



Color Stability of Encapsulated Purple Sweet Potato Extract as Affected by Maltodextrin–Gum Arabic Ratio

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Abstract:

This research aims to determine the effect of the ratio of maltodextrin and gum arabic on the stability of the encapsulation of purple sweet potato pigment ethanol extract against processing factors. This research used the Completely Randomized Design (CRD) method with 5 levels of maltodextrin and gum arabic ratios (1:1, 1:2, 1:3, 1:4, and 1:5) with 3 repetitions to obtain 15 experimental units. The parameters observed were the effect of the concentration of maltodextrin and gum arabic on the color stability of purple sweet potato ethanol extract encapsulates at heating temperatures (60 °C, 70 °C, 80 °C, 90 °C, and 100 °C), sugar concentrations (10%, 20%, 30%, 40%, and 50%), salt concentrations (2%, 4%, 6%, 8%, and 10%), and various pH levels (3–9). The data obtained will be analyzed using ANOVA at a level of 1% and 5% and Duncan's New Multiple Range test (DNMRT) at the 5% level. The optimal formulation was achieved at a 1:5 maltodextrin to gum arabic ratio, which maintained excellent stability up to 100°C, 50% sugar, and 8% salt concentrations, while exhibiting significantly higher pigment resilience in acidic environments than in alkaline conditions.

Keywords: Encapsulation; gum arabic; maltodextrin; natural colouring agent; sweet potato

1. Introduction

Purple sweet potato is one of the sweet potato varieties commonly found in Indonesia and is utilized by the community as a food source and as a natural colorant. It is a tuber rich in antioxidants and high in fiber. Purple sweet potato also contains antioxidants such as anthocyanins, polyphenols, beta-carotene, vitamin C, and vitamin E (Kumalasari & Yensi, 2024).

Purple sweet potato has potential as a purple colorant. The purple color in purple sweet potatoes is caused by the presence of anthocyanin pigments, which spread from the skin to the flesh (As-Salimah et al., 2024). The anthocyanin pigment in purple sweet potatoes ranges around 61.85 mg/100 g. Purple sweet potato has potential as a natural colorant because its amount is higher compared to anthocyanins from other sources, such as roselle flowers at 7.95 mg/100 g, grapes at 26.7 mg/100 g, and dragon fruit at 8.8 mg/100 g. The anthocyanin compound in purple sweet potatoes can be used as an antioxidant that is beneficial for the body (Armanzah & Hendrawati, 2016).

Anthocyanin, as a natural colorant, is generally unstable and easily degraded during storage, so a method is required to overcome this weakness, one of which is through encapsulation. Encapsulation converts anthocyanin into powder, thereby maintaining its color and stability (Lin et al., 2023).

Maltodextrin is a group of carbohydrates frequently used as an encapsulant because it has good coating properties and yields high solubility. The use of maltodextrin as an encapsulant can produce products with low moisture content and low hygroscopicity. According to Celli et al. (2016), the addition of maltodextrin can also improve the color properties of the product. However, according to (Rodríguez-Miranda et al., 2026), the use of maltodextrin alone as a coating material is weak in maintaining the retention of the encapsulated compound. This is because maltodextrin produces low viscosity, which results in a thin coating wall; consequently, the core compound is not maximally encapsulated.

The way to maintain and minimize the degradation of compounds during the encapsulation process is by increasing viscosity, and one coating material that yields high viscosity is gum arabic. This is because gum arabic has a high molecular chain that binds many water molecules, thereby forming a gel. The use of gum arabic as an encapsulant produces more stable compounds because its application as a coating material can protect volatile compounds from oxidation and evaporation (Jalali-Jivan et al., 2026). To increase the stability of purple sweet potato extract, this study was conducted on the encapsulation of the ethanolic extract of purple sweet potato using a mixture of maltodextrin and gum arabic as a coating.

2. Material and Method

Materials

The primary raw material used in this study was purple sweet potato (*Ipomoea batatas* L var. *Nakamurasaki*) purchased from Angso Duo market, Jambi. The chemical used included ethanol (70%), citric acid, maltodextrin DE 15, gum Arabic were of technical grade from local supplier whereas HCl and NaOH were of analytical grade from Merck.

Experimental design

The research design used was a Completely Randomized Design (CRD) with 5 levels of treatment for the ratios of maltodextrin and gum arabic, which were 1:1, 1:2, 1:3, 1:4, and 1:5. The experiment was repeated 3 times, resulting in 15 experimental units. The parameters observed were the stability of anthocyanin color against pH, heating temperature, sugar, and salt.

Material preparation

The raw material used was purple sweet potato purchased from the market, selected with uniform sizes. The sweet potatoes were sorted based on their size and condition. The dimensions of the sweet potatoes used in this study were 8 cm in length and 24 cm in diameter. The selected sweet potatoes were free from rot and damage. Subsequently, the sweet potatoes were washed to remove any adhering soil, peeled using a knife, and sliced into pieces measuring 2x2 cm with a thickness of 1 cm.

Preparation of purple sweet potato for extraction

The solvent preparation was carried out according to Nawi et al. (2015). The solvent used for extraction was a mixture of 70% ethanol and distilled water at a 1:4 ratio, prepared to a total volume of 900 ml; the addition of distilled water to the solvent aimed to increase the solvent polarity so that more anthocyanins could be extracted (Sari et al., 2005). The preparation of 180 ml of 70% ethanol was conducted by adding 131.25 ml of 96% ethanol into a graduated cylinder, followed by the addition of 48.75 ml of distilled water. This mixture was then further diluted with 720 ml of distilled water, and 2% (18 grams) of citric acid was added.

Extraction of purple sweet potato pigment

The purple sweet potato slices were immersed in the solvent that had been acidified with citric acid. The extraction of the purple sweet potato was performed according to Nawi et al. (2015). The purple sweet potato was dissolved in the solvent with a material-to-solvent ratio of 1:4, specifically 300 g of purple sweet potato dissolved in the prepared 900 ml of solvent. After that, it was macerated for 24 hours, filtered using Whatman No. 1 filter paper, and concentrated using a rotary evaporator at 50–60°C until the ethanolic extract of purple sweet potato was obtained. The ethanolic extract of purple sweet potato was then stored in a glass container and used to prepare the encapsulant.

Encapsulation of purple sweet potato pigment ethanolic extract (modified from Nawi et al., 2015)

The encapsulation of the purple sweet potato ethanolic extract was performed according to (Nawi et al., 2015) using maltodextrin and gum arabic as coating materials. Maltodextrin and gum arabic were each dissolved according to the treatments: 5 grams and 5 grams (P1); 3.3 grams and 6.7 grams (P2); 2.5 grams and 7.5 grams (P3); 2 grams and 8 grams (P4); and 1.7 grams and 8.3 grams (P5). These were dissolved in 39 ml of distilled water, and then 1 gram of the purple sweet potato pigment ethanolic extract was added, making a total solution volume of 50 ml. The solution was stirred until homogeneous using a magnetic stirrer for 10 minutes. Then, the solution was dried using a microwave at a 3P power level for 12 minutes with a power of

900 W. The completion of the drying stage was indicated by the solution becoming dry with no remaining water on the surface of the material. Finally, the material was ground using a mortar, sifted through a 60-mesh sieve, and stored in ziplock plastic bags.

Color stability against heating temperature (modified from Winarti & Firdaus, 2010)

A total of 0.1 grams of the purple sweet potato ethanolic extract encapsulant was placed into 5 different test tubes, and 10 ml of distilled water was added to each. The tubes were heated at temperatures of 60, 70, 80, 90, and 100°C for 15 minutes in a water bath. The absorbance value of the material was then measured at $\lambda = 530$ nm using a UV-Vis spectrophotometer.

Color stability against sugar concentration (Wiriani, 2019)

A total of 0.1 grams of the purple sweet potato ethanolic extract encapsulant was placed into 5 different test tubes, and 10 ml of sugar solutions at concentrations of 10%, 20%, 30%, 40%, and 50% were added respectively. The mixture was vortexed until dissolved. The absorbance was then measured at a wavelength of 530 nm using a UV-Vis spectrophotometer.

Color stability against salt concentration (Wiriani, 2019)

A total of 0.1 grams of the purple sweet potato ethanolic extract encapsulant was placed into 5 different test tubes, and 10 ml of salt solutions at concentrations of 2%, 4%, 6%, 8%, and 10% were added respectively. The mixture was vortexed until completely dissolved. The absorbance of the material was measured at a wavelength of 530 nm using a UV-Vis spectrophotometer.

Color stability against pH (Miksusanti et al., 2012)

The purple sweet potato ethanolic extract encapsulant was tested at various pH levels ranging from pH 3 to 9. The test was conducted by weighing 0.1 grams of the sample and dissolving it in 10 ml of distilled water. The mixture was vortexed until completely dissolved, and its pH was measured. A 10 ml portion of the solution was transferred into a 25 ml beaker; 10% NaOH was added dropwise to increase the pH, and HCl was added dropwise to decrease the pH. The color of each treatment was measured at a wavelength of 530 nm using a UV-Vis spectrophotometer.

Data analysis

The obtained data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level. If the treatments showed a significant effect, the analysis was followed by Duncan's New Multiple Range Test (DNMRT) at a 5% significance level.

3. Results and Discussion

Effect of temperature on color stability

The average values of heating temperature and the results of the analysis of variance (ANOVA) on the color stability of the purple sweet potato ethanolic extract encapsulant against the effect of heating temperatures from 60 to 100°C using maltodextrin and gum arabic as coating materials are presented in Figure 1. The color stability of the purple sweet potato ethanolic extract encapsulant using maltodextrin and gum arabic as coating materials at ratios of 1:1, 1:2, 1:3, 1:4, and 1:5, respectively, affects the response to various heating temperatures in maintaining the color values of the anthocyanins contained within the encapsulant.

Significantly different results were obtained at the ratios of 1:1, 1:2, 1:3, 1:4, and 1:5. This indicates that the effect of the coating material ratios of maltodextrin and gum arabic on the stability of the purple sweet potato pigment ethanolic extract encapsulant responds differently to various heating temperatures. The absorbance value or the anthocyanin color value of the purple sweet potato encapsulant in treatment 5 (1:5) exhibits the highest absorbance value compared to the others. Although the absorbance values decreased with increasing temperatures, this treatment was able to inhibit the degradation rate of the compounds contained within it. According to Enaru et al. (2021), anthocyanin pigments have poor color stability; the unsaturated bonds in their molecular structure make anthocyanins easily oxidized by factors such as pH, light, temperature, and oxygen.

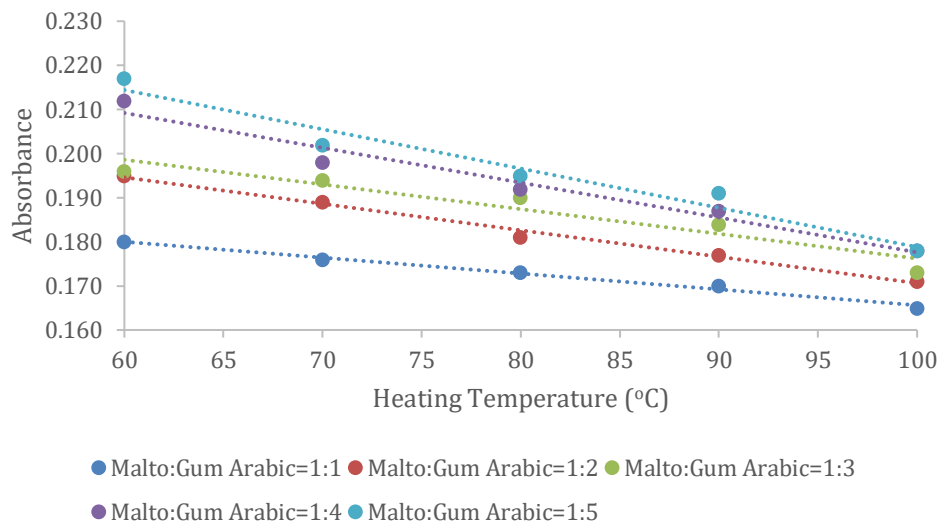


Figure 1. Effect of maltodextrin (M) and gum arabic (GA) ratios on absorbance and color stability at different heating temperatures.

The results of this study demonstrate that a higher proportion of gum arabic relative to maltodextrin better preserves the active compounds within the encapsulant, which is reflected in the high absorbance values shown in Figure 1. A higher absorbance value indicates a higher retention of anthocyanin color compounds within the encapsulant, whereas a lower absorbance value signifies a lower content of these pigment compounds.

Table 1. Linear regression equations and R^2 values for the absorbance of purple sweet potato extract encapsulants at different M:GA ratios and heating temperatures.

M:GA	Regression Equation	R^2
1:1	$y = -0.0004x + 0.202$	0.991
1:2	$y = -0.0006x + 0.231$	0.991
1:3	$y = -0.0006x + 0.232$	0.914
1:4	$y = -0.0008x + 0.257$	0.964
1:5	$y = -0.0009x + 0.268$	0.956

Figure 1 shows that each maltodextrin and gum arabic treatment under heating temperatures of 60°C to 100°C affects the color stability of the purple sweet potato encapsulant. Higher heating temperatures result in lower absorbance values of the purple sweet potato encapsulant, causing the reddish-purple color to fade or leading to the degradation of the anthocyanin pigment compounds. The heating temperature exerts a significant linear decrease on the absorbance values across all ratio treatments. Based on the gradient values, the 1:5 ratio represents the most stable condition due to its slowest degradation rate ($m = -0.0009$), whereas the 1:1 ratio is the least stable or most sensitive, undergoing the fastest decline in absorbance value with the largest gradient value ($m = -0.0004$) as the temperature increases (Table 1). According to Enaru et al. (2021), the decrease in color stability at high temperatures is presumably due to the decomposition of anthocyanins from their aglycone form into chalcones (colorless).

Effect of sugar concentrations on color stability

The experimental data and analysis of variance (ANOVA) on the color stability of purple sweet potato ethanolic extract encapsulant as affected by sugar concentrations of 10%, 20%, 30%, 40%, and 50% using maltodextrin and gum arabic as coating materials are presented in Figure 2. It can be observed that the color stability of the purple sweet potato ethanolic extract encapsulant using maltodextrin and gum arabic coating materials at ratios of 1:1, 1:2, 1:3, 1:4, and 1:5, respectively, is affected by various sugar concentrations in

maintaining the anthocyanin color values. This indicates that the highest absorbance values were obtained in treatment 5 (1:5), with anthocyanin color absorbance values of 0.225 at a 10% sugar level, 0.211 at 20%, 0.203 at 30%, 0.199 at 40%, and 0.193 at 50%. Conversely, the lowest absorbance values were found in treatment 1 (1:1), with anthocyanin color absorbance values of 0.204 at a 10% sugar level, 0.195 at 20%, 0.185 at 30%, 0.181 at 40%, and 0.174 at 50%.

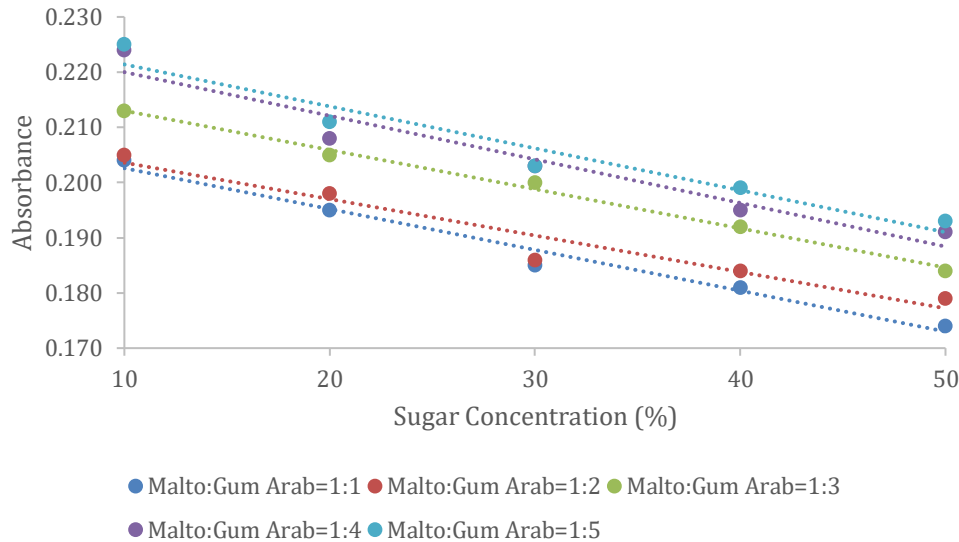


Figure 2. Effect of maltodextrin (M) and gum arabic (GA) ratios on absorbance and color stability at different sugar concentrations.

Significant differences were observed among the 1:1, 1:2, 1:3, 1:4, and 1:5 ratios. The color stability of anthocyanin pigments is affected by pH, temperature, light, oxygen, enzymes, metal ions, and sugars (Zhao et al., 2021). This indicates that the effect of the maltodextrin and gum arabic coating material ratios on the color stability of the purple sweet potato encapsulant responds significantly to various sugar concentrations. As shown in Table 3, the absorbance values (anthocyanin color intensity) of the purple sweet potato encapsulant in treatment 5 (1:5) were the highest compared to the other treatments. Although the absorbance values decreased as the sugar concentration increased, this specific ratio was able to inhibit the degradation rate of the compounds contained within the encapsulant. The addition of gum arabic during processing can protect the compounds contained within, as gum arabic has the ability to form a body as a coating and exhibits a strong binding capacity toward the compounds (Al-Hamayda et al., 2023). This proves that using a higher proportion of gum arabic compared to maltodextrin is more effective in preserving the compounds within the encapsulant, as evidenced by the high and low absorbance values shown in Figure 2. A higher absorbance value indicates that the content of the anthocyanin color compounds in the encapsulant remains high. Conversely, a lower absorbance value signifies a lower content of these pigment compounds.

Table 2. Linear regression equations and R^2 values for the absorbance of purple sweet potato extract encapsulants at different M:GA ratios and sugar concentrations.

M:GA	Regression Equation	R^2
1:1	$y = -0.0007x + 0.210$	0.980
1:2	$y = -0.0007x + 0.210$	0.944
1:3	$y = -0.0007x + 0.220$	0.995
1:4	$y = -0.0008x + 0.228$	0.936
1:5	$y = -0.0008x + 0.229$	0.943

Figure 2 shows that each maltodextrin and gum arabic treatment across sugar levels of 10% to 50% affects the color stability of the purple sweet potato encapsulant. Higher sugar concentrations result in lower

absorbance values of the purple sweet potato encapsulant, causing the reddish-purple color to fade or leading to the degradation of the anthocyanin pigment compounds. Furthermore, the 1:4 and 1:5 ratios represent the most stable conditions with the lowest gradient values ($m = -0.0008$) (Table 2). This finding is supported by Enaru et al. (2021), who stated that among several factors influencing the degradation rate of anthocyanins besides storage duration and high temperatures, an increase in sugar content will reduce the pigment content.

Effect of salt concentrations on color stability

Figure 3 presents the experimental data and analysis of variance regarding the color stability of the purple sweet potato ethanolic extract encapsulant under the influence of various salt levels (2%, 4%, 6%, 8%, and 10%) using maltodextrin and gum arabic coatings. The color stability of the purple sweet potato ethanolic extract encapsulant using maltodextrin and gum arabic coating materials at ratios of 1:1, 1:2, 1:3, 1:4, and 1:5, respectively, is significantly affected by various salt concentrations. The results show that the highest absorbance values were obtained in treatment 5 (1:5), yielding absorbance values of 0.246 at a 2% salt concentration, 0.255 at 4%, 0.264 at 6%, 0.243 at 8%, and 0.235 at 10%. Conversely, the lowest absorbance values were found in treatment 1 (1:1), with values of 0.212 at a 2% salt concentration, 0.218 at 4%, 0.223 at 6%, 0.223 at 8%, and 0.198 at a 10% salt concentration.

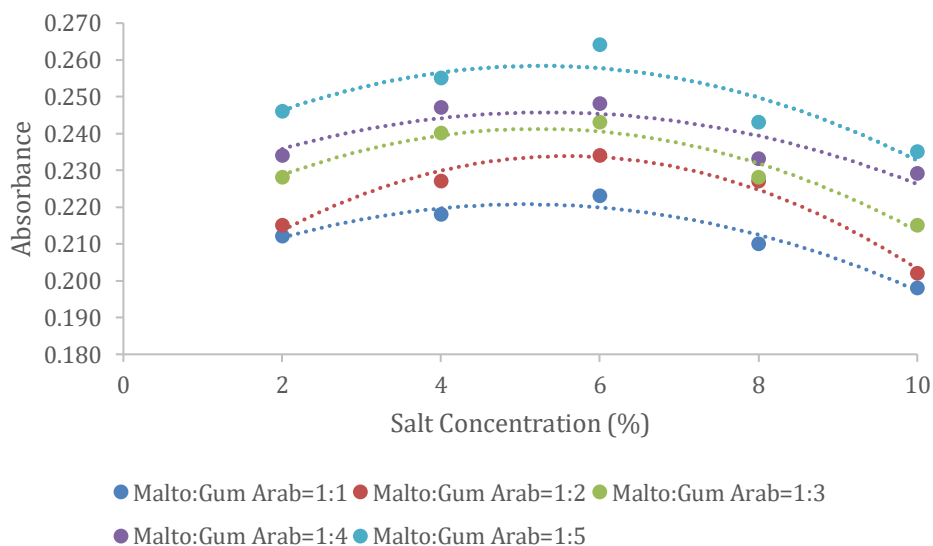


Figure 3. Effect of maltodextrin (M) and gum arabic (GA) ratios on absorbance and color stability at different salt concentrations.

Significantly different results were obtained at the ratios of 1:1, 1:2, 1:3, 1:4, and 1:5. This indicates that the effect of the coating material ratios of maltodextrin and gum arabic on the stability of the purple sweet potato pigment ethanolic extract encapsulant responds significantly to various salt concentrations. As shown in Table 5, the absorbance values (anthocyanin color intensity) of the purple sweet potato encapsulant in treatment 5 (1:5) were the highest compared to the other treatments. Although the absorbance values decreased with increasing salt concentrations, this specific ratio was able to inhibit the degradation rate of the compounds contained within the encapsulant. In line with Enaru et al. (2021), the addition of gum arabic during processing can protect the encapsulated compounds, owing to its ability to form a body as a coating and its strong binding capacity toward the compounds. This proves that a higher proportion of gum arabic relative to maltodextrin is more effective in preserving the compounds within the encapsulant, as evidenced by the high and low absorbance profiles shown in Figure 3. A higher absorbance value indicates that the content of the anthocyanin color compounds in the encapsulant remains high. Conversely, a lower absorbance value signifies a lower content of these pigment compounds.

Table 3. Linear regression equations and R² values for the absorbance of purple sweet potato extract encapsulants at different M:GA ratios and salt concentrations.

M:GA	Regression Equation	R ²
1:1	$y = -0.001x^2 + 0.0098x + 0.196$	0.947
1:2	$y = -0.0016x^2 + 0.0176x + 0.185$	0.973
1:3	$y = -0.0012x^2 + 0.0127x + 0.208$	0.952
1:4	$y = -0.0009x^2 + 0.0095x + 0.220$	0.780
1:5	$y = -0.0011x^2 + 0.012x + 0.227$	0.814

Figure 3 shows that each maltodextrin and gum arabic treatment across salt concentrations of 2% to 10% affects the color stability of the purple sweet potato encapsulant. Higher salt concentrations result in lower absorbance values of the purple sweet potato encapsulant, causing the reddish-purple color to fade or leading to the degradation of the anthocyanin pigment compounds; however, the color remains stable up to an 8% salt concentration. Based on the quadratic gradient values, the effect of salt concentration causes the fastest decline in absorbance value in the 1:2 ratio ($m = -0.0016$) due to its highly sensitive nature, whereas the 1:4 ratio ($m = -0.0009$) proves to be the most stable, experiencing the slowest degradation rate (Table 3). This indicates that the addition of high salt levels induces the color degradation of anthocyanins, thereby causing the pigment to fade.

Effect of pH on color stability

The research data and analysis of variance (ANOVA) on the stability of the purple sweet potato pigment ethanolic extract encapsulant as affected by various pH levels (3, 4, 5, 6, 7, 8, and 9) are presented in Figure 4. The color stability of the purple sweet potato encapsulant anthocyanins at ratios of 1:1, 1:2, 1:3, 1:4, and 1:5, respectively, is affected by different pH levels. The results show that the highest absorbance values were obtained in treatment 5 (1:5) with maltodextrin and gum arabic, yielding absorbance values of 0.275 at pH 3, 0.253 at pH 4, 0.202 at pH 5, 0.185 at pH 6, 0.187 at pH 7, 0.183 at pH 8, and 0.186 at pH 9. Conversely, the lowest absorbance values were found in treatment 1 (1:1) with maltodextrin and gum arabic, with absorbance values of 0.215 at pH 3, 0.183 at pH 4, 0.153 at pH 5, 0.124 at pH 6, 0.137 at pH 7, 0.143 at pH 8, and 0.144 at pH 9.

Significantly different results were obtained at the ratios of 1:1, 1:2, 1:3, 1:4, and 1:5. Anthocyanin stability is influenced by several factors, including pH, temperature, light, and oxygen. This indicates that the effect of the coating material ratios of maltodextrin and gum arabic on the color stability of the purple sweet potato encapsulant responds significantly to various pH levels (3–9). As shown in Table 7, the absorbance values (anthocyanin color intensity) of the purple sweet potato encapsulant in treatment 5 (1:5) were the highest compared to the other treatments. Although the absorbance values decreased as the pH increased, this specific ratio was able to inhibit the degradation rate of the compounds contained within the encapsulant. In line with (Enaru et al., 2021), the addition of gum arabic during processing can protect the encapsulated compounds, owing to its ability to form a body as a coating and its strong binding capacity toward the compounds. This proves that a higher proportion of gum arabic relative to maltodextrin is more effective in preserving the compounds within the encapsulant, as evidenced by the high and low absorbance profiles shown in Figure 4. A higher absorbance value indicates that the content of the anthocyanin color compounds in the encapsulant remains high. Conversely, a lower absorbance value signifies a lower content of these pigment compounds.

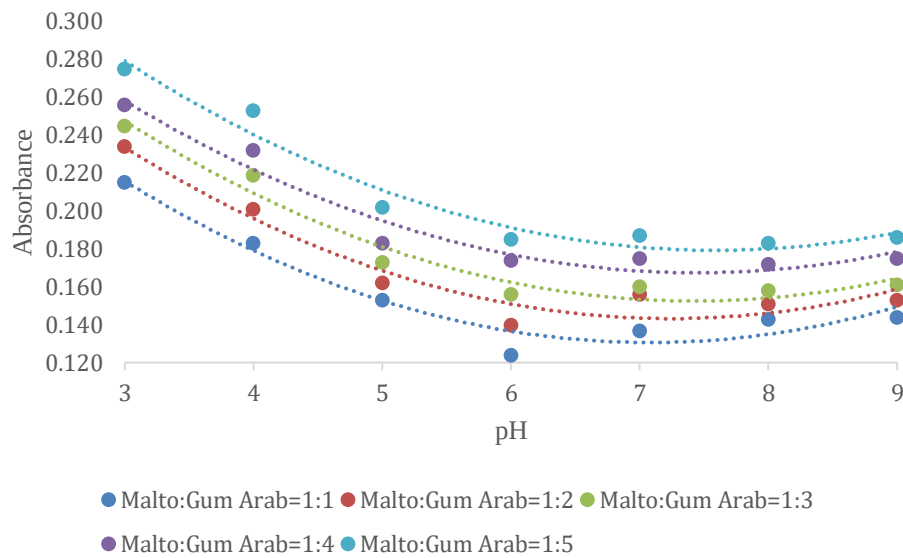


Figure 4. Effect of maltodextrin (M) and gum arabic (GA) ratios on absorbance and color stability at different pH levels.

Table 4. Linear regression equations and R^2 values for the absorbance of purple sweet potato extract encapsulants at different M:GA ratios and pH levels.

M:GA	Regression Equation	R^2
1:1	$y = 0.0051x^2 - 0.0723x + 0.387$	0.948
1:2	$y = 0.005x^2 - 0.0726x + 0.406$	0.942
1:3	$y = 0.0048x^2 - 0.072x + 0.420$	0.964
1:4	$y = 0.0046x^2 - 0.0683x + 0.421$	0.954
1:5	$y = 0.0047x^2 - 0.0719x + 0.452$	0.959

Figure 4 shows that each maltodextrin and gum arabic treatment across pH levels of 3 to 9 affects the color stability of the purple sweet potato encapsulant. An increase in pH results in lower absorbance values of the purple sweet potato encapsulant, causing the reddish-purple color to fade or change; however, its stability is maintained up to pH 4. Based on the quadratic gradient values, the effect of the pH level triggers the most rapid change in absorbance within the 1:1 ratio (0.0051) due to its highly sensitive nature, whereas the 1:4 ratio (0.0046) proves to be the most stable, characterized by the slowest rate of change (Table 4). According to Oancea (2021), anthocyanins are more stable in acidic solutions than in alkaline solutions. The color intensity of anthocyanins decreases in weakly acidic environments. At $pH > 3$, the bright red color of the flavylium cation transforms into a blue quinonoidal base or a colorless carbinol pseudobase as the pH increases up to pH 7. These findings confirm that anthocyanin compounds are stable under acidic conditions and unstable under alkaline conditions.

4. Conclusion

In conclusion, the concentrations of maltodextrin and gum arabic as coating materials significantly affect the stability of the purple sweet potato pigment ethanolic extract encapsulant against heating temperatures (60 °C, 70 °C, 80 °C, 90 °C, and 100 °C), sugar concentrations (10%, 20%, 30%, 40%, and 50%), salt concentrations (2%, 4%, 6%, 8%, and 10%), and various pH levels (3–9). The best treatment was obtained at a maltodextrin to gum arabic ratio of 1:5, which demonstrated stability across heating temperatures of 60 °C to 100 °C and sugar concentrations of 10% to 50%. Meanwhile, it remained stable up to an 8% salt concentration and maintained stability under acidic conditions up to pH 4. Overall, the stability of the encapsulant was inversely affected by the increase in temperature, sugar concentration, salt concentration, and pH. For future studies, it is recommended to evaluate the natural pigment from the purple sweet potato

ethanolic extract under conditions of low temperature, low sugar, low salinity, and highly acidic levels (pH 1–4). These environments are essential for the natural colorant to perform effectively and maintain its functional properties.

References

- Al-Hamayda, A., Abu-Jdayil, B., Ayyash, M., & Tannous, J. (2023). Advances in microencapsulation techniques using Arabic gum: A comprehensive review. *Industrial Crops and Products*, 205, 117556. <https://doi.org/10.1016/j.indcrop.2023.117556>
- As-Salimah, A. M., Sutarno, S., Yani, A. P., Karyadi, B., & Firdaus, M. L. (2024). Analysis of Ascorbic Acid and Borax Using Purple Sweet Potato Extract as A Colorimetric Sensor in Food and Drinks Using Digital Images. *Analit : Analytical and Environmental Chemistry*, 69–80.
- Enaru, B., Dreţcanu, G., Pop, T. D., Stănilă, A., & Diaconeasa, Z. (2021). Anthocyanins: Factors Affecting Their Stability and Degradation. *Antioxidants*, 10(12), 1967. <https://doi.org/10.3390/antiox10121967>
- Jalali-Jivan, M., Nejatian, M., Capanoglu, E., Fathi, M., Tomas, M., Gunal-Koroglu, D., & Rashidinejad, A. (2026). Gum Arabic as a functional biopolymer: From fundamental properties to emerging encapsulation of nutraceuticals and bioactive compounds. *Carbohydrate Polymer Technologies and Applications*, 14, 101129. <https://doi.org/10.1016/j.carpta.2026.101129>
- Kumalasari, I. D., & Yensi, I. (2024). Physicochemical and Sensory Evaluation of Purple Sweet Potato and Jackfruit Seed Flour-Based Food Bars. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, 13(2), 181–199. <https://doi.org/10.21776/ub.industria.2024.013.02.5>
- Lin, Y., Li, C., Shi, L., & Wang, L. (2023). Anthocyanins: Modified New Technologies and Challenges. *Foods*, 12(7), 1368. <https://doi.org/10.3390/foods12071368>
- Miksusanti, M., Elfita, E., & S, H. S. H. (2012). Aktivitas Antioksidan dan Sifat Kestabilan Warna Campuran Ekstrak Etil Asetat Kulit Buah Manggis (*Garcinia mangostana* L.) dan Kayu Secang (*Caesalpinia sappan* L.). *Jurnal Penelitian Sains*, 15(2). <https://doi.org/10.56064/jps.v15i2.97>
- Nawi, M. N., Muhamad, I. I., & Mohd Marsin, A. (2015). The physicochemical properties of microwave-assisted encapsulated anthocyanins from *Ipomoea batatas* as affected by different wall materials. *Food Science & Nutrition*, 3(2), 91–99. <https://doi.org/10.1002/fsn3.132>
- Oancea, S. (2021). A Review of the Current Knowledge of Thermal Stability of Anthocyanins and Approaches to Their Stabilization to Heat. *Antioxidants*, 10(9), 1337. <https://doi.org/10.3390/antiox10091337>
- Sari, P., Agustina, F., Komar, M., Unus, M. F., & Lindriati, T. (2005). Ekstraksi dan Stabilitas Antosianin dari Kulit Buah Duwet. *Jurnal Teknol. dan Industri Pangan*, XVI(2), 142–150.
- Winarti, S., & Firdaus, A. (2010). Stability of Red Color Rosella Extract for Food and Beverage Colorant. *Jurnal Teknologi Pertanian*, 11(2). <https://jtp.ub.ac.id/index.php/jtp/article/view/312>
- Wiriani, D. (2019). *Potensi Pemanfaatan Mikroenkapsulan Antosianin dari Limbah Cair Pengolahan Pati Ubi Jalar Ungu Sebagai Antidiabetes pada Tikus Hiperglikemia yang Diinduksi Dengan Streptozotocin* [Thesis, Universitas Sumatera Utara]. <https://repositori.usu.ac.id/handle/123456789/20190>
- Zhao, Y.-W., Wang, C.-K., Huang, X.-Y., & Hu, D.-G. (2021). Anthocyanin stability and degradation in plants. *Plant Signaling & Behavior*, 16(12), 1987767. <https://doi.org/10.1080/15592324.2021.1987767>