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Profiling Pigmented Plants Cell Membrane Permeability on Different Solvents Condition

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ABSTRAK

Penelitian ini bertujuan mengamati profil permeabilitas membran sel tumbuhan berpigmen pada pelarut dengan kondisi yang berbeda. Spesimen wortel, kunyit, dan ubi ungu direndam pada pelarut organik yang berbeda, yakni pelarut alkohol 35%, alkohol 70%, air suhu dingin, dan air suhu ruang. Metode penelitian yang digunakan adalah kuantitatif deskriptif. Pengambilan data dilakukan dengan dokumentasi. Variabel terikat penelitian ini adalah tingkat kepekatan akhir pelarut organik dan waktu pertama pelarut organik berubah warna (release time). Hasil menunjukkan setiap spesimen memiliki hasil yang berbeda. Wortel menghasilkan tingkat kepekatan yang rendah dalam alkohol dengan release time 20 – 35 menit dan tidak mengubah warna air. Kunyit dan ubi ungu menghasilkan tingkat kepekatan lebih tinggi pada alkohol dibandingkan air. Release time kunyit dan ubi ungu pada alkohol adalah 5 menit serta lebih cepat dibandingkan dengan release time kunyit dan ubi ungu pada air. Pelarut terbaik ketiga spesimen adalah alkohol 70% karena menghasilkan tingkat kepekatan tertinggi dan release time tercepat.

Kata kunci: membran sel, pelarut organik, permeabilitas, suhu.

ABSTRACT

This study aims to observe the profiling pigmented plant cell membrane permeability on different solvents condition. Carrot, turmeric, and purple sweet potato specimens were soaked in different organic solvents, namely 35% alcohol, 70% alcohol, cold water, and room temperature water. The research method used is descriptive quantitative. Data collection is done by documentation. The dependent variable of this research is the final concentration of the organic solvent and the first time the organic solvent changes color (release time). The results show that each specimen has different results. Carrots produce a low concentration of alcohol with a release time of 20-35 minutes and do not change the color of the water. Turmeric and purple sweet potato produce a higher concentration of alcohol than water. Turmeric and purple yam release time on alcohol is 5 minutes and is faster than the release time of turmeric and purple yam on water. The best solvent for the three specimens is 70% alcohol because it produces the highest concentration and the fastest release time.

Keywords: cell membrane, organic solvent, permeability, temperature.

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INTRODUCTION

Organisms are composed of cells. The cell is the structural and functional unit of living things. Cells consist of organelles that have their respective roles (Agustina et al., 2021). Cell organelles include the nucleus, cell membrane, cytoplasm, vacuoles, ribosomes, mitochondria, endoplasmic reticulum, etc. (Thomy & Harnelly, 2018).The cell membrane is the outermost part of the cell as a barrier between the cell cytoplasm and the environment. The components of the cell membrane are lipids and membrane proteins (Agustina et al., 2021). The lipid forms the bilayer structure of the cell membrane. The lipid membrane is the basic barrier of the cell. The structure of the lipid membrane is flexible. The protein membrane is the guard membrane of the cell. Signals are received and generated by membrane proteins for internal and external communication. The important roles played by membrane proteins are cell adhesion, transport of metabolites, ion gradients forming, and are responsible for the processes of synthesis and degradation of membrane components. The cell membrane has four basic roles, i.e. separation, exchange, integration, and metabolism (Buehler, 2016).

The characteristic of the cell membrane is selective permeability. This causes not all substances can enter the cell. The permeability of cells is due to the presence of transporter proteins and ion channels (Agustina et al., 2021).

Osmosis is a type of passive transport. The definition of osmosis is the movement of a solution containing ions and molecules through the cell membrane from a low-concentration (hypotonic) solution to a high-concentration (hypertonic) solution (Hasanah et al., 2021). Osmosis is divided into two types, i.e. endosmosis (osmosis takes place inside the cell) and exosmosis (osmosis takes place outside the cell) (Wahyuni et al., 2019). Osmosis events occur through aquaporins (Kulbacka & Satkauskas, 2017). Aquaporins are integral membrane proteins that act as specific water channels found in all organisms (Advinda, 2018).

Osmosis plays a role in plant life. Osmosis events occur in plants in the process of absorbing water from the soil and stomatal opening (Wahyuni et al., 2019). Osmosis is also applied in life. Some examples of the application of osmosis in life are :

1. Osmotic dehydration in fruits and vegetables with NaCl for improving storability (Yadav & Singh, 2014);
2. Salinity treatment for gaining pigment from microalgae in the food industry (Sun et al., 2023);
3. Food colouring from natural pigments such as tofu (Setianingsih et al., 2021).

The osmosis process requires proper treatment to obtain optimum results. Treatments that affect osmosis include the type of solvent and temperature (Rahman & Perera, 1999). The purpose of this study was to observe the profiling pigmented plant cell membrane permeability on different solvents condition.

METHODS

The method of this research is descriptive quantitative without repetition. Data was taken by documentation. The tools and materials needed were ruler, knife, basin, transparent

containers, tissue, room temperature water, cold water, tap water, 70% alcohol, pigmented specimens: carrot (*Daucus carota* L.), turmeric (*Curcuma domestica* Val.), and purple sweet potato (*Ipomoea batatas* var. Ayamurasaki).

The independent variable of this research are pigmented specimens, organic solvent type, and organic solvent temperature. The dependent variable of this research are the concentration level of the organic solvent and first-time colour changes of the organic solvent (*release time*).

Samples cut into 1 cm x 1 cm x 0.5 cm with total 40 pieces. Samples washed with running water then dried with tissue. The organic solvents were prepared (room temperature water, cold water, 70% alcohol, 35% alcohol). Room temperature water was cooled in the refrigerator or mixed with ice cubes as cold water solvent. 70% alcohol was added with water (1:1) as 35% alcohol solvent. 4 transparent containers (transparent glass or mineral water bottles) were filled 70 mL with each solvent and were labeled. 10 pieces of samples were added to each solvent. *Release time* was recorded. The concentration level was recorded after 60 minutes of immersion. Concentration levels scoring based on the solvents color change (Table 1) (Doi, 2014 with modification).

Table 1. Concentration levels score and the change in solvents color

Concentration Level	Change in Solvents Color
0	No change
1	Slightly colored
2	Medium colored
3	Highly colored
4	Very highly colored

RESULTS AND DISCUSSION

Based on Figure 1, release time of each specimen were different in different solvents. Carrot had a longer release time in alcohol solvent than turmeric and purple sweet potato. Carrot release time was 35 minutes at 35% alcohol and 20 minutes at 70% alcohol while turmeric and purple sweet potato had a release time of 5 minutes at both 35% and 70% alcohol. Carrot did not change the color of the water after 60 minutes of immersion. Turmeric had a faster release time than purple sweet potato in cold water and room temperature water. Release time of turmeric in room temperature water was faster than cold water. This shows that temperature affects the process of osmosis. Temperature affects the cell wall. High temperature for cell immersion caused density and structure of the cell wall decreases. As a result, the osmosis process becomes faster (Saputra et al., 2018).

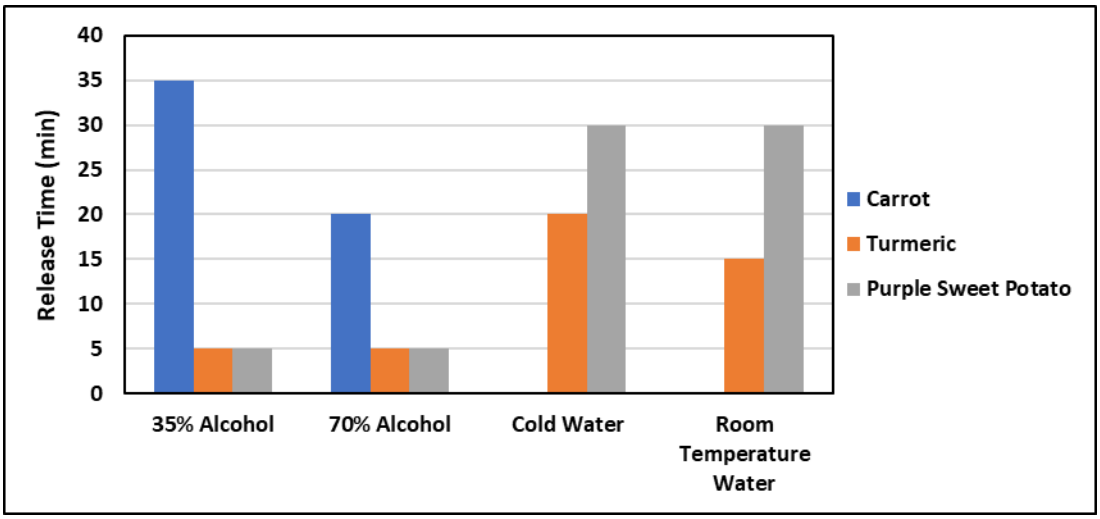


Figure 1. *Release time* for every specimen on different solvent

Based on Figure 2 and Figure 3, the solvent with the best concentration level for all specimens was 70% alcohol. The alcohol type used in this research was ethanol. Ethanol plays a role in membrane physical structure disruption, including liposomes, plasma membranes, and membranes of cell organelles (mitochondria and endoplasmic reticulum) (Tóth et al., 2014). Purple sweet potato had the highest level of concentration at 35% alcohol and 70% alcohol. Turmeric had the highest concentration of cold water and room temperature water among the three specimens. Carrot soluble in alcohol but are insoluble in water. This causes no colour change in the water solvent on carrot specimens.

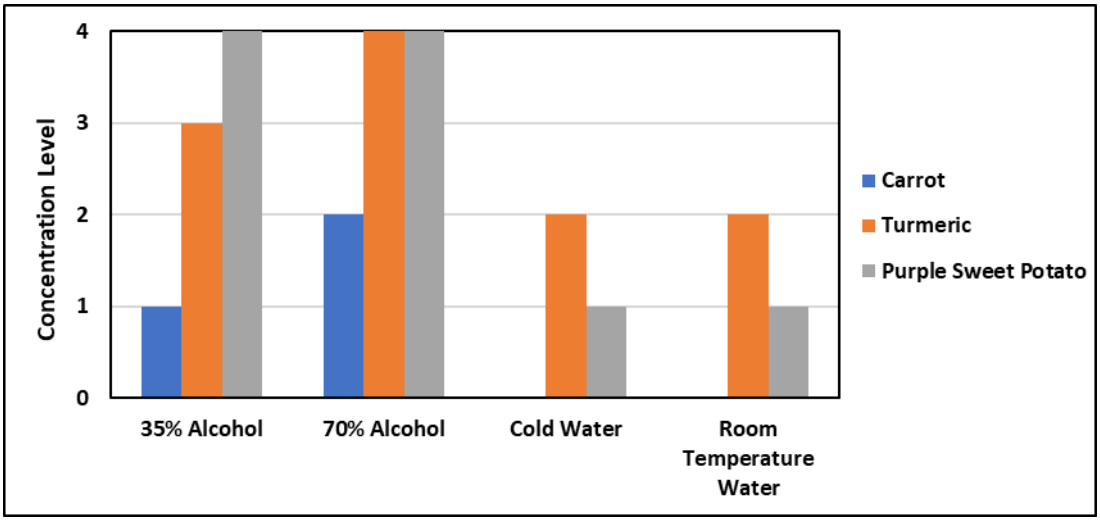
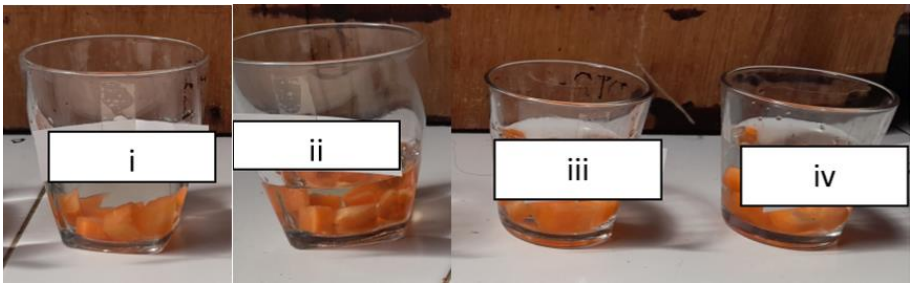
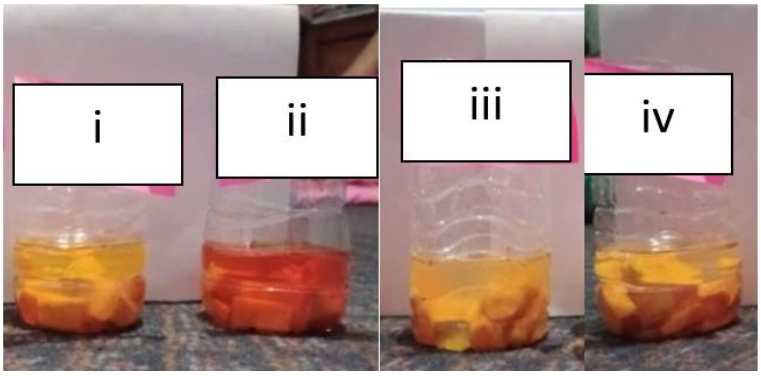


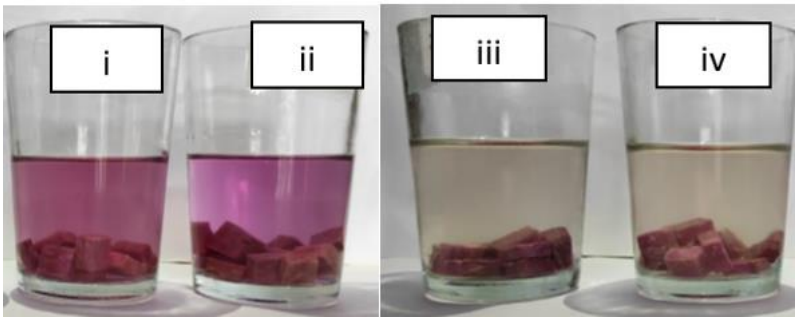
Figure 2. Concentration level after 60 minutes for every specimen on different solvent



a



b



c

Figure 3. Results after 60 minutes of immersion (a) carrot, (b) turmeric, (c) purple sweet potato. Notes: (i) 35% alcohol, (ii) 70% alcohol, (iii) cold water, (iv) room temperature water

Water is a hypotonic solvent. It causes water to be able to immerse into the cells (Ulfa et al., 2020). Therefore, this reason is thought to be the cause of water resulting in a longer release time and lower concentration level than alcohol.

Carrot contains β-carotene pigment which produces an orange color. The color of β-carotene in carrot is difficult to observe in solvents because carrots have thick cell walls that caused β-carotene pigments difficult to leave the cells (Ribas-Agustí et al., 2013). The colour of water solvent does not change because β-carotene does not dissolve in water (Ishimoto et al., 2019). β-carotene has a low solubility level in alcohol solvents (Honda et al., 2018). This causes the alcohol solvent to have an orange color that is not intense in this experiment.

Turmeric contains curcumin pigment. Curcumin has a solubility in alcohol or ethanol of 1 mg/mL (highly soluble) (Enzo Life Science, 2023) while its solubility in water is 60 µg/mL (Górnicka et al., 2023). This causes turmeric to be more concentrated in alcohol than in water. The best turmeric solvent for hydrocarbons is ethanol (Popuri, 2013). However, Wahyuningtyas et al. (2017) stated that the curcumin content of turmeric in ethanol,

methanol and acetone solvents is not significantly different. Ethanol is significantly different from isopropanol solvent.

Purple sweet potato contains anthocyanin pigment. The amount of dissolved anthocyanins increase when treated with high temperatures. The minimum temperature for the resulting changes is 115 ^{o}C (Yudiono, 2011). Therefore, the concentration level of purple sweet potato in cold water and room temperature water did not differ because the temperature of the room temperature water treatment did not reach 115 ^{o}C. Anthocyanins are more soluble in alcohol than water (Ifadah et al., 2021). This is consistent with the results of this study that the concentration level of purple sweet potato soaked in alcohol was higher than purple sweet potato soaked in water.

CONCLUSION

Temperature and organic solvents affect the permeability of cell membranes which causes cell pigments to come out and colour the solvent. The best solvent for the three specimens is 70% alcohol because it has the fastest release time and produces the highest concentration level. The solvent also affects the solubility of pigments because each pigment has a different level of solubility in different solvents.

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