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Physicochemical Characterization And Antioxidant Potential Of Powder Drink With The Combination Of Dayak Onion (*Eleutherine Palmifolia*) And Tempe

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ABSTRACT
Antioxidants play an important role in protecting body health. Sources of natural antioxidants that have not been widely developed are dayak onion and tempe. This research aims to evaluate the antioxidant properties and physicochemical quality characteristics of dayak onion powder dried using the spray dryer (SD) and fluidized bed dryer (FBD) methods and the best combination with tempe powder to produce drink powder. Specifically, this research examines the antioxidant capacity (IC50), total flavonoid content, and color characteristics of dayak onion powder dried using SD and FBD, analyzed with the Independent Sample T-test. The best product of dayak onion powder was dried using FBD instrument and obtained an IC50 antioxidant capacity of 9.16 ± 0.0a ppm, total flavonoids of 6.14 ± 0.04a mgQE/g, whiteness level of 60.6 ± 0 .13b, brightness of 65.3 ±0.16b, a+ of 13.5±0.10a, and b+ of 13.13±0.08b. Dayak onion powder was combined with tempe powder to produce a drink powder, which was evaluated for its physicochemical characteristics using the RAL method and Duncan's test. The best combination of powdered drink products is 40% dayak onion powder + 50% tempe powder, has an IC50 antioxidant capacity (662.95 ± 0.03c ppm) and total flavonoids (4.74 ± 0.04c mgQE/g), with chemical characteristics quality requirements Indonesian National Standard (SNI 7612-2011): protein (32.02±0.35b %w/w), moisture (6.55±0.01b %w/w), ash (1.80±0, 00b %w/w), fat (17.32±0.01b %w/w), aw (0.23±0.01ab) and physical characteristics: viscosity (15.017±0.04b cP), solubility index (9.771 ±0.07b g/ml), bulk density (0.7145±0.00b g/ml) and sedimentation index (9.515±0.18b%).

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INTRODUCTION

Dayak onion is a local plant from Central Kalimantan that can grow wild and easy to cultivate. The main active compound of dayak onion is flavonoid; besides that, it also contains alkaloids, glycosides, saponins, tannins, triterpenoids, polyphenols, and phenols (Anggi & Magfirah, 2019). Phenol is an organic compound with antioxidant potential and is able

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to reduce lipids (Zeni et al., 2017). Subramaniam (2012) stated that dayak onions have secondary metabolites such as phenols, flavonoids, tannins, steroids, protein alkaloids, reducing sugars and terpenoids. A previous study found that dayak onion contains antioxidant phenols, polyphenols (Kuntorini & Astuti, 2010), quercetin, and its derivatives (Lee et al., 2015).

Antioxidants have an important role in protecting the body's health, especially natural antioxidants obtained from plant extracts (Xu et al., 2017). According to Zhang et al. (2015), high antioxidant activity can reduce the level of oxidative stress in the body, which can reduce chronic diseases, such as cardiovascular disease and cancer. Oxidative stress is a condition when the body contains more radicals than antioxidants (Febrinda et al., 2014). Foods high antioxidants protect against chronic diseases such as cardiovascular disease, cancer, diabetes and neurodegenerative diseases (Jideani et al. 2021).

Another source of natural antioxidants is tempe. Tempe is a daily food for Indonesians. Tempe is a fermented soy product that can increase protein digestibility and contains isoflavone aglycones to prevent free radicals (Astawan et al., 2013). Consumption reached 0.143 kg per capita per week in 2023, an increase from 0.140 kg in 2022 (BPS, 2023). Tempe, the result of fermented soybeans, can increase protein digestibility and contains isoflavone aglycones to prevent free radicals (Astawan et al, 2013). However, the shelf life of tempe and dayak onion is short because they have high water content, causing difficulty in distribution.

This study aims to produce a powder drink with a combination of dayak onion and tempe to extend the shelf life and distribution easier. Various results of the study reported the characteristics and functional effects of dayak onion and tempe, but none have combined them. The combination of these two commodities is expected to increase the prophylaxis potential, so it can be an alternative food for sources of antioxidants and protein. This study was conducted in two stages. The first stage was making dayak onion powder with two different drying instruments, a spray dryer (SP), and fluidized bed dryer (FBD) to determine the best drying method. The second stage was formulating the best treatment for dayak onion with tempe powder. Then, a powder drink with the combination of dayak onion and tempe was analyzed for sensory evaluation to evaluate the level of consumer acceptance, chemical tests, physical tests, and bioactivity tests were carried out to determine the best formula.

METHODS

Research Materials

The materials used were dayak onion from Kahayan market in Palangkaraya, Central Kalimantan. Tempe from Rumah Tempe Indonesia in Bogor, commercial gum arabic as a stabilizer and food grade CMC from Mitra Jaya Chemical as a thickening agent, and commercial honey powder as a sweetener.

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Research Methods

The proximate analysis of powder drink referred to as AOAC, (2012), consisted of protein content with the Kjeldahl method, water and ash content with the gravimetry method, fat content with the Soxhlet method and carbohydrate content which was calculated (by difference methods). Water activity (aw) referred to as Nielsen (2010). DPPH analysis referred to as Hidayati et al., (2017), analysis of total flavonoids referred to as Vongsak et al., (2013). The sensory test was done by brewing drink powder. The test has been completed by 50 untrained panelists and scored on a scale of 6, out of 1 (dislike very much) to 6 (like very much). Each panelist will rate four samples based on aroma, taste, color, viscosity and overall attributes. Physical analysis consisted of solubility index was analyzed according to the method of Benkovic et al., (2018), bulk density was carried out according to the method used by Jan, et al. (2018). Viscosity referred to as Ali et al., (2014) and sedimentation index referred to as Senanayake et al., (2013).

Research Design

This study was conducted in two stages. The first stage was processing dayak onion to powder using two types of drying instruments, which are spray dryer (SP) and fluidized bed dryer (FBD). Moreover, analysis was carried out using test parameters of antioxidant capacity, total flavonoid, yield, color intensity, and whiteness. Data from testing results in stage I was carried out with statistical analysis using an independent sample t-test with a confidence level of 95% to determine the difference in data between the two samples. The independent sample t-test can show whether there is a significant difference in mean value between two samples. The best treatment for dayak onion powder was used in stage II, which was the formulation of a powder drink mixed with tempe powder. Furthermore, sensory evaluation was carried out on 50 panelists, chemical tests (proximate and aw analysis), physical tests (viscosity, sedimentation index, solubility, and bulk density) and bioactivity test (antioxidant capacity and total flavonoid) were carried out. Data analysis was carried out using the ANOVA test, followed by the Duncan test using the R Studio application. The formulation of dayak onion powder and tempe powder was added with 5% CMC and 5% gum Arabic as a stabilizer. The weight per formula used was 30 grams, then 1.2 grams of honey powder were added as flavoring (4% of the total net weight of the sample), and the final weight was 31.2 grams. Making tempe powder drink refers to the study by Nutria (2018) with modification. Formulation of the comparison of dayak onion and tempe powder drink in Table 1.

Table 1 the formulation design of powder drink with the combination of dayak onion and tempe powder

Formula	Treatment
T1	(dayak onion powder 20% + tempe powder 70%)
T2	(dayak onion powder 40% + tempe powder 50%)
T3	(dayak onion powder 60% + tempe powder 30%)
T4	(dayak onion powder 80% + tempe powder 10%)

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Making Dayak Onion and Tempe Powder

The drying process with a spray dryer (SP) was carried out by destroying the dayak onion using a blender, then adding water (1:1 b/b), stirring with a shaker for 3 hours, followed by filtering and adding 25% maltodextrin of the final weight of dayak onion extract, and then drying with spray dryer (SP) was carried out. Drying using a fluidized bed dryer instrument was carried out by slicing thinly with a knife, drying with a fluidized bed dryer for 3 hours at a temperature of 43oC, then grinding with a blender and sifting with an 80 mesh sieve. Analysis carried out on dayak onion powder included: antioxidant capacity, total flavonoids, color intensity, whiteness and yield.

Then dayak onion powder with the best characteristics is combined with tempe powder and analysis is carried out: sensory evaluation to see the level of consumer acceptance, chemical tests (proximate and water activity), physical tests (sedimentation index, viscosity, solubility index and kamba density) and analysis are carried out. antioxidant capacity to determine the best formula.

RESULTS AND DISCUSSION

Physicochemical Characteristics of Dayak Onion Powder

Dayak onion powder from spray dryer (SD) and fluidized bed dryer (FBD) drying methods was analyzed for antioxidant capacity using the DPPH method and total flavonoids. The results showed that dayak onion powder using the FBD method had a higher antioxidant capacity and total flavonoids. The results of the analysis of dayak onion powder can be seen in Table 2.

Table 2 the comparison of the test results of dayak onion powder

No	Parameters	Method	
		Spray dryer	fluidized bed dryer
1	IC50 Antioxidant (ppm)	185.90± 0.00^{b}	9.16±0.00 ^{a}
2	Total Flavonoid (mgQE/g)	6.08±0.05^{b}	6.14±0.04^{a}
3	Redness (a+)	13.6±0.10^{a}	13.5±0.10^{a}
4	Yellowish (b+)	8.5±0.13^{b}	13.13±0.08^{a}
5	Brightness (L)	81.5±0.20 ^{a}	65.3±0.16^{b}
7	Whiteness	75.5±0.23 ^{a}	60.6±0.13^{b}
6	Yield (%)	10.8±0.27^{b}	39.5±0.77^{a}

Table 2 shows that the results of the independent sample t-test of dayak onion powder with spray dryer (SP) and fluidized bed dryer (FBD) method are significantly different at the 95% significance level. The fluidized bed dryer (FBD) method has a higher mean value in the parameters of antioxidant activity (very strong), total flavonoid, yield, and color value b+ (yellowish). The average value of the antioxidant activity, total flavonoid, and yield become the main value of a product if the product is to be marketed,

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so the best treatment for drying dayak onion is fluidized. The average of a+ value (redness) does not show a significant difference. Redness in powder can be affected by the red pigment from the anthocyanin compound from the flavonoid group. The stability of anthocyanin and its degradation rate is mainly influenced by temperature. The existence of oxygen and its interaction with other components, such as sugar or ascorbic acid, affects the stability of anthocyanin (Pramiastuti et al., 2021). The main cause of pigment loss is related to the hydrolysis of anthocyanin due to the ratio between the rate of red color loss from anthocyanin and the rate of free sugar formation (Ozela et al., 2007). In the spray dryer (SP) method, extraction was carried out with water and filler in the form of maltodextrin. The addition of maltodextrin also affects the color of the spray dryer (SP) product, so it has a higher L value and whiteness.

Sensory Characteristics of Dayak Onion and Tempe Combination Drink Powder

The drink powder formulation combined with dayak onions and tempe was subjected to sensory evaluation by 50 panelists. Sensory evaluations tested include: aroma, flavour, color, viscosity and overall preference. The results of the sensory evaluation can be seen in Figure 2.

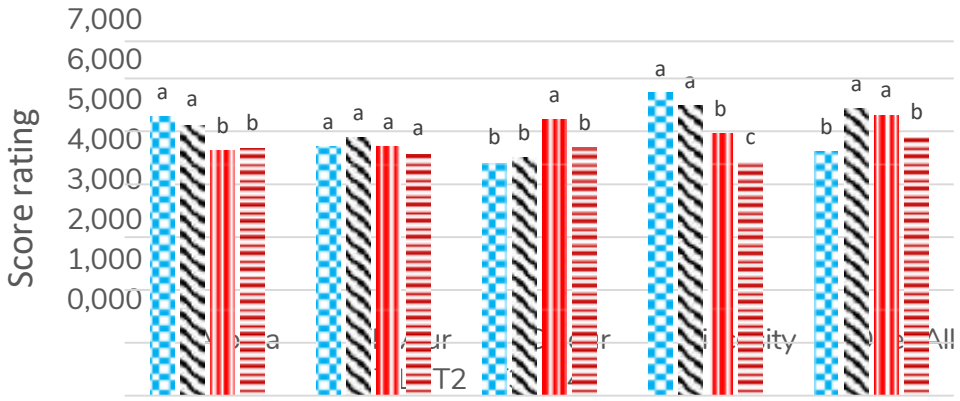

Figure 1 the results of sensory evaluation of powder drink formula

The image is a bar chart depicting the sensory attribute scores (Aroma, Flavour, Colour, Viscosity, and Overall) for four different treatments (T1, T2, T3, and T4). Each bar represents the average score for each attribute, and the letters above the bars indicate statistically significant differences between treatments based on statistical analysis. The aroma value, the highest score was achieved by T1, followed by T2 and T4, which had nearly the same scores, while T3 had the lowest score. In terms of flavour, T1 again had the highest score, followed by T2, T4, and lastly T3. The colour intensity, T1 and T2 had the highest and nearly identical scores, followed by T3 and T4. The viscosity value, T1 again achieved the highest score, followed by T2 and T4, with T3 having the lowest score. Overall, T1 obtained the highest scores across almost all sensory attributes compared to the other treatments, indicating that this treatment might be the most preferred or have the highest quality according to the evaluated sensory attributes. T3 tended to have the lowest scores,

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suggesting that this treatment might be the least preferred or have the lowest quality.

Figure 1 shows that the most preferred product by panelists is the T2 formula (40% dayak onion powder + 50% tempe powder). The most preferred aroma parameters were the formulas T1 and T2. This can be influenced by the aroma of tempe powder, which is more savory than the aroma of dayak onion powder. The distinctive aroma of tempe powder is caused by the volatile components formed from lipid oxidation. Lipid oxidation is an important source of flavor compounds, so the longer the heating process, the more volatile compounds are formed, affecting the aroma (Anwar et al., 2022). In the taste parameter, the average value of products is not significantly different. The color is influenced by the base color of dayak onion powder, which has a reddish-white color, while tempe has a dull white color. The higher the percentage of dayak onion powder added, the higher the preference level of panelists. Viscosity is influenced by the dissolved solid of the product, which is the percentage of tempe powder. Powder drink becomes thicker if the percentage of tempe powder used is higher.

The Characteristics of Chemical Analysis of Powder Drink with the Combination of Dayak Onion and Tempe

The drink powder combined with dayak onion and tempe was analyzed for its chemical components using proximate analysis and water activity (aw). The results of the proximate analysis of the drink powder combined with dayak onions and tempe can be seen in Table 3.

Table 3 the results of proximate analysis

Treatment	Parameter			
	Protein (%w/w)	Moisture (%w/w)	Ash (%w/w)	Fat (%w/w)
T1 (dayak onion powder 20% + tempe powder 70%)	38,30±0.01^{a}	6,76±0.01^{a}	1,78±0.00^{a}	18,65±0.40^{a}
T2 (dayak onion powder 40% + tempe powder 50%)	32,02±0.35^{b}	6,55±0.01^{b}	1,80±0.00^{b}	17,32±0.01^{b}
T3 (dayak onion powder 60% + tempe powder 30%)	23,36±0.33^{c}	6,49±0.12^{c}	1,80±0.00^{b}	15,59±2.00^{c}
T4 (dayak onion powder 80% + tempe powder 10%)	9,97±0.27^{d}	6,32±0.00^{c}	1,82±0.00^{c}	8,21±1.80^{d}

Table 3 shows that products T1, T2, T3, and T4 in the parameters of protein content and fat content are significantly difference at a significant level of 5%. Protein content and fat content are highly affected by the percentage of tempe powder added. The protein molecule can bind, absorb, and retain water in large amounts (Sarofa et al., 2014). This is in accordance with the results of the study, which show that the higher the protein content in a product, the higher the water content. Water content will affect the shelf

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life of a product. According to SNI 7612:2011, soy-based powder drink requires a minimal protein content of 30%, maximal water content of 10%, maximal ash content of 6%, and minimal fat content of 17%. The four products qualify requirements for water and fat content, but only products T1 and T2 qualify minimum requirements for protein and fat content. The main requirement of soy-based powder drinks is the protein content. Ash content is the combination of inorganic components (96%) or minerals in a food ingredient. Ash content represents the mineral total in food ingredients. Organic materials in the combustion process will burn, but inorganic components will not; ash is an inorganic residue from the combustion or oxidation of organic components in food ingredients, so its consumption needs to be limited (Wahyudi, 2018).

Table 4 The Average Value of Water Activity (a_w)

Treatment	Water Activity (a_w)
T1 (dayak onion powder 20% + tempe powder 70%)	$0{,}23\pm0.01^{a}$
T2 (dayak onion powder 40% + tempe powder 50%)	$0{,}23\pm0.01^{ab}$
T3 (dayak onion powder 60% + tempe powder 30%)	$0{,}22\pm0.01^{b}$
T4 (dayak onion powder 80% + tempe powder 10%)	$0{,}20\pm0.01^{c}$

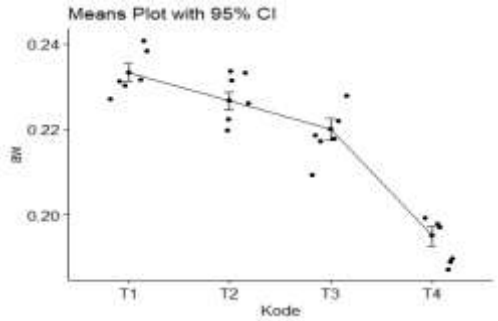

Figure 2 data distribution from the results of a_w analysis

The results of the analysis of variance showed that the different formulation treatments with the addition of BD powder and tempeh powder had significant differences (α=5%) in terms of water activity (a_w). From the average value of water activity (a_w), it was found that products T1 and T2 were significantly different from products T3 and T4. The four beverage powder products have small aw values. Powdered products have low water availability or water activity (a_w), so they are able to inhibit microbial growth, chemical and enzymatic reactions that occur in the product (Rifna et al. 2019). The smaller the a_w value of a product, the lower the risk of microorganisms growing and being able to inhibit

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enzymatic reactions that risk damaging the product. This is in accordance with the opinion of Tapia et al. (2007) that the growth of microorganisms can be avoided in the aw value range below 0.61.

The Characteristics of Physical Analysis of Powder Drink with the Combination of Dayak Onion and Tempe

The drink powder combined with dayak onion and tempe was analyzed for its physical properties to determine its quality and character. The results of the physical analysis of the drink powder combined with dayak onions and tempe can be seen in Table 3.

Table 5 the results of physical analysis of powder drink product

Treatment	Sedimentation (%)	Viscosity (cP)	Solubility (g/ml)	Bulk Density (g/ml)
T1 (dayak onion powder 20% + tempe powder 70%)	7.20±0.21^{a}	16.87±0.25^{a}	10.81±0.36^{a}	0.78±0.00^{a}
T2 (dayak onion powder 40% + tempe powder 50%)	9.51±0.18^{b}	15.02±0.04^{b}	9.77±0.07^{b}	0.71±0.00^{b}
T3 (dayak onion powder 60% + tempe powder 30%)	12.60±0.11^{c}	14.08±0.20^{c}	8.57±0.08^{c}	0.64±0.00^{c}
T4 (dayak onion powder 80% + tempe powder 10%)	13.51±0.16^{d}	12.05±0.12^{d}	7.13±0.05^{d}	0.55±0.00^{d}

Table 5 states that the average value of index sedimentation, viscosity values, index solubility and bulk density index has a significant effect at the 5% significance level. The sedimentation index or rate of solution settling is the process where solid particles suspended in a fluid settle and accumulate at the bottom of a body of water or other surfaces. A product is stated as stable if it has a low sedimentation value because the product does not easily form sedimentation after being diluted in the water (Faiqoh, 2021). The viscosity of a product is affected by the concentration and type of protein, as well as the swelling ability (Sze-Tao & Sathe, 2000). This is in accordance with the results of the study, which show that the higher the protein content, the higher the viscosity value. Products T1 and T2 are superior to products T3 and T4 because they have low average sedimentation and high viscosity values.

The results of water solubility analysis show that products T1 and T2 have higher values than products T3 and T4. A good powder product is a product with high solubility because the easier the material dissolves in the water, the better the product is (Abdurrasyid, 2021). Bulk density in products T1 and T2 has the highest average. Based on

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Stranzinger et al. (2019), the smaller the molecule size, the easier it is to compress the product, and with smaller gaps between molecules, the bulk density will be greater. Products with great bulk density will narrow the space between molecules, which will increase the cohesiveness of particles. This can inhibit the entry of water vapor, which will increase the chance of clumping and product damage. Color characteristics from the results of color measurement, which are L (brightness), a+ (redness), b+ (yellowish), and whiteness, can be seen in Figure 4.

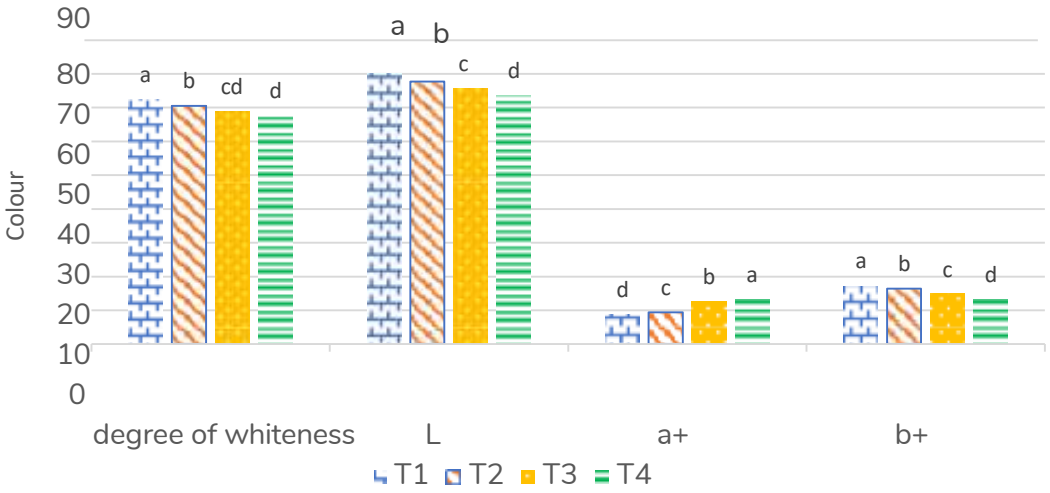

Figure 4 the results of color intensity and whiteness analyses

The results of color analysis show a significant difference between the average L, a+, and b+ values of products T1, T2, T3, and T4. Based on Figure 4, L (brightness) and b+ (yellowish) values are significantly different from the Duncan Test, affecting the final value of whiteness. L value of the product that is close to 100, the brightness level of the white acrobatic color is higher (brighter) and vice versa (Kaemba et al., 2017). Redness (a+) generated can indicate high antioxidant activity because it contains anthocyanin compounds (Einbond et al., 2004). Anthocyanin compound is a sub-class of flavonoids and provides red, purple, and blue colors for flowers, fruits, and vegetables. The color stability of anthocyanin is really affected by pH, type of solvent, temperature, oxygen, light, and enzyme (Rein, 2005). Yellowish (b+) can be affected by nonpolar compounds, such as fat and carotenoids, in the sample. Carotenoid compounds are the pigment groups and natural antioxidants that can reduce free radicals causing yellow-orange and red in the plant (Panjaitan et al., 2003).

Antioxidant Capacity of Dayak Onion and Tempe Combination Drink Powder

The combination of dayak onion and tempe drink powder was analyzed for its antioxidant capacity using the DPPH method and total flavonoid test. The results of the proximate analysis of the drink powder can be seen in Table 6.

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Table 6 the results of bioactivity analysis

Treatment	Parameter	
	IC50 Antioxidant (ppm)	Total Flavonoid (mgQE/g)
T1	88.59± 0.02^{d}	3.17±0.04^{d}
T2	62.95±0.03^{c}	4.74±0.04^{c}
T3	47.93±0.10^{b}	5.46±0.10^{ab}
T4	32.29±0.03^{a}	5.79±0.08^{a}

The lower the IC50 value, the higher the antioxidant activity. IC50 value is an indicating sample concentration that can cause a loss of 50% of radical activity (Ervina et al., 2016). Based on Molyneux (2004), IC50 value < 50 ppm has very strong antioxidant activity, IC50 value < 50-100 ppm has strong antioxidant activity, IC50 value < 100-150 50 ppm has medium antioxidant activity, and IC50 value < 151-200 ppm has weak antioxidant activity. The analysis results of IC50 antioxidant activity in Table 6 indicate that products T1 and T2 have strong antioxidant capacity (in the range of 50-100 ppm), while products T3 and T4 have very strong antioxidant capacity (range <50 ppm).

The Comparison of the Best Product with Commercial Product

After chemical, physical, and bioactivity analyses and sensory evaluation were carried out, the results showed that product T2 is the most preferred and meets the nutritional requirements according to SNI 7612:2011.

Table 7 comparison of T2 products, literature and commercial tempe powder

Parameter	Product T2	Literature	Commercial Tempe Powder
Chemical Analysis			
Protein content (%w/w)	32.02±0.35^{b}	29.6±0.1^{a} *	38.73±0.17
Water content (% w/w)	6.55±0.01^{b}	6.9±0.1^{a} *	4.55±0.01
Ash content (% w/w)	1.80±0.00^{b}	0.4±0.0^{b} *	1.55±0.05
Fat content (%b/b)	17.32±0.01^{b}	15.2±0.0^{b} *	17.33±0.11
Crude fiber (% w/w)	4.78±0.20	-	-
Total Carbohydrate by Difference (% w/w)	42.31		39.84
Water activity	0.23±0.01^{ab}	0.24±0.01 **	0.23±0.01 **
Bioactivity Analysis			
IC50 Antioxidant (ppm)	62.95±0.03^{c}	6798.5± 91,06^{b}***	134±0.22
Total Flavonoid (mgQE/g)	4.74±0.04-		2.27 ± 0.07
Physical Analysis			

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Parameter	Product T2	Literature	Commercial Tempe Powder
Whiteness	70.53±0.81^{b}	55.95±0.14**	-
L	77.67±0.10^{b}	82.69±0.01**	-
a+	9.37±0.07^{c}	-1.56±0.12**	-
b+	16.38±0.45^{b}	19.84±0.74**	-
Sedimentation Index (%)	9.51±0.18^{b}	10.18±0.55 **	11.09±0.21
Viscosity (cP)	15.02±0.04^{b}	18.67±0.76 **	32.17±0.76 **
Solubility Index (g/ml)	9.77±0.07^{b}	9.70±0.18 **	8.41±0.08
Bulk Density (g/ml)	0.71±0.00^{b}	0.43±0.00 **	0.59±0.00 **

Source: *Abdurrasyid et al. 2021 ** Mahdi et al. 2022 ***Padah dan Dewi 2022

The best product (T2), additional testing was carried out, which is fiber analysis, total phenolic, and calculation of total carbohydrates by difference to complete product profile. Product T2 was then compared with commercial tempe powder products and other tempe powders in the literature. Comparison of product characteristics is presented in Table 7.

Table 7 shows a comparison between the T2 powder drink and other powder drinks studied in the literature and a comparison of the test results of commercial products. The results of the physical analysis indicate that commercial products have a higher average than product T2 and tempe powder by Abdurrasyid et al. (2021). The results of the chemical analysis indicate that product T2 has a higher average than tempe powder Abdurrasyid et al. (2021). The a_w activity value is not different. The value of bioactivity analysis in product T2 is superior because of the addition of Dayak onion in the formula.

CONCLUSION

The characteristics of dayak onion powder using the fluidized bed dryer (FBD) method have an average value of antioxidant activity, total flavonoids, b+ (yellowish) color value and higher yield compared to spray dryers. The best formulation treatment for dayak onion powder and tempe powder is T2 with the addition of 40% dayak onion powder, 50% tempe powder, 5% CMC and 5% gum arabic. The best treatment T2 qualify the requirements of SNI 7612:2011 and can compete with commercial products. It is necessary to add other antioxidant potential test parameters for comparison methods. Drink powder can be developed to be marketable and have a measurable shelf life. Further research needs to be carried out to further examine the influence of product consumption on biochemical parameters related to body health.

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