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RESEARCH PAPER

Chemical changes of aloe vera gel during the preparation of instant powder and its antioxidant activity

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Abstract

Aloe vera contains flavonoid compounds with high antioxidant activity in powder form, which is usually affected by the encapsulating agent. Maltodextrin is currently used as an encapsulating agent because of its high solubility, while gum arabic is a viscous substance that increases oxidation resistance. Therefore, this study aimed to produce aloe vera instant powder with a mixture of maltodextrin and gum arabic as an encapsulating agent and evaluate the chemical changes during the preparation of powder with high antioxidant activity. The powder was processed by mixing aloe vera gel with an encapsulating agent of maltodextrin and gum arabic mixture in a ratio of 1/1 with variations of 5%, 10% and 15%. Each sample was dried using a drum dryer at 120°C, 130°C and 140°C. During preparation, the samples were analyzed for their moisture content, phenolic content, flavonoid content and antioxidant activity expressed as DPPH radical scavenging activity. The results showed that the addition of encapsulating agents decreased the moisture content, phenolic content, and flavonoid content of aloe vera gel, however no significant effect ($p>0.05$) on antioxidant activity. Drying at a higher temperature will produce aloe vera powder with higher antioxidant activity. The aloe vera instant powder which was produced with a 5% encapsulating agent at the drying temperature of 130°C had high antioxidant activity of 26.21±7.58%.

1. Introduction

The antioxidant properties of flavonoids are beneficial for health because of their ability to increase immune responses and disease resistance (Li *et al*., 2019). It has also been reported that flavonoids such as quercetin, myricetin, kaempferide are found in aloe vera and can act as anti-viral agents (Sultana and Anwar, 2008; Zou *et al*., 2020). The aloe vera contains flavonoid compounds which have many hydroxyl groups that are capable of scavenging free radicals or as antioxidants. According to Wariyah and Riyanto (2020), flavonoids in aloe vera gel powder showed hypoglycemic effects that reduced blood sugar in diabetic rats.

The processing of aloe vera powder has been carried out by Wariyah and Riyanto (2016) and Wariyah *et al.* (2022), where a decrease in antioxidant activity compared to fresh aloe vera gel was reported. Flavonoids such as tocopherol (vitamin E) are unstable to heat (Anyala-Aponte *et al*., 2021) and the addition of fillers during the processing of powder proportionally reduces flavonoids. Wariyah and Riyanto (2016) used 2.5-10% maltodextrin as encapsulating agents during the processing, and the results indicated that the antioxidant activity expressed as Radical Scavenging Activity (RSA) decreased with increasing maltodextrin. Aloe vera gel powder with a maltodextrin encapsulating agent of 2.5% showed fairly high anti-oxidative activity with an RSA value of 35.59±2.65%. In addition to the use of maltodextrin, gum arabic as an encapsulating agent for gallic acid in the processing of powders can also protect gallic acid from damage by increasing the resistance to antioxidant activity during drying as indicated by the RSA values of 25.4% in gallic acid and 35.6% in gallic acid nano-capsules with gum arabic (Hassani *et al.,* 2020). However, the use of a combination of maltodextrin and gum arabic for encapsulation of

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barberry extract (*Berberis vulgaris*) which is rich in anthocyanins was better to protect from oxidation (Mahdavi *et al*., 2016). Premi and Sharma (2017) found that the encapsulated drumstick oil powder (EDOP) with a combination of maltodextrin and gum arabic with a ratio of 50:50 resulted in high oxidation stability of EDOP which is indicated by the low peroxide value after 30 days of storage at 45°C.

The decrease in the antioxidant activity in the processing of aloe vera powder is influenced by the conditions during processing. Flavonoids, which are part of phenolic compounds are very unstable to temperature (Ma *et al.,* 2021). Galaz *et al*. (2017) reported that in the processing of pomegranate peel powder dried with a drum dryer at a temperature of 100-120°C, the percentage of phenol decreased with increasing temperature. It was also noted that the aloe vera gel extract dried using a blower oven caused more damage (Wariyah *et al*., 2022).

The reduction in antioxidant activity during processing occurs due to the addition of ingredients other than aloe vera gel during preparation or due to the use of high temperatures. Therefore, this study aimed to evaluate the changes in the antioxidant activity of aloe vera gel during the preparation and processing of aloe vera powder using a mixture of maltodextrin and gum arabic as an encapsulating agent by drying with a drum dryer.

2. Materials and methods

2.1 Materials

The aloe vera leaf used was *Aloe vera* var. *chinensis*, obtained from the Ave-Ku, farmer association in Sambiroto Village, Sentolo District, Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. Maltodextrin (Q. L. Starch Co. Ltd, China), and gum arabic (FT Powder TIC Gums, Westchester, USA) were purchased commercially. The chemical for the analysis of antioxidant activity with pro-analytical qualifications, DPPH (1,1-Diphenyl-2-picrylhydrazil), gallic acid as a standard for phenol analysis, were purchased from Merck (Darmstadt, Germany), while quercetin, myricetin, naringenin, kaempferol as flavonoids standard purchased from Sigma Aldrich Chemical Co. (St. Louis, MO, USA).

2.2 Sample preparation

This study was conducted in a completely randomized design with variations in the amount of encapsulating agent and drying temperature. The aloe vera powders were made with the encapsulating agent of a mixture of maltodextrin and gum arabic with a ratio of 1:1 and based on a previous study (Premi and Sharma, 2017) and the powder was prepared according to the method described by Wariyah and Riyanto (2016). In this study, the aloe vera gel was taken from the inner parts of the leaves, peeled, washed in running water, drained, cut into pieces, and mashed with a blender (Philip CR 2115). Then the aloe vera gel slurry was added with an encapsulating agent (mixture of maltodextrin and gum arabic) with a variation of 5%, 10%, and 15%. The mixture was stirred with a blender until smooth to obtain a homogeneous mixture. The aloe vera gel and the mixture of gel slurry–encapsulating agent were analyzed for their chemical properties (moisture content, phenolic content, flavonoid content, DPPH radical scavenging ability).

2.3 Drying of the slurry and preparation for chemical analysis

Each treatment sample was dried using a drum dryer (Holland GRV 77) with a temperature variation of 120° C, 130°C, and 140°C. The powder was stored in 0.8 mm polyethylene plastic, and coated with aluminium foil, then stored at -20°C until used. The powder was analyzed for its moisture content and antioxidant activity based on the ability to capture DPPH free radicals.

Before chemical analysis (phenolic content, flavonoid content and antioxidant activity), the sample was extracted by using ethanol (Hu *et al*., 2003; Gallaz *et al.*, 2017). Extraction was carried out by mixing two grams of the aloe vera gel sample (fresh) or slurry with 20 mL of an 80% ethanol solution using a homogenizer in a dark room for 60 min. Each supernatant was filtrated through Whatman paper No. 2 and stored at -20°C before use.

2.4 Determination of moisture content

The raw material (aloe vera gel), the mixture of gel-encapsulating agent and aloe vera powder were analyzed for their moisture content using the static gravimetric method (AOAC, 2005). Each sample was dried at a temperature of 100 to 105°C until the weight difference before and after the samples were heated in constant weight.

2.5 Determination of phenolic content

The phenolic content of aloe vera gel and its slurry (mixed of gel aloe vera–encapsulating agent) was determined by using the Folin-Ciocalteu method, and the gallic acid act as a standard (Gallaz *et al*., 2017). Standard of the gallic acid with concentrations 20, 40, 60, 80, and 100 µg/mL or extracted sample were diluted with a ratio of 1:100. About 0.2 mL of each sample was mixed with 3.75 mL distilled water, 0.25 mL Folin-

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Ciocalteu 50% reagent and 0.5 mL of 10% Na_2CO_3. The mixed sample was then homogenized and incubated in a dark room for 60 mins. The absorbance of the sample was measured at ʎ = 765 nm by using spectrophotometer (Shimadzu UV mini-1240). Phenolic content (%) calculated as mg gallic acid equivalents (GAE) per mg dry weight of sample multiple by 100.

2.6 Determination of flavonoid content

The flavonoid contents were determined by using aluminium chloride colorimetric assays with a standard solution of quercetin (Ling *et al*., 2019). Standard quercetin with concentrations 0.2, 0.4, 0.6, 0.8, and 1.0 mg/mL and the extracted sample was inserted into a reaction tube filled with 4.8 mL distilled water. About 0.3 mL of 5% $NaNO_2$ was then added and the mixture was homogenized for 5 mins using a vortex (Thermo Scientific M37610-33, China). About 0.3 mL of $AlCl_3$, 2 ml NaOH 1 M and top up with distilled water until the volume reached 10 mL. The absorbance of the sample was measured by spectrophotometer (Shimadzu UV mini -1240) at ʎ = 414 nm. The total flavonoid contents (%) were calculated based on the curve of quercetin standard and presented as equivalent mg quercetin per mg dry weight of sample multiple by 100.

2.7 Identification of flavonoid in aloe vera gel

The flavonoid compounds in the aloe vera gel were identified by using High-Performance Liquid Chromatography (HPLC) (KNAUER, Berlin, Germany). The HPLC, equipped with Smartline manager 5000, Smartline pump 1000, Smartline UV 2500, column thermostat and Rheodyne injector USA. Software Chromgate version 3.3.2 was used as a data integrator.

Flavonoid compound was identified according to Andersen and Markham (2006) and Sanghavi *et al*. (2014). Sample preparation was conducted by extraction and acid hydrolysis to obtain an extract solution with a concentration of 10 mg/mL according to the standard operating procedure applied at the Chemistry Laboratory of the Faculty of Science and Mathematics, Universitas Satya Wacana Salatiga, Central Java. A micro membrane filter (Whatman 0.45 µm) was used to filter the sample prior to injection to HPLC. Set up for the operational optimum condition of HPLC was stationer phase column Eurosphere C-18 (150 × 4.6 mm, 5µm) QK, mobile phase 0.1% H_3PO_4 and acetonitrile (60:40 v/v) isocratic, flow rate 1.0 mL/min, column temperature 30°C and UV detection at 370 nm. Flavonoid compound identification is conducted according to its retention time by referring to standard flavonoids such as quercetin, myricetin, naringenin and kaempferol.

2.8 Determination of antioxidant activity

The antioxidant activities of the samples (aloe vera gel), aloe vera gel-encapsulating agent mixture, aloe vera powder) were determined based on their ability to scavenge DPPH radicals (Hu *et al*., 2003; Galaz *et al*., 2017). DPPH stock solution with concentration 6,10-5.0 M was prepared and kept in the refrigerator. Prior to analysis, the stock solution of DPPH was diluted with ethanol to reach the concentration of 0.1 mM.

Antioxidant activity was analysed by adding 1 g extract ethanol with 2.5 mL DPPH 0.1mM solution followed by homogenisation. The absorbance of the sample was measured at ʎ = 517 nm; t = 0 and t = 30 min after incubation in the dark room by using a spectrophotometer (Shimadzu UV mini 1240). Antioxidant activity calculated as percentage of radical scavenging activity (RSA) (Yen dan Duh, 1994):

$$\text{Radical Scavenging Activity (\%)} = [1-(A_T/A_o)] \times 100\%$$

Whereas A_o = absorbance value at t = 0 min, and A_T absorbance value at t = 30 mins.

2.9 Experimental design

In this study, we used a completely randomized design with two factors, which involved the amount of encapsulating agent and drying temperature. The difference between treatments was determined by F test, while the significant difference between samples was determined by Duncan's Multiples Range Test (DMRT) and the data was analysed using SPSS for Windows 19.

3. Results and discussion

3.1 Aloe vera gel compounds

The component analysis was carried out on the aloe vera gel related to its properties as an antioxidant. The results of the chemical analysis of the aloe vera gel are presented in Table 1. The moisture content of aloe vera gel according to Elbandy *et al*. (2014) is about 96.31%. Table 1 shows the moisture content of the aloe vera gel was about 98.68±0.16% similar to the previous studies that the aloe vera gel moisture content is 98.74±0.88 % (Riyanto and Wariyah, 2021). The phenolic content of aloe vera according to Hęś *et al.* (2019) was 6.56%, while Elbandy *et al*. (2014) reported that the phenolic content and flavonoid components in aloe vera were 0.77 mg/g and 0.44 mg/g, respectively. There were differences in the phenolics content and flavonoids content in aloe vera gel. According to Hu *et al*. (2003), the phenolic content, including flavonoids in this plant was affected by the type and the age of plant harvest. In *Aloe vera barbadensis* variety, the flavonoid contents were high at the age of 4 years of harvest, while this

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study used *Aloe vera* var. *chinensis*, which was 2 years old. Hęś *et al*. (2019) also reported that its phenolic content was influenced by the type and harvest conditions, time, climate, aloe species, and the method of harvesting leaves. Therefore, differences are possible for each type of material used.

Table 1. Moisture, phenolic and flavonoid content of aloe vera gel.

Component	Percentage (%)
Moisture	98.68±0.16
Phenolic compound	2.58±0.65
Flavonoid	1.05±0.10
Radical scavenging activity (RSA)	6.89±0.40

Values are presented as mean±SD.

The antioxidant activity of aloe vera gel expressed as radical scavenging activity (RSA) was approximately 6.89±0.40%. According to Hęś *et al.* (2019), RSA aloe vera extract was 11.93%. The RSA value is related to the phenol content and the method of preparation. This study used the fresh gel as a sample, while Hęś *et al*. (2019) investigations were in the form of extracts, therefore, different antioxidant activities were obtained.

3.2 Flavonoid compounds of aloe vera gel

The flavonoid compounds of the aloe vera gel were shown in Table 2 and its chromatogram was presented in Figure 1. Table 2 and Figure 1 show that the flavonoid compounds of the aloe vera gel were myricetin, quercetin and kaempferol. The naringenin flavonoid compounds were not identified. The amount of myricetin, quercetin and kaempferol detected were 0.012, 0.0039 and 6.89 mg/g or 12.00, 3.90 and 6890 mg/kg, respectively. According to Sultana and Anwar (2008), flavonoid compounds in aloe vera were myricetin, quercetin and kaempferol with the levels of 1283.50, 94.80 and 257.7 mg/kg, respectively. Elbandy *et al.* (2014) have reported that aloe vera contains 375.21 ppm naringenin and kaempferol at 2.05 ppm. Hu *et al.* (2003) found that the flavonoid content of aloe vera gel depends on the harvest age. *Aloe vera barbadensis* Miller harvested at three years old has higher flavonoid content than harvested at two and four years old (4.70 and 3.63 mg/kg, respectively). The current research used *Aloe vera* var. *chinensis* harvested at two years old which affects the level of flavonoid compound. According to Quispe *et al.* (2018), the chemical composition of any plant depends upon the type or variety, the local geographical condition, type of soil. Lucini *et al.* (2015) reported that no myricetin or quercetin was identified in *A. barbadensis Mill* and *A. arborescens Mill*. Aloe vera planted in an oasis condition of warm water was reported to contain the flavonoid compound of kaempferol-3-O-hexosyl-Opentoside and naringenin-4′-methoxy-7-Oglucuronide. This study used *Aloe vera* var. *chinensis*, obtained from Sentolo District, Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. The mentioned area belongs to the mountain area with tropical weather temperatures without any irrigation facility. The difference in planted area and temperature may contribute to the differences in the composition of aloe vera. Tawfik *et al*. (2001) stated high aloin production was obtained under shade and water-stressed plants grown in loamy sand soil.

Table 2. Flavonoid compounds of aloe vera gel.

Compound	Amount (mg/g)
Myricetin	0.0120±0.0013
Quercetin	0.0039±0.0002
Naringenin	ND
Kaempefrol	6.89±0.40

ND: Not detected.

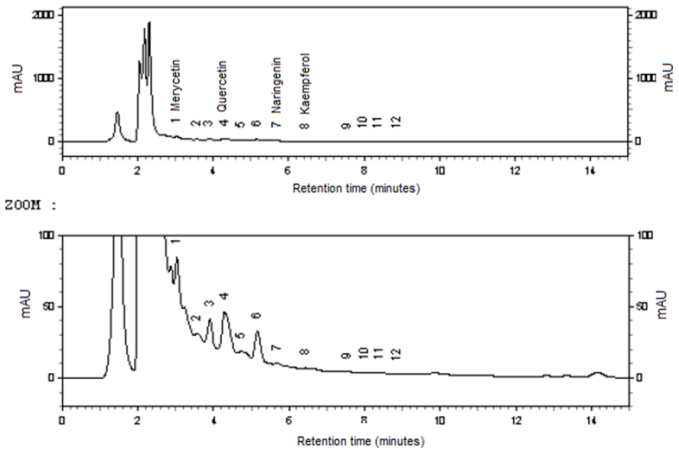

Figure 1. HPLC chromatograms flavonoid of aloe vera gel.

3.3 The component of the aloe vera gel- encapsulating agent mixture

Aloe vera powder was made by adding an encapsulating agent, which was a mixture of maltodextrin and gum arabic into the gel slurry. The effect of encapsulating agent addition on the chemical components of the aloe vera gel mixture is presented in Table 3.

The results showed that the moisture content of the mixture of aloe vera gel and the encapsulating agent was significantly different, which decreased with the addition of the encapsulating agent. This was due to the increase in total solids in the mixture that reduced the percentage of moisture. Similarly, the levels of phenolic content and flavonoid content proportionally decreased. Table 3 showed that the antioxidant activity, which was expressed as the ability to scavenge DPPH or RSA radicals was not significantly different. The main phenolic compounds in the aloe vera gel are flavonoid compounds that are antioxidants (Hęś *et al*., 2019). The result of Ma *et al*. (2019), showed three samples of dried -apple skin consist phenolic content in the range of 2,939.45-2,500.00 mg GAE/ 100 g, however, the

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Table 3. Moisture, phenolic, and flavonoid content of aloe vera gel-encapsulating agent mixture.

Encapsulating agent addition (%)	Moisture (%)	Phenol (% db)	Flavonoid (% db)	RSA (%)
5	94.64±0.03^{c}	0.43±0.073^{b}	0.24±0.022^{c}	6.17±0.0203
10	90.26±0.12^{b}	0.39±0.030^{b}	0.17±0.012^{b}	6.45±0.0004
15	83.82±2.71^{a}	0.15±0.057^{a}	0.09±0.003^{a}	5.63±0.0198

3 Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

variation in some phenolic content levels in dried-apple skin did not show a significantly different of the antioxidant activity. This indicated that a wide range of phenolic content exists which may affect the significant result of the analysis.

3.4 Aloe vera powder

Table 4 shows the moisture content and free radical scavenging ability (RSA) of aloe vera powder that has been dried using a drum dryer. The results showed that the interaction treatment between the encapsulating agent 18 amount and drying temperature was not significantly different ($p>0.05$), while there was a difference in the amount of encapsulating agent. The moisture content of aloe vera powder with 5% and 10% encapsulating agents was not significantly different, but the use of 15% encapsulating agent had the lowest moisture content and was significantly different. According to Ma *et al*. (2019), the drying rate of the material is affected by the temperature and equipment used for the process. Galaz *et al*. (2017) reported that the use of a drum dryer in drying pomegranate peels showed that the higher the temperature, the faster the drying and the lower the moisture content. It was further recorded that the increase in temperature was not necessarily in tandem with the moisture content achieved. Drying the 19 pomegranate peel at temperatures of 100°C, 110°C, and 120°C, the moisture content of the powder achieved was 0.5%, 1.6% and 2.6%, respectively.

The antioxidant activity of aloe vera powder presented in Table 4 showed a significant difference in RSA. The results indicated that the higher the drying temperature and the more encapsulating agent, the lower the antioxidant activity. Meanwhile, compounds in aloe vera with antioxidant activity are phenols. Ma *et al*. (2019) reported that the stability of phenolic compounds was influenced by temperature and drying methods. The greater the temperature, the higher the oxidative damage of phenol, thereby reducing the ability to scavenge free radicals. Since the addition of an encapsulating agent also affected the RSA value, the more encapsulating agent, the lower the antioxidant activity. According to Wariyah and Riyanto (2016), the addition of 5-15% maltodextrin proportionally reduced antioxidant activity. In this study, the use of a 5% encapsulating agent with a drying temperature of 130-140°C produced aloe vera powder with high antioxidant activity. According to Galaz *et al*. (2017), drying using a drum dryer at a temperature of 120°C only needs a short time (257 sec) to complete the drying process, which reduces the loss of polyphenols during the longer time of drying. Therefore, the RSA value of powder with a 5% encapsulating agent and a drying temperature of 130°C produced a powder with high antioxidant activity.

4. Conclusion

Aloe vera gel added with encapsulating agent showed lower moisture, phenol and flavonoid content, but no significant effect on the antioxidant activities. The decrease in chemical compounds takes place due to the increase of total solid compounds from the addition of encapsulating agents. Drying using a drum dryer at a higher temperature produced aloe vera powder with

Table 4. Moisture content and antioxidant activities of aloe vera powder.

Encapsulating agent addition (%)	Drum drying temperature (°C)	Moisture (%)	RSA (%)
5	120	6.85±0.73	10.34±2.99^{a}
	130	5.53±0.87	26.21±7.58^{c}
	140	6.53±0.02	22.77±6.61^{c}
10	120	6.03±1.41	10.48±1.42^{a}
	130	5.19±0.06	16.50±5.51^{b}
	140	6.33±0.11	12.44±0.71^{a}
15	120	5.70±0.93	9.71±1.68^{a}
	130	4.40±0.14	11.57±0.19^{a}
	140	5.32±1.22	11.73±1.83^{a}

3 Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

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higher antioxidant activities due to the shorter drying time. According to its antioxidant activity, the correct processing of aloe vera powder with higher antioxidant activity was produced by using a 5% encapsulating agent mixture of maltodextrin and gum arabic at a ratio 1:1, followed by drying using a drum dryer at a temperature of 130°C.

Conflict of interest

The authors declare no conflict of interest.

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