S. D., Bintoro, V. P., Budi, S., & Abduh, M. (2022). Pengaruh konsentrasi bahan pengikat terhadap nilai rendemen, kadar air, aktivitas air dan warna pada nori artifisial daun cincau. *Jurnal Aplikasi Teknologi Pangan*, *11*(2), 47–52. https://doi.org/10.17728/jatp.14367

Ragab, E. S., Zhang, S., Korma, S. A., Buniowska-Olejnik, M., Nasser, S. A. A., Esatbeyoglu, T., ... & Nassar, K. S. (2023). Physicochemical and rheological properties of stirred yoghurt during storage induced from high-intensity thermosonicated goat and cow milk. *Fermentation*, *9*(1), 42. https://doi.org/10.3390/fermentation9010042

Ramanda, M. R., Ulfa, M. N., & Rahma, Z. D. (2026). Pengaruh suhu pengeringan sorgum dan kacang tunggak terhadap sifat fisikokimia dan sensori serbuk minuman serelia. *Agrisaintifika Jurnal Ilmu-Ilmu Pertanian*, *10*(1), 87–101. https://doi.org/10.32585/ags.v10i1.7522

Safitri, Y. D., Nugraheni, K., Fitriyanti, A. R., & Isworo, J. T. (2024). Total bakteri asam laktat dan total padatan terlarut yoghurt kelapa dengan penambahan bunga telang berdasarkan lama penyimpanan. *Prosiding Seminar Nasional Unimus*, *7*, 1262–1269. Retrieved from https://prosiding.unimus.ac.id/index.php/semnas/article/viewFile/1823/1828

Santi, I. N., Utama, I. M. S., & Madrini, I. A. G. B. (2021). Pengaruh suhu dan waktu pengeringan terhadap karakteristik fisikokimia buah naga merah (*Hylocereus polyrhizus* (Weber) Britton & Rose) kering. *Jurnal Hortikultura Indonesia*, *12*(1), 69–80. https://doi.org/10.29244/jhi.12.1.69-80

Saraswati, I. (2016). Pengaruh nilai pH terhadap warna dari kayu secang (*Caesalpinia sappan* L.) sebagai indikator alami baru. *Media Medika Muda*, *1*(3), 151–156. Retrieved from https://ejournal2.undip.ac.id/index.php/mmm/article/view/2607

Copyright © 2026 Universitas Sebelas Maret

Sari, Y. (2018). Pengaruh pemanasan terhadap kestabilan pigmen betalain dari buah naga merah (*Hylocereus polyrhizus*). *Orbital: Jurnal Pendidikan Kimia*, *2*(1), 37–42. https://doi.org/10.19109/ojpk.v2i1.2168

Septiyani, R., & Rahmawati, E. (2019). Perbedaan aktivitas antioksidan pada minuman tradisional wedang uwuh original, seduh, celup, instan dan sirup. *CHEMICA: Jurnal Teknik Kimia*, *6*(1), 23–29. https://doi.org/10.26555/chemica.v6i1.14061

Setiawan, S. C. E., Yuliantara, A., & Murti, P. D. B. (2024). Pangan fungsional dari bahan pangan tradisional: Tinjauan pustaka. *Agrointek : Jurnal Teknologi Industri Pertanian*, *18*(3), 552–560. https://doi.org/10.21107/agrointek.v18i3.15464

Setyawardani, T., Sumarmono, J., & Dwiyanti, H. (2021). Preliminary investigation on the processability of low-fat herbal cheese manufactured with the addition of moringa, bidara, and bay leaves extracts. *IOP Conference Series: Earth and Environmental Science*, *1012*(1), 012081. https://doi.org/10.1088/1755-1315/1012/1/012081

Shakty, F. K. N., & Anggreini, R. A. (2023). Wedang uwuh: Tinjauan komprehensif tentang potensi antioksidan dan efek kesehatan untuk meningkatkan metabolisme diabetes. *Prosiding Seminar Nasional Teknologi Pangan*, *1*(1), 24–35. Retrieved from https://sntp.upnjatim.ac.id/fstproceeding/index.php/sntp/article/view/4

Sibuea, P., & Siantar, V. N. L. (2022). Aktivitas antioksidan yoghurt dengan penambahan ekstrak buah bit (*Beta vulgaris* L.) dan mutu probiotik yang dihasilkan. *Jurnal Riset Teknologi Pangan dan Hasil Pertanian (RETIPA)*, *3*(1), 22–29. https://doi.org/10.54367/retipa.v3i1.2243

Sihombing, D. R., Daniela, C., & Telaumbanua, C. N. (2026). Inovasi yoghurt instan kacang merah bebas gluten kaya antioksidan melalui metode foam mat drying. *Jurnal Teknologi Pengolahan Pertanian*, *8*(1), 73–84. https://doi.org/10.35308/jtpp.v8i1.15208

Sueishi, Y., Masamoto, H., & Kotake, Y. (2019). Heat treatments of ginger root modify but not diminish its antioxidant activity as measured with multiple free radical scavenging (MULTIS) method. *Journal of Clinical Biochemistry and Nutrition*, *64*(2), 143–147. https://doi.org/10.3164/jcbn.18-41

Suhag, R., Kellil, A., & Razem, M. (2024). Factors influencing food powder flowability. *Powders*, *3*(1), 65–76. https://doi.org/10.3390/powders3010006

Tacazily, I. V., Sakul, S. E., & Rumondor, D. B. J. (2024). Karakteristik pH, total padatan dan sifat sensoris yogurt dengan penambahan serai (*Cymbopogon citratus*). *Prosiding Seminar Nasional Fakultas Peternakan Universitas Sam Ratulangi Manado*, *1*, 95–107. Retrieved from https://ejournal.unsrat.ac.id/v3/index.php/semnas-fapet-unsrat/article/view/55451

Van Engeland, C., Haut, B., & Debaste, F. (2025). A closer look at the potential mechanisms of action of protective agents used in the drying of microorganisms: A review. *Microorganisms*, *13*(2), 435. https://doi.org/10.3390/microorganisms13020435

Widanti, Y. A., Nuraini, V., & Ariyanto, S. D. (2019). Sifat sensoris dan aktivitas antioksidan wedang uwuh kelor dengan variasi cara penyeduhan. *Research Fair Unisri*, *3*(1), 290–297. https://doi.org/10.33061/rsfu.v3i1.2588

Widyaningsih, T. D., Siska, A. I., Fanani, R., & Martati, E. (2020). Traditional drink of black cincau (*Mesona palustris* BL)-based wedang uwuh as immunomodulator on alloxan-induced diabetic rats. *Nutrition and Food Science*, *50*(6), 1123–1133. https://doi.org/10.1108/NFS-05-2019-0165

Winasih, P. A., Supriyadi, S., & Turahman, T. (2023). Uji aktivitas antioksidan wedang uwuh dengan variasi formula jenis jahe dan waktu penyeduhan. *Jurnal Sains dan Kesehatan*, *5*(5), 633–642. https://doi.org/10.30872/jsk.v5i5.545

Wisnawa, P. I. P. (2022). *Spire insights: Industri yoghurt di Indonesia kian menjanjikan*. Technobusiness. Retrieved from https://technobusiness.id/insight/ys-insights/2022/04/20/spire-insights-industri-yogurt-di-indonesia-kian-menjanjikan/

Yudhistira, B., Pratiwi, H., & Atmaka, W. (2025). Pengaruh pengeringan dan pengecilan ukuran terhadap sifat bubuk *Stevia rebaudiana*.

Copyright © 2026 Universitas Sebelas Maret

Teknotan: Jurnal Industri Teknologi Pertanian, *19*(3), 219–224. https://doi.org/10.24198/jt.vol19n3.6

Zulaikhah, S. R., & Fitria, R. (2020). Pengaruh penambahan sari buah pisang ambon (*Musa paradisiaca*) sebagai perisa alami terhadap warna, total padatan terlarut dan sifat organoleptik yogurt. *Jurnal Sain Peternakan Indonesia*, *15*(4), 434–440. https://doi.org/10.31186/jspi.id.15.4.434-440

Zulaikhah, S. R., & Karseno, K. (2024). Total padatan dan warna L*, a*, b* yogurt dengan penambahan sari buah naga merah (*Hylocereus polyrhizus*) yang berbeda levelnya. *Jurnal Peternakan Indonesia*, *26*(3), 120–127. https://doi.org/10.25077/jpi.26.3.120-127.2024

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