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ผลของการขาดน้ำหลังการเก็บเกี่ยวต่อคุณภาพและอายุการปักแจกันของกล้วยไม้ตัดดอกสกุลหวาย

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โครงงานวิทยาศาสตร์ฉบับนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
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Effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers

Miss Treesukon Raksiri

A Senior Project in Partial Fulfilment of the Requirements
For the Degree of Bachelor of Science in Botany
Department of Botany
Faculty of Science, Chulalongkorn University
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Title	Effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers
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บทคัดย่อ

กล้วยไม้สกุลหวายเป็นไม้ตัดดอกที่ได้รับความนิยมในประเทศไทยและเป็นไม้ตัดดอกที่สำคัญสำหรับการส่งออก อย่างไรก็ตาม กล้วยไม้สกุลหวายส่วนใหญ่จะไม่ได้แช่น้ำทันทีหลังการเก็บเกี่ยวจนกว่าจะบรรจุในหลอดพลาสติกที่มีน้ำเพื่อการส่งออกหรือการขนส่ง ดังนั้น อาจทำให้ดอกไม้ขาดน้ำและนำไปสู่การเสื่อมสภาพอย่างรวดเร็ว การทดลองนี้จึงมีวัตถุประสงค์เพื่อศึกษาผลของการขาดน้ำหลังการเก็บเกี่ยวต่อคุณภาพและอายุการปักแจกันของกล้วยไม้ตัดดอกสกุลหวาย ‘สุรีย์พืช’ ‘สุพินยา’ และ ‘เอียสกุล’ โดยเก็บดอกกล้วยไม้ทั้ง 3 พันธุ์ในสภาพขาดน้ำเป็นเวลา 0 12 24 และ 48 ชั่วโมงหลังการเก็บเกี่ยวก่อนนำไปปักในน้ำ จากผลการศึกษาพบว่า การขาดน้ำหลังการเก็บเกี่ยวมีผลต่อคุณภาพและอายุการปักแจกันของกล้วยไม้ตัดดอกสกุลหวายทั้งสามพันธุ์ โดยทำให้การบานของดอกตูมและการหลุดร่วงของดอกเพิ่มขึ้น ในขณะที่คะแนนคุณภาพของดอกบานลดลงเมื่อเปรียบเทียบกับชุดควบคุม อย่างไรก็ตาม การขาดน้ำมีผลเพียงเล็กน้อยต่อการเปลี่ยนสีของกลีบดอกกล้วยไม้สกุลหวาย นอกจากนี้ยังพบว่ากล้วยไม้ที่ขาดน้ำเป็นเวลา 12 ชั่วโมงทั้งสามพันธุ์มีอายุการปักแจกันที่ยาวนานที่สุดและคุณภาพของดอกที่ดีที่สุดเมื่อเปรียบเทียบกับชุดทดลองที่ขาดน้ำเป็นเวลา 24 และ 48 ชั่วโมง ดังนั้น หากไม่สามารถนำกล้วยไม้ตัดดอกสกุลหวายไปแช่น้ำทันทีหลังการเก็บเกี่ยว ภาวะขาดน้ำเป็นเวลา 12 ชั่วโมงก่อนบรรจุในหลอดพลาสติกที่มีน้ำเพื่อการขนส่งหรือส่งออก นับเป็นระยะเวลาขาดน้ำที่มากที่สุดที่ดอกกล้วยไม้สกุลหวายทั้งสามพันธุ์ยังสามารถคงคุณภาพและอายุการปักแจกันไว้ได้ดีที่สุด

คำค้นหา: กล้วยไม้สกุลหวาย, ไม้ตัดดอก, คุณภาพ, อายุการปักแจกัน

Title	Effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers
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Abstract

Dendrobium orchids are popular cut flowers in Thailand and are the most important cut flower for exports. However, most cut *Dendrobium* flowers are harvested and kept dry for a few hours until either packed in water tube for export or transportation without placing in water to local market. This can cause water stress of the flowers and induce early senescence of the florets. This experiment was conducted to determine the effects of postharvest water deficit on quality and vase life of cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers. Cut *Dendrobium* flowers were kept dry 0, 12, 24 and 48 hours after harvest and then placed in water. The results showed that water deficit affected quality and vase life of postharvest cut *Dendrobium* flowers of all cultivars tested by increasing flower bud opening and florets abscission and decreasing open flower quality scores. However, water deficit had only a small effect on petal color changes of the florets. Nevertheless, the longest vase life and the best flower quality of the florets in all cultivars were found in the inflorescences which were exposed to water deficit for 12 hours when compared with the inflorescences that were exposed to water deficit for 24 and 48 hours. Therefore, keeping the inflorescences dry if needed after harvest up to 12 hours before packing in water tube for transport or export to local market could be considered as one way to maintain quality and vase life of cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers.

Keywords: *Dendrobium*, cut flowers, water deficit, quality, vase life

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Treesukon Raksiri

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CHAPTER 1

INTRODUCTION

1. Introduction

Thailand is the world's foremost orchid producer and exporter (Charoenwattana, 2013). The genus *Dendrobium* is a member of Orchidaceae family, with over 1500 species mainly grown in tropical and subtropical Asia and eastern Australia. *Dendrobium* hybrids have become popular worldwide as commercial cut flowers and potted plants due to their valuable characteristics including floral colors, forms, size, specific fragrance, and long of vase life (Kuehnle et al., 1997). *Dendrobium* orchids are popular cut flowers in Thailand and are exported more than 50 percent of the flowers (Thammasiri, 2015).

The vase life of cut flowers especially cut orchid flowers depends on pre- and postharvest handling. It also depends on the floral cultivar (Durkin, 1992). Moreover, the vase life of some cut flowers is shortened by an interference of hormonal regulations such as ethylene and abscisic acid, whereas the limiting factor of the vase life in many flowers is water stress. Early physiological research of cut flowers dealt with their water relations. For example, cut alstroemeria flowers were able to recover with full turgor from water stress after being refreshed in water (Wangstaff et al., 2010). The vase life of cut flowers is ended by changes of color, closure of flower, wilting of petals or abscission of petals. Symptoms of natural senescence are often not detected when flowers are cut and put in water. But symptoms of water stress, such as premature wilting of flowers and leaves can be presented due to blocking of water flow in the stems. Roses, gypsophila, astilbe, bouvardia, and acacia flowers revealed water stress symptoms and flowers like tulips, freesia, and iris did not demonstrate this early water stress (van Doorn, 1997). Moreover, maintaining the water balance was proved to be of great importance in increasing the lifetime of the cut flower. The balance of water can be defined loosely as the difference between the rate at which water transpires and the rate at which water moves through the stem (Fujino, Reid, and Kohl, 1983). In addition, senescence time of cut *Dendrobium* hybrids is different and one of the main reasons for this variation in vase life may also be due to differences in ethylene sensitivity (Almasi et al., 2012).

Most cut *Dendrobium* inflorescences are harvested and kept dry for a few hours to a day until either packed in water tube for export or transportation without placing in water to local market. This can cause water stress of the inflorescences and induce early senescence of the florets. To determine the longevity of the cut *Dendrobium* flowers exposed to water deficit after harvest, cut *Dendrobium* 'Suree Peach', *Dendrobium* 'Supinya' and *Dendrobium* 'Eia Sakul' flowers were kept dry and placed in water for 0, 12, 24 and 48 hours after harvest. Physiological responses, flower quality and vase life of cut *Dendrobium* flowers were observed 0, 12, 24 and 48 hours and every 2 days after placing in water until the end of vase life. The results can be applied to maximize vase life of cut *Dendrobium* flowers for export and local market.

2. Objective

To determine the effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers.

3. Expected benefits

The results of this study can be applied to maximize vase life of cut *Dendrobium* flowers for export and local market.

CHAPTER 2

LITERATURE REVIEWS

1. *Dendrobium* orchids

The genus *Dendrobium* is a member of Orchidaceae family, which comprises more than 1500 species mainly grown in tropical and subtropical Asia and eastern Australia. *Dendrobium* hybrids became worldwide popular as commercial cut flowers (Kuehnle et al., 1997). It has unique characteristics among the cut orchids due to color varieties, larger number of florets in the inflorescence and recurrent flowering (Fadelah et al., 2001). *Dendrobium* orchid hybrids are the most famous cut flowers in the floral trade of orchid, especially in Southeast Asia countries (Yu et al., 2001). *Dendrobium* orchids are common cut flowers with more than 50 percent of the flowers exported in Thailand (Thammasiri, 2015).

2. Postharvest longevity of cut flowers

The longevity of cut flowers after harvest is very important in determining the value of the crop, particularly cut flowers considering the global nature of the flower industry and the need for long handling and transportation times. Many investigations have been carried out into the longevity and quality of cut flowers by adding various preservatives to the vase water (Naidu and Reid, 2012), resulting in considerably delayed senescence of cut flowers. In cut flowers, the processes of flower bud opening and color development demand substrates and energy for their satisfactory production (Kaltaler and Steponkus, 1974; Uthaichay et al., 2007).

3. Water deficit in cut flowers after harvest

Water deficit can be described as any tissue or cell water content below the highest water content in the most hydrated state (Taiz et al., 2014). Water stress can affect plant growth whether the water deficit develops and results in changes in plant development processes (Taiz et al., 2014). Water deficit in cut rose flower is considered a major cause of rapid senescence and early flowers wilting (Rogers, 1973). During dry transportation and storage, cutting roses are vulnerable to water stress. The immediate stress symptom is the bending of the peduncles (bent neck). However, the flowers could recover when being placed in water. The incident of bending neck terminates the vase life of cut roses even though the stem bases are kept in water continuously after harvest (Harlevy et al., 1978; Hu et al., 1998).

The short vase life of roses is often associated with water stress that is characterized by incomplete bud opening, rapid loss of fresh weight and water deficit and insufficient turgidity maintenance (Thwala et al., 2013). Several researchers have reported the value of water, sugar and various chemical preservatives for maintaining the quality of cut flowers (Han, 1997; Hunter et al., 2004). Waithaka et al. (2001) reported that neck drop of cut rose flower was caused by improper transport of water through the neck tissue and tended to be characteristic of varieties. Hence, water is a major component of cut flowers and water loss without replenishment causes wilting and dropping of the flower. Nevertheless, the probability that the anti-senescence factor is water and the degrading changes in cut flower result from water imbalance cannot be ruled out while an early symptom of senescence in cut flower is loss in fresh weight (Thwala et al., 2013).

Apelbaum and Yang (1981) reported that water stress in plants can lead to increased production of ethylene. However, little difference was found between production of ethylene in non-cut and cut Golden Wave roses (Halevy and Mayak, 1975), whereas, the effect of water stress on ethylene production during vase life has not been studied in particular. Intact rose petal life was usually limited by abscission in which was regulated by ethylene (Woltering and van Doorn, 1988). In roses, moderate water stress during dry storage can have little effect on the time required for wilting and increased production of ethylene during vase life (Faragher et al., 1987). In addition, Mayak et al. (1985) reported that water loss resulted in a temporary increase in the ethylene production of White Sim carnation flowers as well as in a shorter vase life.

Furthermore, signs of water stress have been found to be the most frequent cause for the end of vase life in most rose cultivars. Botrytis is the second important cause of the end of vase life and the third cause is physiological senescence (Fanourakis et al., 2015). The most distinctive symptoms of water stress include loss of petal turgor (wilting of the flowers), bent neck and wilted leaves (van Doorn, 2012).

4. Ethylene and senescence of cut flowers

Longevity of the flowers is one of the most important traits of cut flowers. Ethylene is a key factor in many plant species which regulates flower senescence (Pareek, 2016).

4.1 Water stress and ethylene

Keeping cut flowers dry will typically reduce their fresh weight and therefore reduce their water potential. This lower water potential could improve ethylene production (Drory et al. 1995). Ethylene can increase drying and abscission of the floral bud, it can inhibit or encourage opening of the bud, encourage the abscission of open flowers, decrease the time for wilting or abscission of the petals, and promote yellowing of the leaves and abscission of the leaves (van Doorn, 2012). In addition, a blockage is created in the xylem of many cut flowers during the course of vase life which results in water stress.

This could also cause increased production of ethylene. This ethylene, during dry storage, may have the same effects as the ethylene created by water stress (van Doorn, 2012). Inflorescences of 'Star Gazer' lily cut flowers showed an increase in ethylene production after dry storage for 2 weeks (Han and Miller 2003).

4.2 Ethylene response of cut flowers

Ethylene controls multiple aspects of plant growth and development in a wide range of flower species, including flower opening, petal senescence and abscission (Abeles et al., 1992; Reid and Wu, 1992; van Doorn and Woltering, 2008). In many flowers such as orchids and roses, ethylene is responsible for the early senescence (Leiv et al., 2005). Ethylene speeds up the wilting of petals or the abscission of flower part in some plant species but has little effect on other plant species. Ethylene sensitivity in cut flowers usually assessed on the basis of whether symptoms of senescence are found after exposure to a steady concentration of ethylene (Pareek, 2016). Through aging, ethylene sensitivity of the flowers rises in some plant species. Sepal abscission of *Delphinium* hybrid cv. ‘Bellamosum’ flowers is not caused by ethylene treatment (40 µl l^{-1}) on the day after harvest (Ichimura et al., 2009). Due to high ethylene in cut flower, senescence patterns of flowers showing high sensitivity to ethylene can be classified into two types: a petal-wilting type in which ethylene induces petal wilting, and a petal-abscission type in which ethylene induces petal and sepal abscission (Pareek, 2016).

Depending on the cultivar, ethylene may inhibit or stimulate flower opening in cut roses or result in an irregular flower form (Reid et al. 1989), but the increase in ethylene production in cut roses placed directly after harvest occurs after flower opening and therefore has no impact on opening (Halevy and Mayak, 1975; Faragher and Mayak, 1984). Nevertheless, opening of flowers could be affected by the production of ethylene during and shortly after dry storage, when rose buds produce significant amounts of ACC and ethylene (Faragher et al., 1987).

In cut rose flowers, ethylene can also be a factor in the lack of bud opening. With relation to the role of ethylene in the flower bud opening of cut roses, it has been reported that the flower opening is ethylene-influenced and the effect of ethylene is cultivar-dependent. For flower bud opening, the cultivars can be roughly divided into three groups: inhibited opening, stimulated opening and non-ethylene-influenced opening (Reid et al., 1989; Yamamoto et al., 1994).

Dehydration can lead to the production of ethylene in detached plant organs, such as lettuce leaves (Ripoll, 2019), *Tulipa gesneriana* (Wang, 2020) and carnation flowers (Yakimova and Woltering, 1997). In addition, ethylene was also reported to respond during rehydration, which usually occurred after dehydration during postharvest treatment. In Cleopatra mandarin seedlings, a rapid and significant increase in the production of ethylene was observed after rehydration in the leaves of water-stressed plants, resulting in leaf abscission (Tudela and Primo-Millo, 1992). In wheatears, rehydration of plants at maximum turgor after desiccation induces a high production of ethylene (Beltrano et al., 1997).

Additionally, the short vase life of many cut flowers remains a challenge for the floral industry in general. Flowers are highly perishable; the very active survival of their physiology even after harvest and the start of their senescence very often depends on ethylene action (Reid, 2012; Roein et al., 2009).

4.3 Ethylene biosynthesis

For ethylene biosynthesis, methionine is converted by SAM synthetase into S-adenosyl-methionine (SAM) (Keunen et al., 2016). ACC synthase (ACS) then produces 1 aminocyclopropane-1-carboxylic acid (ACC) from SAM. This also releases 5′-methylthioadenosine (MTA), which is recycled back to methionine via the so-called "Yang process" (Keunen et al., 2016). Eventually, ACC is oxidized to ethylene, CO_2 and cyanide (HCN) by ACC oxidase (ACO). Furthermore, using malonyl-CoA, ACC may be transformed to its main 1-malonyl-ACC (MACC) conjugate. It may also react with GSH to form **γ**-glutamyl-ACC (GACC) or JA to form jasmonyl-ACC (JA-ACC) (Keunen et al., 2016) (Figure 1).

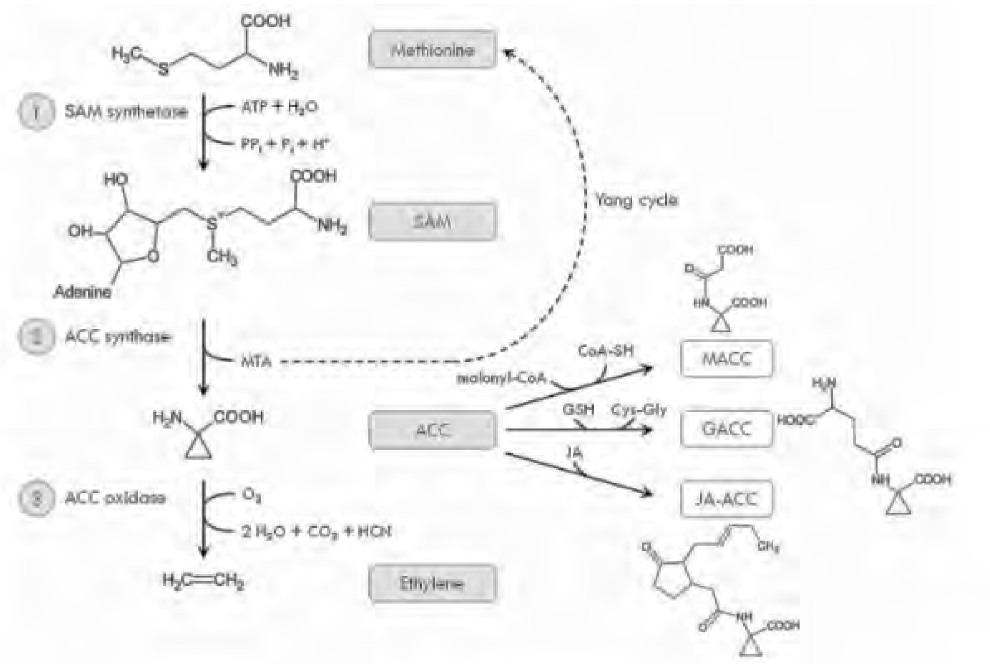

Figure 1 Ethylene biosynthesis pathway (Keunen et al., 2016)

5. Flower bud opening

Flower bud opening is generally due to cell expansion (van Doorn and van Meeteren, 2003). The complete opening of the flower bud is defined by an increase in the area of the petals and increased dry and fresh petal weights (Kuiper et al., 1995). However, flower opening in many flowers species is regulated by ethylene (Reid and Wu, 1992). Flower bud opening in roses involves morphological and physiological floral changes which lead to expansion and petal reflection. The expansion goes from the outer to the inner whorls and leads to increased flower diameter (Faragheret al., 1984; Evans and Reid, 1988; Van Doom et al., 1991).

6. Floret abscission

Floret abscission starts with the degradation of cell walls (middle lamella) of the cells in a specialized region called the abscission zone (AZ), which results in the separation of organs from the plant body. The separation of plant organs from the main plant body occurs when either an injury due to biotic/abiotic stress or as a regular process in plant growth and development (Addicott, 1982; Taylor and Whitelaw, 2001; Patharkar et al., 2017).

Organs abscission pattern and form differ among plant species, which may be due to the adaptation or evolutionary pressure to a specific environment. Plant hormones such as ethylene, auxin, cytokinin (CK), abscisic acid (ABA), and jasmonic acid (JA) play an important role in the mechanism and regulation of senescence and abscission. Ethylene plays a major role in the initiation and activation of abscission (Gulfishan et al., 2019). According to Tripathi and Tuteja (2007), they reported that flowers, petals, and leaves treated with ethylene showed early senescence. However, other hormones like ABA and auxin are also involved (Gulfishan et al., 2019).

7. Color values (*L*, a*, b**)

In the color measurements, *L** *a** *b** is the most used color space due to the uniform distribution of colors and because it is very close to the human perception of colors (León, et al., 2006). *L** is the lightness component (ranges from 0 to 100), and *a** (from green to red) and *b** (from blue to yellow) are chromatic components (range from 120 to 120). These components are used to determine the three basic color dimensions: hue, chroma and lightness (Crozier, 1999; Pathare, Opara, and Al-Said, 2013).

CHAPTER 3

METHODOLOGY

1. Preparation of plant materials

Inflorescences of *Dendrobium* 'Suree Peach', 'Supinya and 'Eia Sakul' were purchased from a local orchid farm in Nakorn Pathom. Inflorescences with 60% open flowers were selected for the water deficit treatments. The stem ends were re-cut to give a uniform length of peduncles at approximately 12-15 cm (Yoodee et al., 2013).

2. Determination of the effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers

2.2. Inflorescences of cut *Dendrobium* 'Suree Peach' (32 inflorescences) were divided into four treatments and each treatment (8 inflorescences) was subdivided into four replications (each with 2 inflorescences). A completely randomized design (CRD) was applied.

2.2. The four treatments of cut *Dendrobium* 'Suree Peach' inflorescences were kept dry for 0, 12, 24, and 48 hours respectively.

2.3. After keeping dry the inflorescences were placed in water tube containing 10 ml distilled water until the end of vase life. The inflorescences were kept in the laboratory room at 25°C under cool-white fluorescent lights and 70% relative humidity throughout the experiment for 12 hours a day (Yoodee et al., 2013). The postharvest quality was observed and recorded 0, 12, 24, and 48 hours and every 2 days after placing in water until the end of vase life. The effects of postharvest water deficit on quality and vase life of cut *Dendrobium* flowers were determined as follows.

2.3.1 The petal color (*L*, a*, b**) was measured using a colorimeter (Color Reader CR-10, Konica Minolta Sensing, Inc., Japan).

2.3.2 The open florets of flower bud after treatment were counted and calculated as percentages of flower bud opening as follows (Chucouisuwan, 2012).

$$\%\,Flower\ bud\ opening = \frac{The\ number\ of\ open\ florets\ \times 100}{The\ initial\ number\ of\ flower\ bud}$$

2.3.3 The number of floret abscission were counted and calculated as percentages of florets abscission as follows (Chucouisuwan, 2012).

$$\%\,Floret\ abscission = \frac{The\ number\ of\ abscised\ florets\ \times 100}{The\ initial\ number\ of\ florets}$$

2.3.4 Cut *Dendrobium* flowers were considered to have reached the end of their vase life when one of the following senescence symptoms was detected: bending of the pedicel (bent-neck; neck angle greater than 45°), wilting, closed flower, obvious line on petal and sepal or dropped (Figure A1-A3). The vase life of cut *Dendrobium* flowers was terminated when these senescence symptoms occur 50% of the open florets (In et al., 2017).

2.3.5 Open flower quality scores were observed on the first open floret from the lowermost of the inflorescence. Scores were ranked according to senescence symptoms as follows: 5 (no symptom), 4 (1 symptom), 3 (2 symptoms), 2 (more than 2 symptoms), 1 (withered or dropped).

2.4 Inflorescences of cut *Dendrobium* 'Supinya' and 'Eia Sakul' were divided, treated and determined the effects of postharvest water deficit on quality and vase life as same as cut *Dendrobium* 'Suree Peach'.

3. Statistical analysis

The experiment of each cultivar was repeated four times for each treatment. A completely randomized design (CRD) was applied. Data were analyzed using analysis of variance (ANOVA) and the treatment means were compared using least significant difference (LSD) at $P \leq 0.05$. For open flower quality scores, nonparametric statistical analysis: Kruskal-Wallis test was performed. All other experiments, statistical analyses were performed using SPSS version 22.0 (SPSS Inc., USA).

4. Venue of the study

The study was carried out at a phytotron room and plant physiology laboratory, Department of Botany, Faculty of Science, Chulalongkorn University.

CHAPTER 4

RESULTS

1. The effects of postharvest water deficit on quality and vase life of cut *Dendrobium* 'Suree Peach' flowers

1.1 Color changes of petals

*L** value (lightness) of cut *Dendrobium* 'Suree Peach' flowers was significantly different ($P \leq 0.05$) in all treatments from 12-48 hours (day 0-2) and from 144 hours (day 6) until the end of vase life (day 6-10) compared with control. However, the *L** value was gradually increased in all treatments after placing the inflorescences in water until the end of vase life (Figure 2, Table A1).

*a** value (red/green value) was significantly different ($P \leq 0.05$) in all treatments after placing the flowers in water for 12 hours and from 192 hours (day 8) until the end of vase life (day 8-14), compared with control. Moreover, *a** value was moderately declined in all treatments after placing the inflorescences in water until the end of vase life (Figure 3, Table A2).

*b** value (blue/yellow value) showed significantly differences ($P \leq 0.05$) among all treatments at 0-12 hours, 96 hours (day 4), 192 hours (day 8), and 336 hours (day 14) compared to control (Figure 4, Table A3).

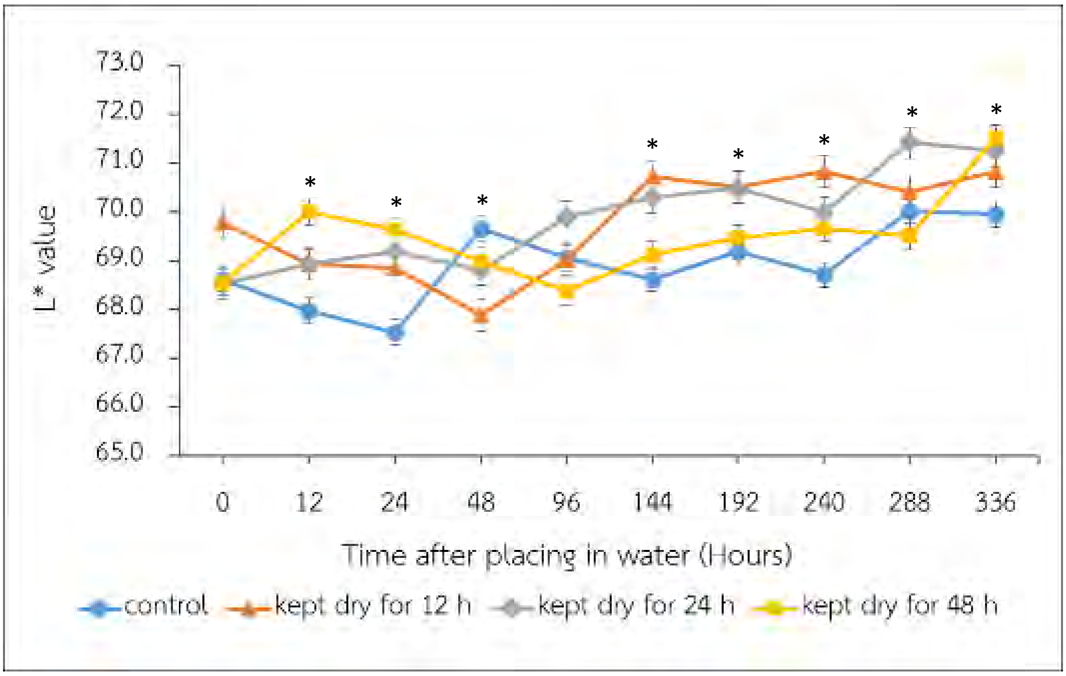

Figure 2 *L** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

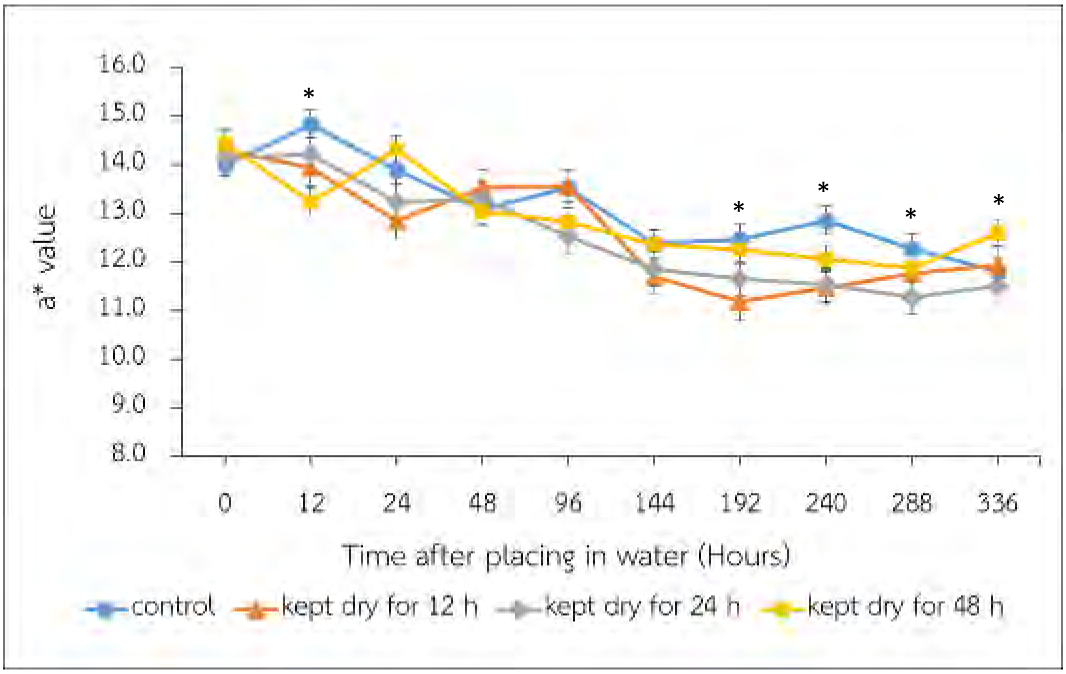

Figure 3 *a** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

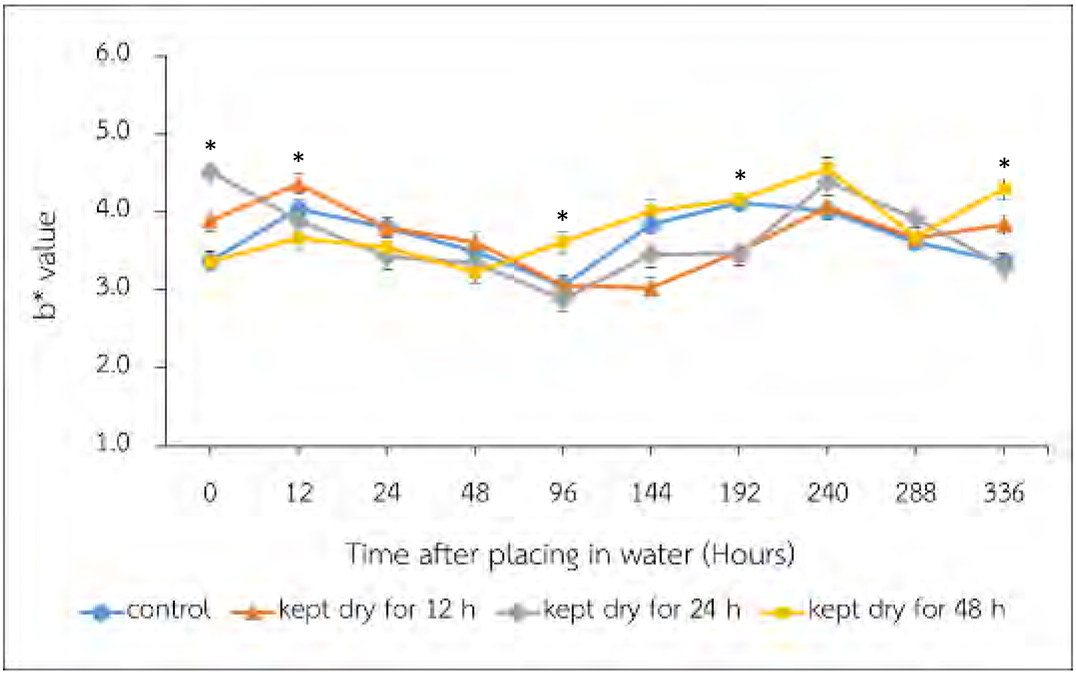

Figure 4 *b** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at $P \le 0.05$.

1.2 Flower bud opening

Flower bud opening of cut *Dendrobium* 'Suree Peach' flowers which were kept dry for 24 and 48 hours were significantly higher than control after placing in water for 24 hours (day 1). However, the percentages of flower bud opening in all treatments including control were increased after placing in water (Figure 5, Table A4).

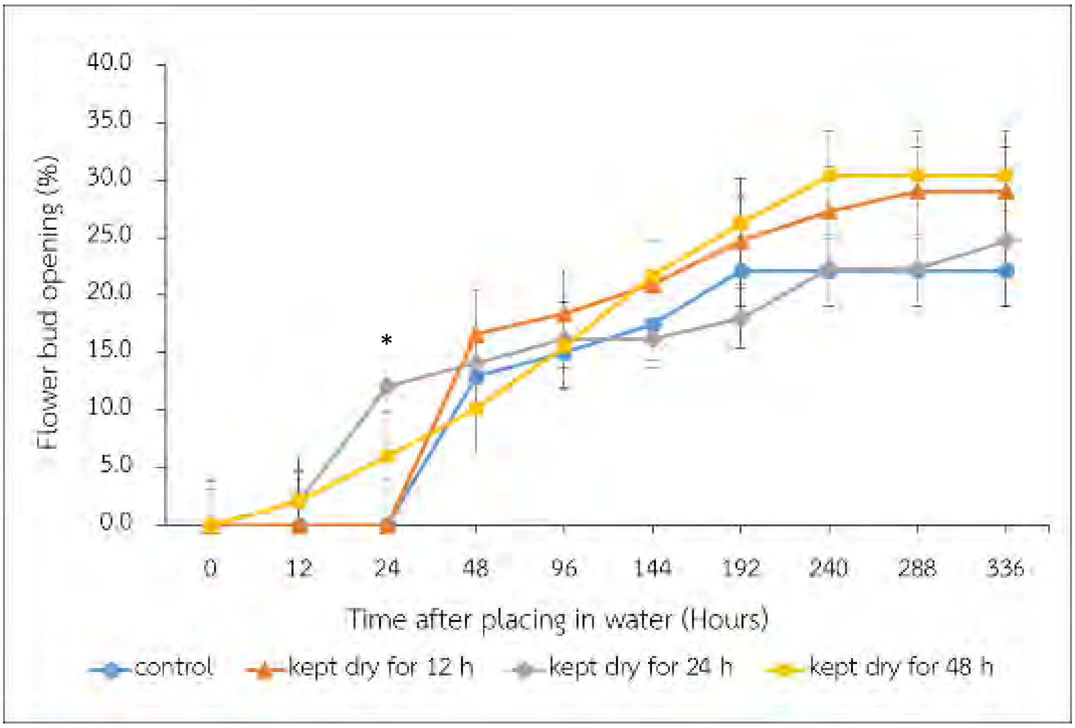

Figure 5 Flower bud opening of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

1.3 Floret abscission

Floret abscission of cut *Dendrobium* 'Suree Peach' flowers that were kept dry for 48 hours was significantly higher than other treatments, including control after placing in water from 144 to 240 hours (day 6-10), and at 336 hours (day 14) (Figure 6). Nevertheless, the percentages of floret abscission in all treatments were increased after placing in water until the end of vase life, including control (Figure 6, Table A5).

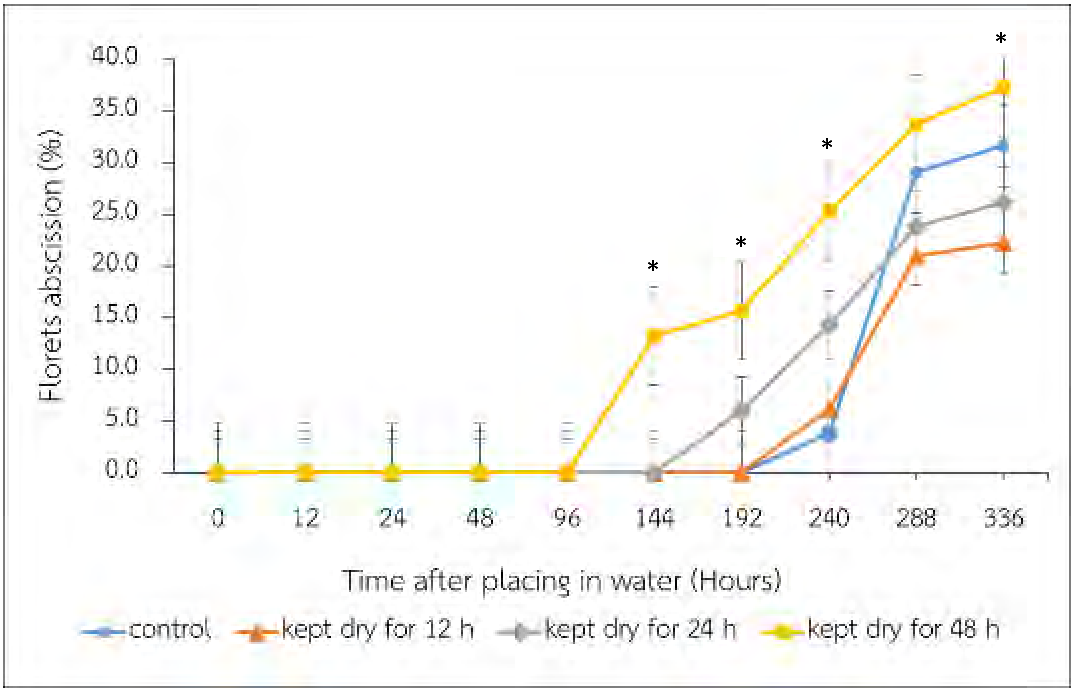

Figure 6 Floret abscission of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at $P \leq 0.05$.

1.4 Open flower quality scores

Open flower quality scores of cut *Dendrobium* 'Suree Peach' flowers showed significant differences among all treatments at 0 hour after placing in water compared to control. However, the scores started to significantly increase in all treatments within 12 hours of placing in water compared with control. After placing in water for 48 hours (day 2), the scores of the treatment which was exposed to water stress for 48 hours was slightly dropped and then started to significantly decrease until the end of vase life compared to control, while other treatments including control remained stable then started to considerably declined from 192 hours (day 8) until the end of vase life (Figure 7, Table A6).

Furthermore, the lowest open flower quality score was observed in the treatment which was exposed to water deficit for 48 hours (Figure 7). The inflorescences which were kept dry for 48 hours had significantly lower open flower quality scores than other treatments from 144-192 hours (day 6-8) after placing in water until the end of vase life (Figure 7, Table A6).

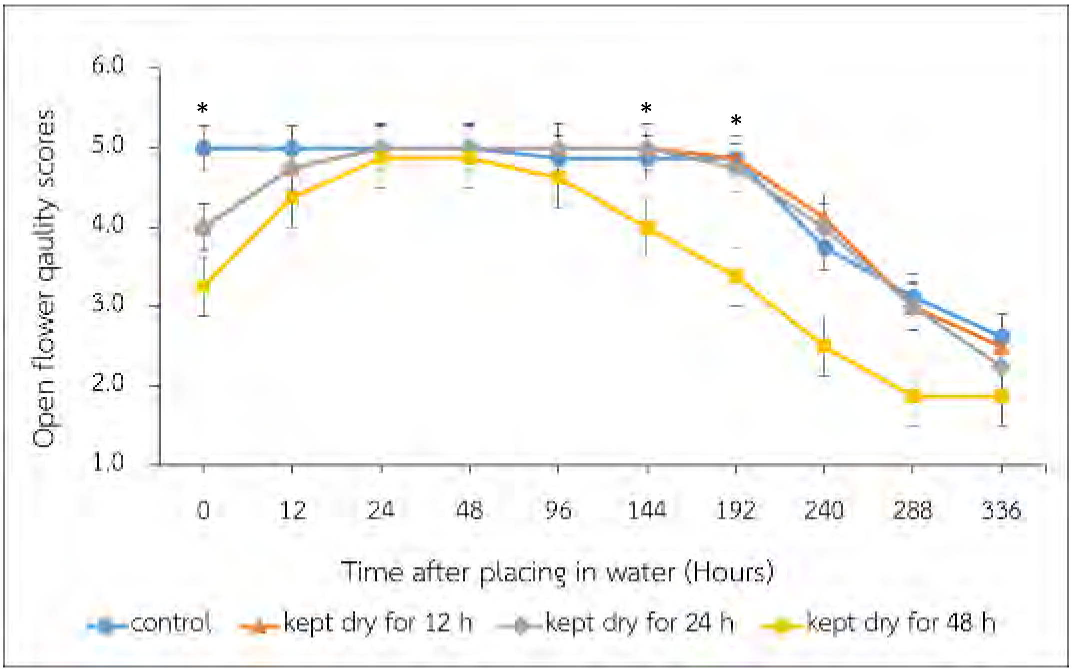

Figure 7 Open flower quality scores of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

1.5 Vase life of cut *Dendrobium* ‘Suree Peach’ flowers

The longest vase life was observed in cut *Dendrobium* ‘Suree Peach’ flowers which were exposed to water deficit for 12 hours, whereas the shortest vase life was observed in the treatment of water deficit for 48 hours. However, there was no significant difference ($P \leq 0.05$) observed in all treatments for vase life of cut flowers (Table 1).

Table 1 Vase life of cut *Dendrobium* ‘Suree Peach’ flowers

Treatments	Vase life (hours ± SE)
Control	324.0 ± 7.9
Kept dry for 12 h	330.0 ± 6.0
Kept dry for 24 h	324.0 ± 7.9
Kept dry for 48 h	312.0 ± 12.8
	ns

ns not significantly different at the 0.05 level.

1.6 The deterioration of the vase life of cut *Dendrobium* 'Suree Peach' flowers

Cut *Dendrobium* 'Suree Peach' flowers which were exposed to water deficit for 12, 24 and 48 hours started to show bending of pedicel symptom (indicated by arrows) after kept dry for 12, 24 and 48 hours respectively, compared to control treatment (Figure 8B). After placing in water for 12 hours, the inflorescences started to recover from water stress. After placing the inflorescences in water for 24 hours, the flower bud of the inflorescences in the treatment which exposed to water stress for 24 hours started to open (Figure 9B), followed by other treatments including control after 48 hours of placing in water (Figure 10A).

The florets of the treatment that were exposed to water deficit for 48 hours started to wilt after 144 hours (day 6) (Figure 11A), while in the treatments which the inflorescences were exposed to water stress for 24 and 12 hours started to show the symptom at 240 hours (day 10) and at 336 hours (day 14) respectively (Figure 12A-13).

After 240 hours (10 days) of placing the inflorescences in water, open flowers of the inflorescences which exposed to water deficit for 48 hours started to drop (Figure 12A), whereas open flowers in the treatment which the inflorescences were exposed to water deficit for 24 hours started to drop at 336 hours (day 14) (Figure 13). However, the open flowers of the treatment which exposed to water deficit for 12 hours and control dropped after 336 hours (day 14) of placing in water (not show).

After day 14 (336 h) of placing all the inflorescences of cut *Dendrobium* 'Suree Peach' in water, the treatments which exposed to water deficit for 24 and 48 hours reached the end of their vase life. On the other hand, the inflorescences which exposed to water deficit for 12 hours still maintained their postharvest quality of the flowers (Figure 13).

Figure 8 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers before treatments (A), and after placing in water 0 hour (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 9 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers after placing in water 12 hours (A) and 24 hours (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

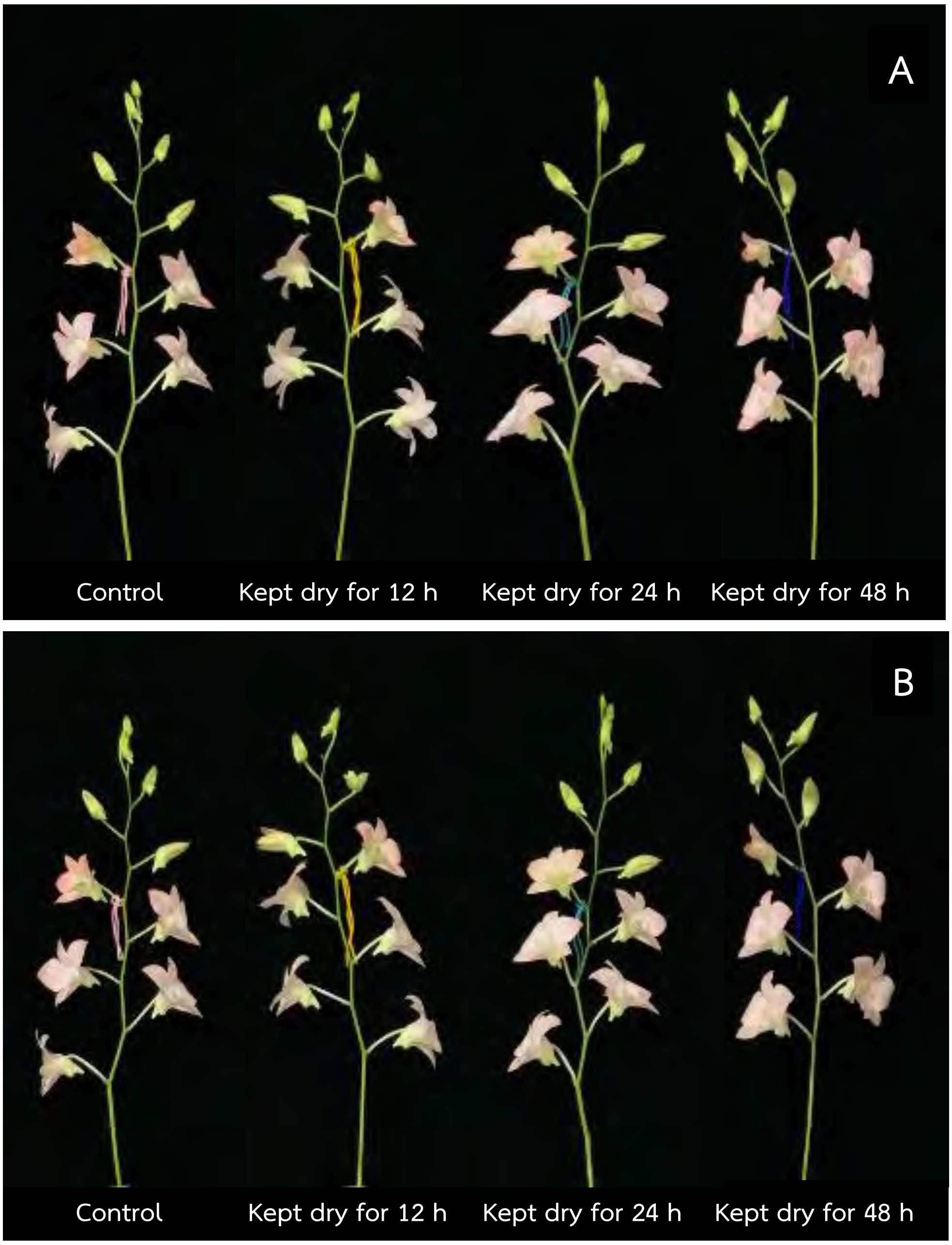

Figure 10 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers after placing in water 48 hours (A) and 96 hours (4 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 11 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers after placing in water 144 hours (6 days) (A) and 192 hours (8 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 12 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers after placing in water 240 hours (10 days) (A) and 288 hours (12 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 13 Inflorescences of cut *Dendrobium* 'Suree Peach' flowers after placing in water 336 hours (14 days) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

2. The effects of postharvest water deficit on quality and vase life of cut *Dendrobium* 'Supinya' flowers

2.1 Color changes of petals

*L** value (lightness) of cut *Dendrobium* 'Supinya' flowers showed significant difference among all treatments from 0-96 hours (day 0-4), and from 192-240 hours (day 8-10) after placing the flowers in water, compared to control. However, the trend of *L** value was increased in all treatments throughout the time then began to decrease at 192 hours (day 8) in the treatments which the flowers were kept dry for 24 and 48 hours (Figure 14, Table A7).

*a** value (red/green value) of the flowers showed significant difference in the treatment which the flowers were kept dry for 48 hours after placing in water from 0 hour until the end of vase life, compared to control. For the flowers which were kept dry for 24 hours had significantly different *a** value from 0-12 hours and from 48-240 hours (day 2-10) when compared to control. There was significantly different in the treatment which the flowers were kept dry for 12 hours from 12-240 hours (day 0-10), compared to control (Figure 15, Table A8).

The flowers which kept dry for 12 hours was significantly different form control for *b** value (blue/yellow value) at 0 hour and from 24-240 hours (day 1-10) after placing in water. There was significantly different for *b** value in the treatment which the flowers were exposed to water deficit for 24 hours from 0-12 hours and from 48-240 hours (day 2-10) after placing in water when compared with control. Moreover, the treatment that the flowers were exposed to water deficit for 48 hours was significantly different *b** value from control from 0-12 hours, 48-96 hours (day 2-4), and 192-240 hours (day 8-10) (Figure 16, Table A9).

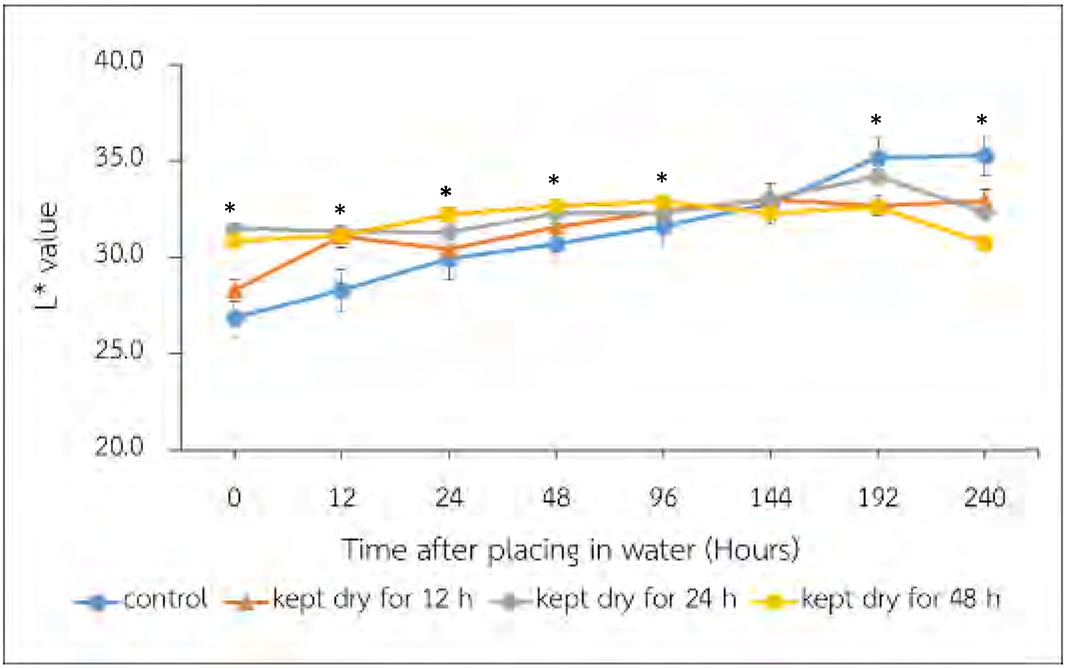

Figure 14 *L** value of petal of cut *Dendrobium* ‘Supinya’ inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).
* Significantly different (LSD) at P ≤ 0.05.

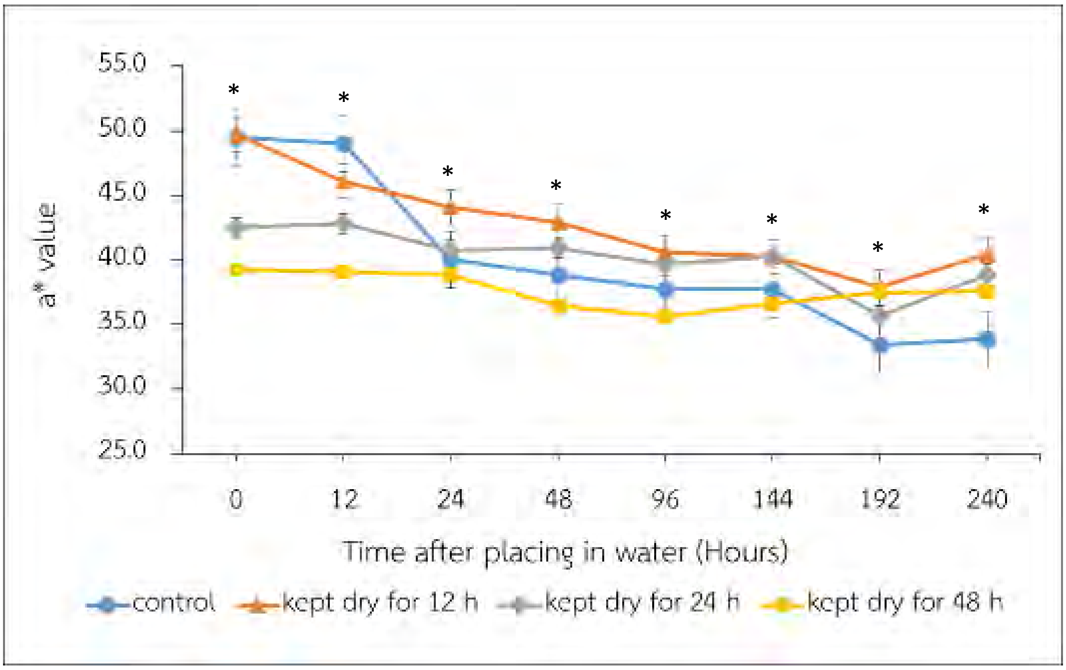

Figure 15 *a** value of petal of cut *Dendrobium* ‘Supinya’ inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).* Significantly different (LSD) at P ≤ 0.05.

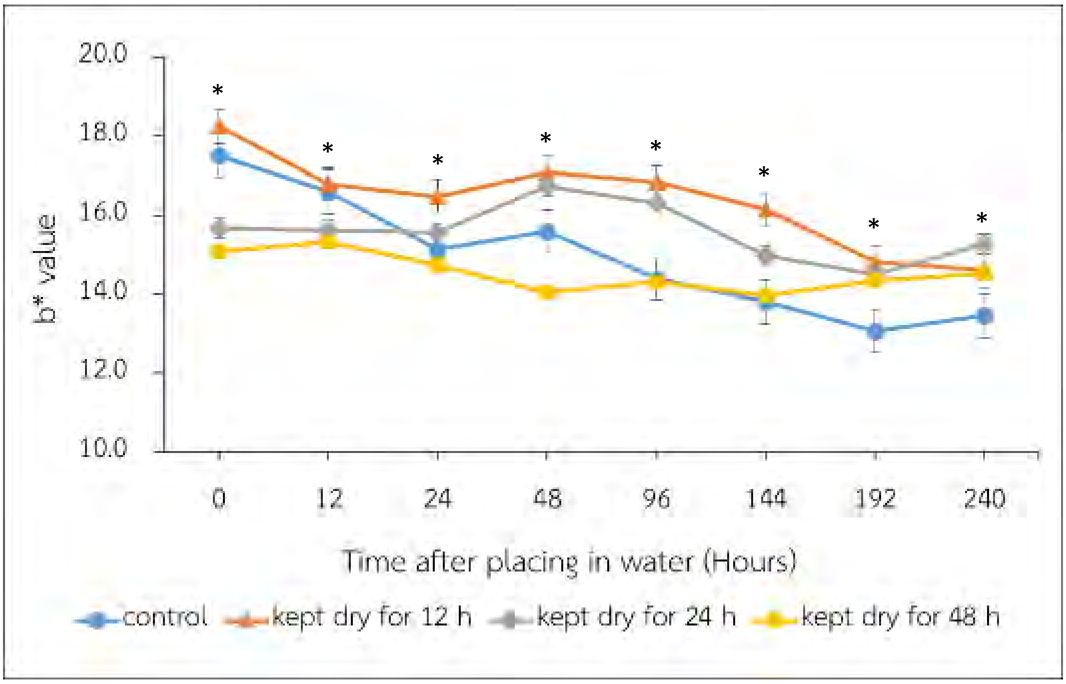

Figure 16 *b** value of petal of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at $P \leq 0.05$.

2.2 Flower bud opening

Flower bud opening of cut *Dendrobium* 'Supinya' flowers which kept dry for 48 hours was significantly higher than control after 48 hours until 192 hours (day 2-8) of placing in water. On the other hand, the flowers which were exposed to water deficit for 12 and 24 hours were not significantly different from control after placing in water from 0 hour until the end of vase life (Figure 17, Table A10).

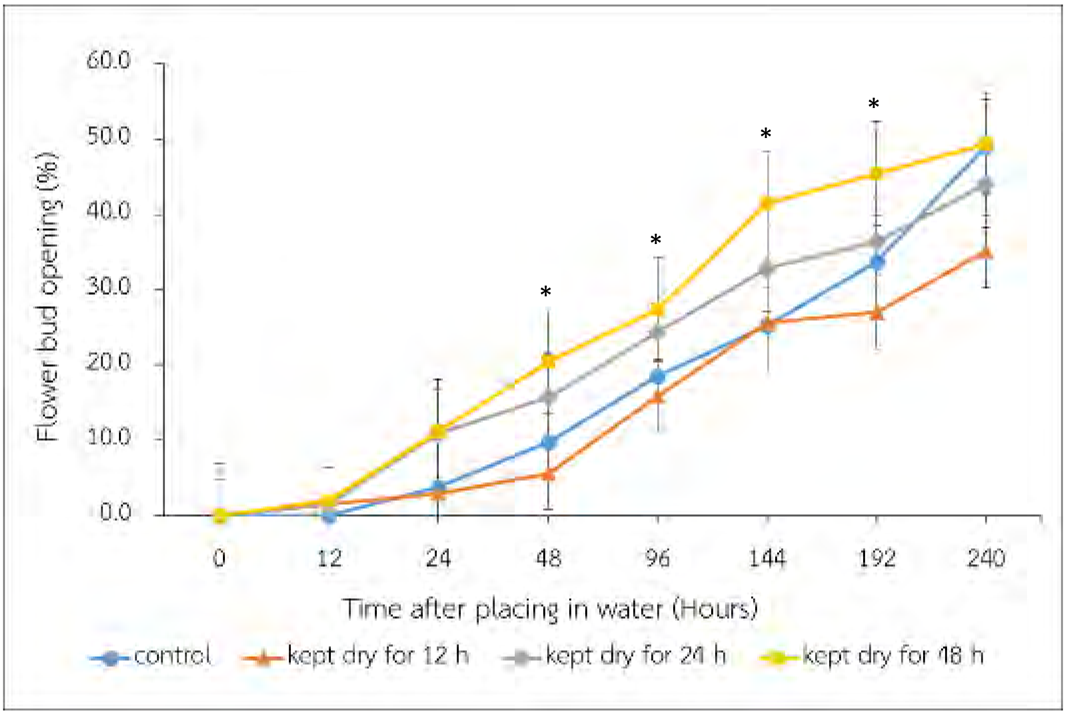

Figure 17 Flower bud opening of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at $P \leq 0.05$.

2.3 Floret abscission

There was a significant difference in percentage of floret abscission between control and the treatments which the flowers were kept dry for 24 and 48 hours after placing the inflorescences in water from 144 hours (day 6) until the end of vase life (240 hours; day 10). In contrast, there was no significant difference between the treatment in which the flowers were kept dry for 12 hours and control. However, the trends of floret abscission of the flowers in all treatments, including control were increased throughout the time of placing in water (Figure 18, Table A11).

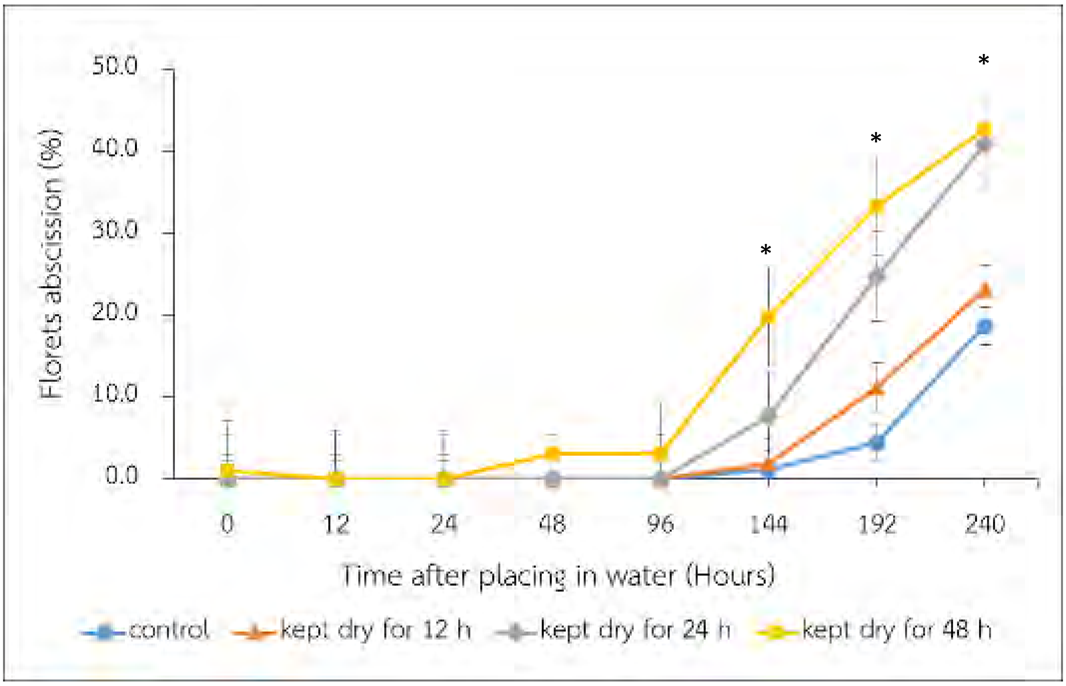

Figure 18 Floret abscission of cut *Dendrobium* ‘Supinya’ inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

2.4 Open flower quality scores

Open flower quality scores of cut *Dendrobium* 'Supinya' flowers was significantly lower than control in all treatments at the beginning of placing in water (0 hour). Although, the scores began to gradually increase in all treatments within 12 hours of placing in water compared with control (Figure 19, Table A12).

After 12 hours of placing the flowers in water, the flowers which kept dry for 12 hours was not significantly different from control until the end of vase life. For the treatment that the flowers were kept dry for 24 hours, the score was significantly different from control again from 96-144 hours (day 4-6). As well as the treatment which kept dry for 48 hours, the score was significantly different from control at the beginning of placing the flowers in water (0 hour) until 144 hours (day 6). However, there was no significant difference in all treatments, including control for open flower quality scores after placing in water from 192-240 hours (day 8-10). In addition, the lowest open flower quality score was observed in the treatment which the flowers were exposed to water deficit for 48 hours (Figure 19, Table A12).

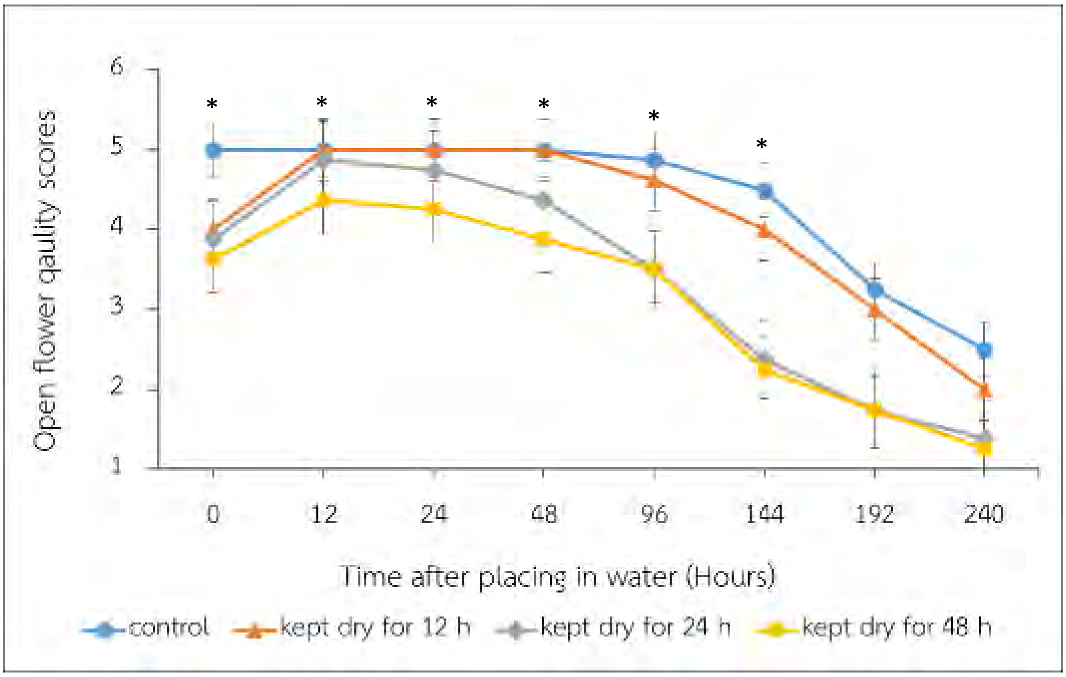

Figure 19 Open flower quality scores of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

2.5 Vase life of cut *Dendrobium* 'Supinya' flowers

The longest vase life of the flowers was observed on the flowers that were exposed to water deficit for 12 hours, followed by the treatments which the flowers were exposed to water deficit for 0 (control), 24, and 48 hours respectively. However, there was no significant difference in all treatments for vase life of cut flowers (Table 2).

Table 2 Vase life of cut *Dendrobium* 'Supinya' flowers

Treatments	Vase life (hours ± SE)
Control	215.0 ± 7.9
Kept dry for 12 h	216.0 ± 9.1
Kept dry for 24 h	210.0 ± 8.8
Kept dry for 48 h	204.0 ± 7.9
	ns

ns not significantly different at the 0.05 level.

2.6 The deterioration of the vase life of cut *Dendrobium* 'Supinya' flowers

Cut *Dendrobium* 'Supinya' flowers that were kept dry for 24 and 48 hours started to show bending of pedicel symptom (indicated by arrows) after they were kept dry for 24 and 48 hours compared to control respectively. In contrast, the flowers in which kept dry for 12 hours did not show the symptom (Figure 20B).

After 12 hours of placing the flowers in water, the flowers which were exposed to water deficit for 24 and 48 hours started to recover from water stress symptom compared to control. Moreover, it was found that flower bud of the inflorescences which were kept dry for 24 hours began to open after placing in water for 24 hours (Figure 21A), followed by the inflorescences which were kept dry for 48 hours and control (Figure 21B).

The florets in which were kept dry for 24 and 48 hours wilted rapidly after placing in water for 96 hours (day 4) (Figure 22) while the florets which were kept dry for 12 hours showed wilting symptom after being placed in water for 144 hours (day 6) (Figure 23A).

The florets that were exposed to water deficit for 48 hours significantly dropped after placing in water for 144 hours (day 6), compared to control (Figure 23A). On the other hand, the florets which were exposed to water deficit for 24 and 12 hours began to drop after placing in water for 192 hours (day 8), compared to control (Figure 23B).

After 240 hours (day 10) of placing the flowers in water, the flowers which were exposed to water deficit for 48 and 24 hours reached the end of vase life (50% of open florets showed senescence symptoms; especially the florets dropped). In contrast, the flowers which exposed to water deficit for 12 hours and control still remained their vase life after 10 days of being placed in water (Figure 24).

Figure 20 Inflorescences of cut *Dendrobium* 'Supinya' flowers before treatments (A), and after placing in water 0 hour (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 21 Inflorescences of cut *Dendrobium* 'Supinya' flowers after placing in water 12 hours (A) and 24 hours (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 22 Inflorescences of cut *Dendrobium* 'Supinya' flowers after placing in water 48 hours (A) and 96 hours (4 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 23 Inflorescences of cut *Dendrobium* 'Supinya' flowers after placing in water 144 hours (6 days) (A) and 192 hours (8 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

Figure 24 Inflorescences of cut *Dendrobium* 'Supinya' flowers after placing in water 240 hours (10 days) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

3. **The effects of postharvest water deficit on quality and vase life of cut *Dendrobium* 'Eia Sakul' flowers**

3.1 Color changes of petals

The petal color, *L** value (lightness), *a** value (red/green value) and *b** value (blue/yellow value) of cut *Dendrobium* 'Eia Sakul' flowers were not significantly different ($P \leq 0.05$) in all treatments after placing in water (Figure 25-27, Table A13-A15).

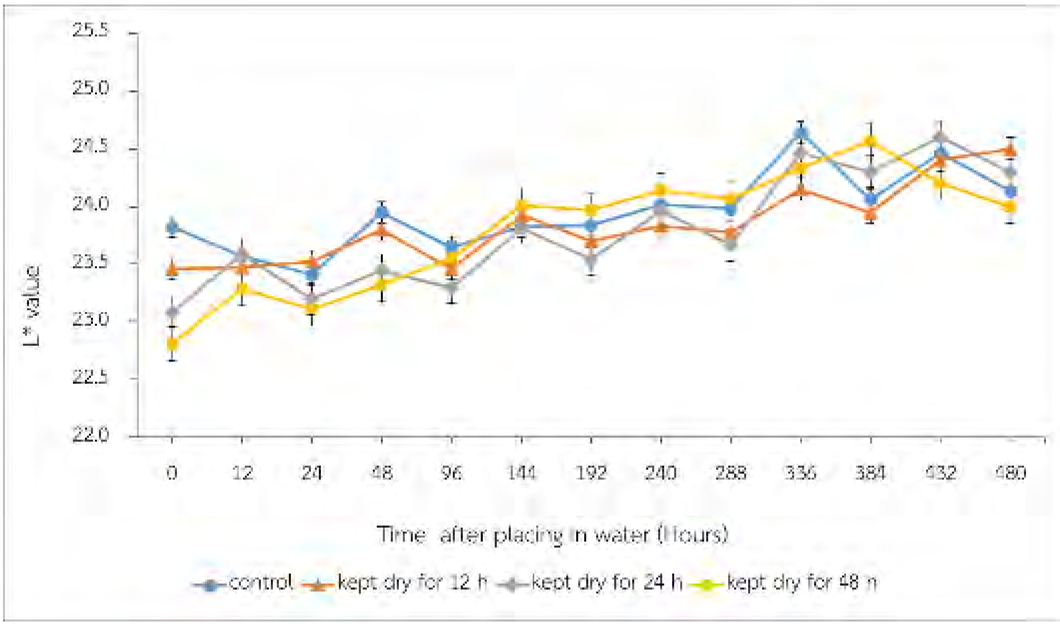

Figure 25 *L** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

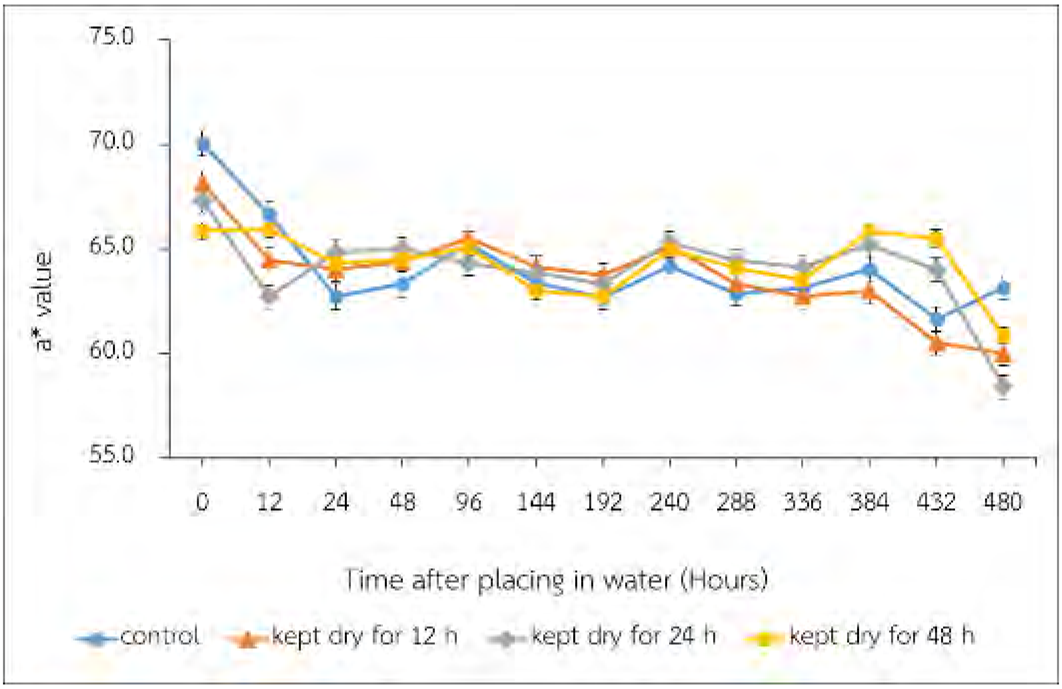

Figure 26 *a** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

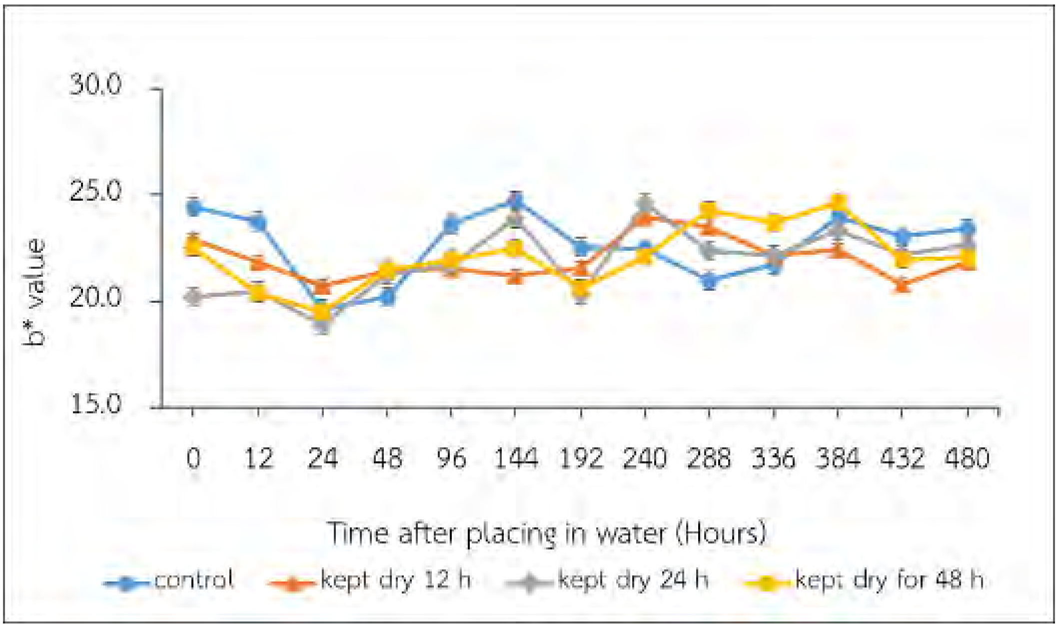

Figure 27 *b** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

3.2 Flower bud opening

Flower bud opening of cut *Dendrobium* 'Eia Sakul' flowers which kept dry for 48 hours was significantly higher than control ($P \leq 0.05$) after placing in water from 12 hours until the end of vase life, whereas the treatments which the flowers were kept dry for 24 hours was not significantly different from control after placing in water from 0 hour until the end of vase life (Figure 28, Table A16).

In addition, the flowers which were exposed to water deficit for 12 hours was not significantly different from control from 0-240 hours (day 10) of placing in water. Although, after 288 hours (day 12) of placing the flowers in water, the flower bud opening started to significantly higher than control until the end of vase life (Figure 28, Table A16).

The percentages of flower bud opening in which the flowers exposed to water stress for 12 and 24 hours were moderately increased after placing in water while the treatment which the flowers exposed to water stress for 48 hours was dramatically increased after placing in water compared to control. The treatment which the flowers exposed to water stress for 48 hours has the highest percentages of flower bud opening (Figure 28, Table A16).

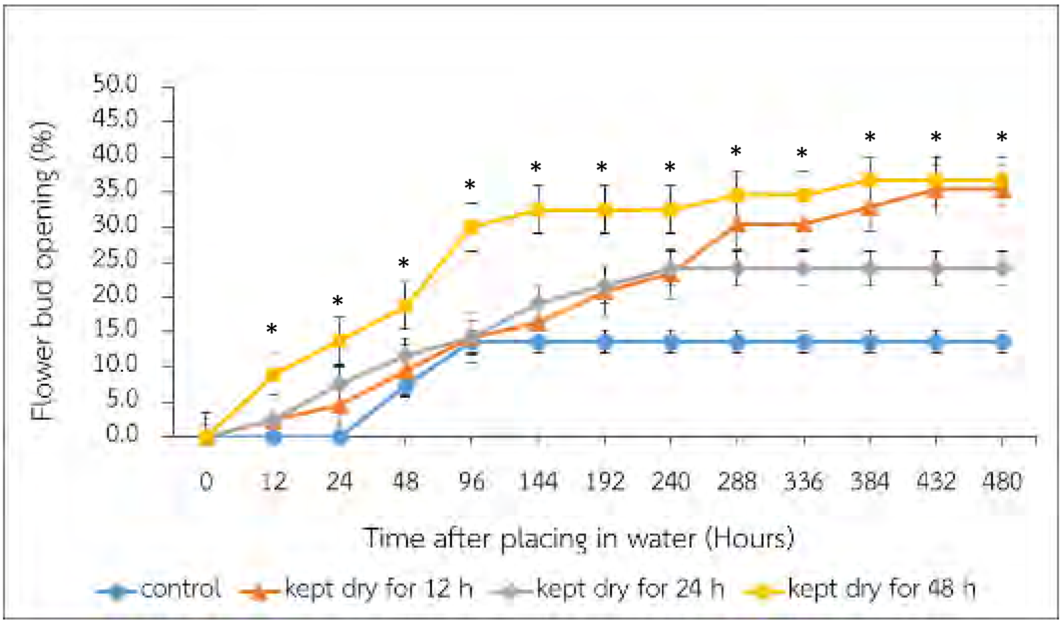

Figure 28 Flower bud opening of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

3.3 Floret abscission

Floret abscission of cut *Dendrobium* ‘Eia Sakul’ flowers which kept dry for 48 hours was significantly higher than control and other treatments ($P \leq 0.05$) at 144 hours (day 6) after placing in water until the end of vase life. On the other hand, the flowers which exposed to water deficit for 12 hours had significantly lower percentages of floret abscission than control and other treatments from 336-384 hours (day 14-16) after placing in water until the end of vase life. Furthermore, the percentages of florets abscission in all treatments were increased after placing in water until the end of vase life, especially the treatment which the flowers exposed to water deficit for 48 hours has highest percentages of florets abscission, followed by the treatments which the flowers exposed to water deficit for 24 and 12 hours respectively (Figure 29, Table A17).

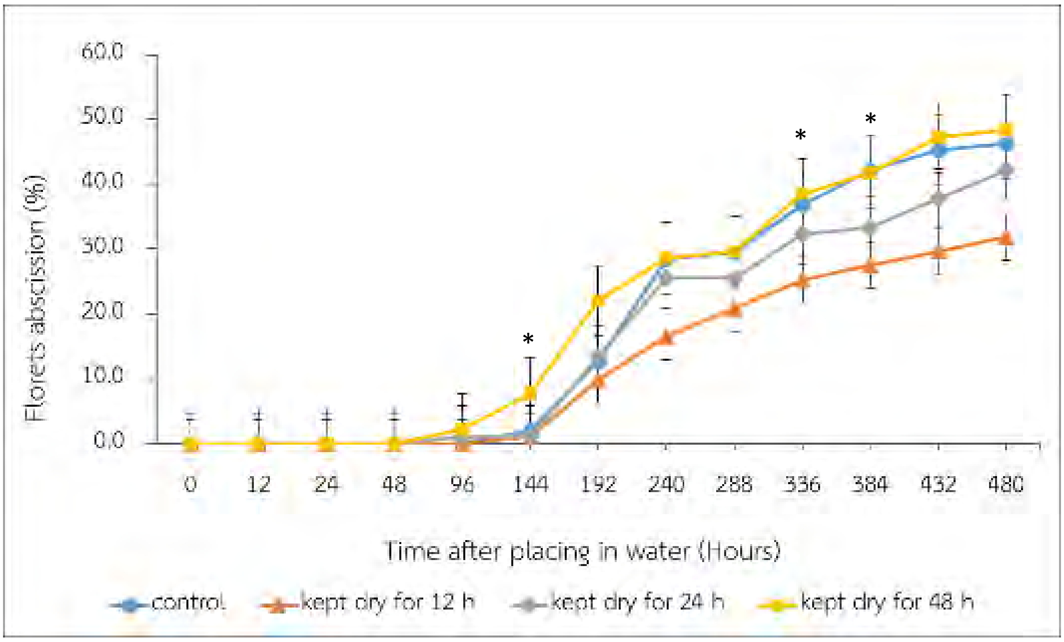

Figure 29 Floret abscission of cut *Dendrobium* ‘Eia Sakul’ inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at $P \leq 0.05$.

3.4 Open flower quality scores

The open flowers quality scores of cut *Dendrobium* 'Eia Sakul' flowers were decreased in all treatments after placing in water. The scores in all treatments were significantly lower than control ($P \le 0.05$) after placing in water for 0 hour (day 0). As well as in the treatments which the flowers were kept dry for 24 and 48 hours, the scores were significantly lower than control at 192 hours (day 8) after placing in water. However, the inflorescences in all treatment could recover from water deficit by increasing the open flower quality scores within 12 hours of refreshing in water.

Moreover, the open flower quality scores in the treatment which the flowers were exposed to water stress for 48 hours started to dramatically decrease after 24 hours of placing in water while the treatments which the flowers were exposed to water stress for 12 and 24 hours, including control started to dramatically decline from 48 hours (day 2) until the end of vase life. In addition, the lowest open flower quality scores was observed in the treatment which the flowers were kept dry for 48 hours (Figure 30, Table A18).

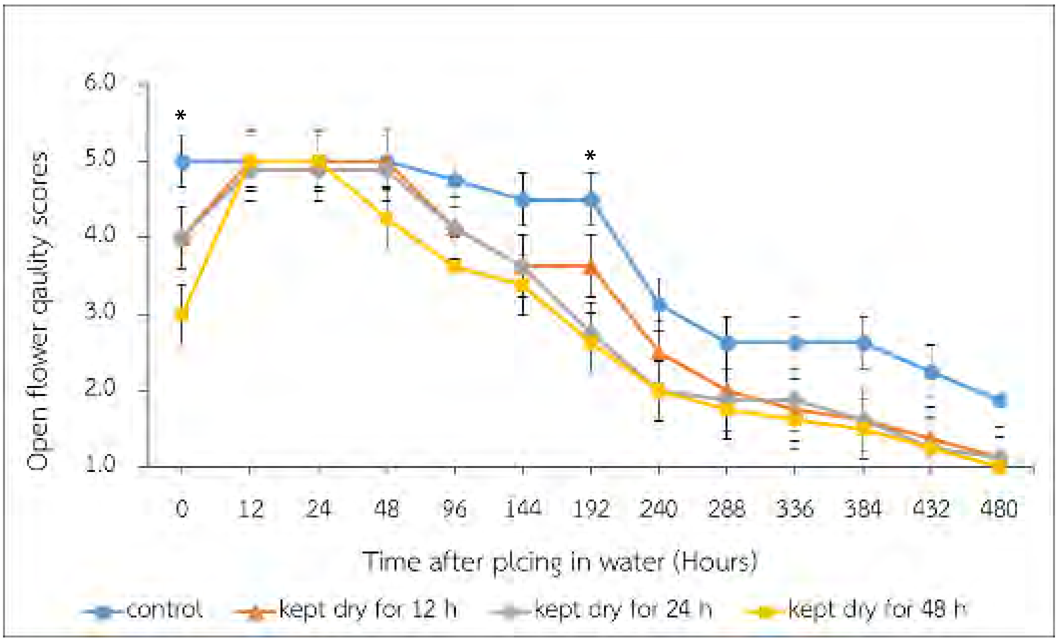

Figure 30 Open flower quality scores of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days (mean ± SE).

* Significantly different (LSD) at P ≤ 0.05.

3.5 Vase life of cut *Dendrobium* 'Eia Sakul' flowers

The longest vase life was observed in cut *Dendrobium* 'Eia Sakul' flowers which kept dry for 12 hours. Whereas, the shortest vase life was observed in the treatment which kept dry for 24 hours. However, there was no significant difference ($P \leq 0.05$) observed in the vase life of cut *Dendrobium* 'Eia Sakul' flowers in all treatments (Table 3).

Table 3 Vase life of cut *Dendrobium* 'Eia Sakul' flowers

Treatments	Vase life (hours ± SE)
Control	408.0 ± 35.1
Kept dry for 12 h	426.0 ± 30.7
Kept dry for 24 h	372.0 ± 28.3
Kept dry for 48 h	384.0 ± 36.3
	ns

ns not significantly different at the 0.05 level.

3.6 The deterioration of the vase life of cut *Dendrobium* 'Eia Sakul' flowers

Cut *Dendrobium* 'Eia Sakul' flowers which exposed to water deficit for 12, 24 and 48 hours started to show the bending of pedicel symptom (indicated by arrows) after placing in water for 0 hour compared to control (Figure 31B). After placing in water for 12 hours, the inflorescences started to recover from water deficit and the flower bud of the inflorescence which exposed to water deficit for 48 hours started to open (Figure 32A).

The flowers of all treatments including control started to show wilting symptom and the flower buds of the treatment which exposed to water deficit for 48 hours started to drop after placing in water at 144 hours (day 6) (Figure 34A).

After placing in water for 10 days (240 h), open flower of the inflorescence which exposed to water deficit for 48 hours and control started to drop (Figure 35A).

After 288 hours (day 12) of placing all the inflorescences in the water, the treatments which exposed to water deficit for 24 and 48 hours including control reached the end of their vase life. On the other hand, the inflorescences which exposed to water deficit for 12 hours still maintained their postharvest quality (Figure 35B).

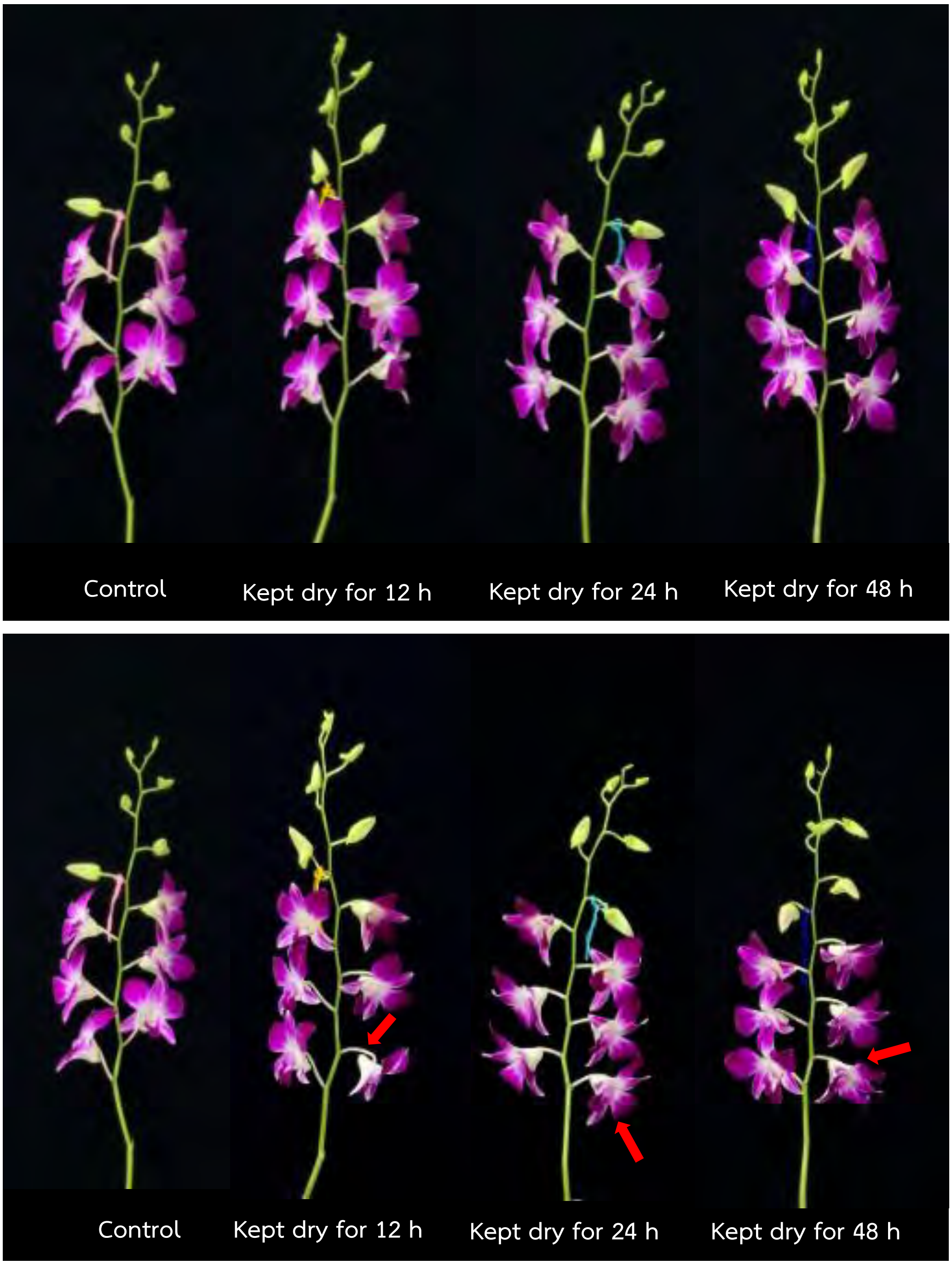

Figure 31 Inflorescences of cut *Dendrobium* 'Eia Sakul' flowers before treatments (A), and after placing in water 0 hour (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

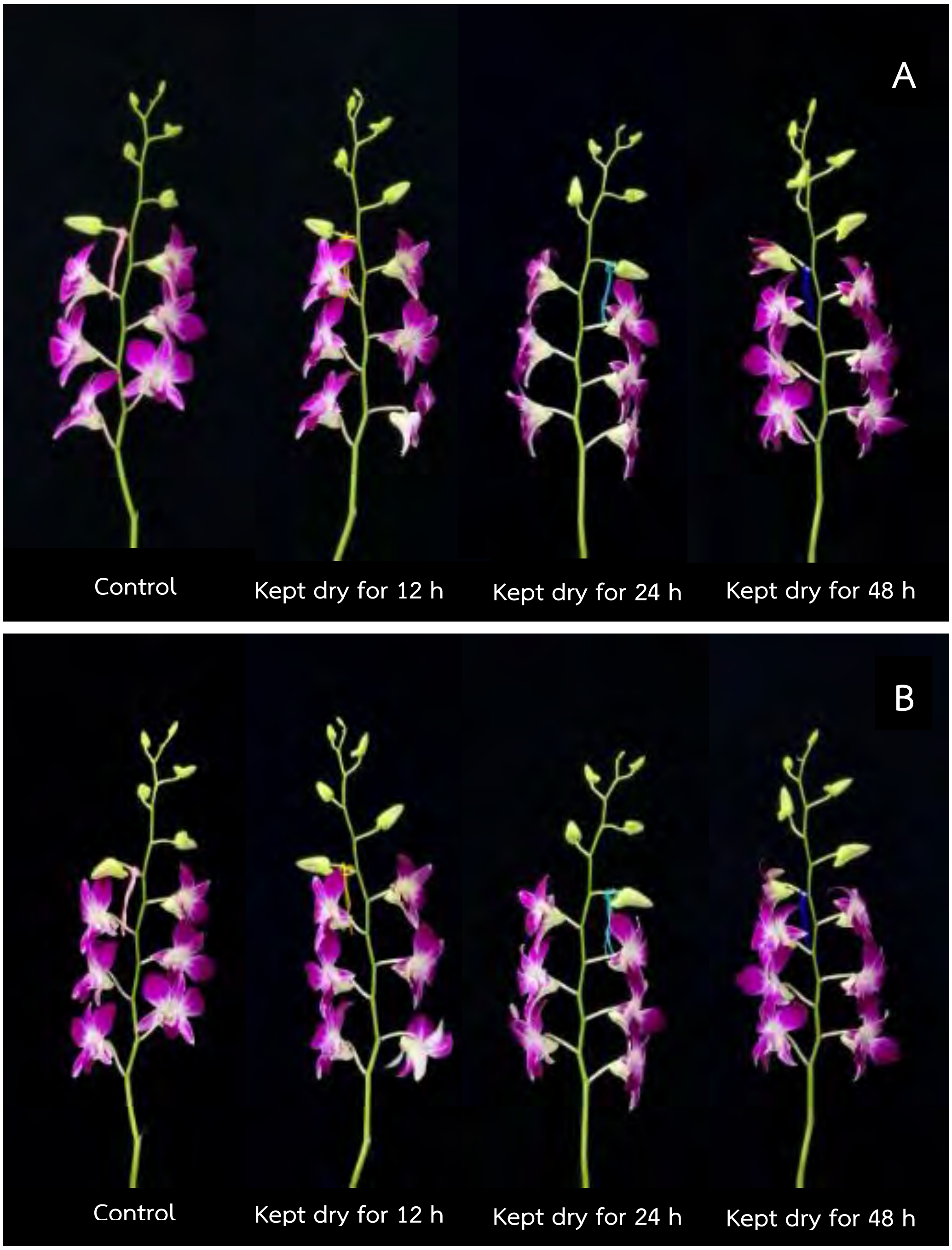

Figure 32 Inflorescences of cut *Dendrobium* 'Eia Sakul' flowers after placing in water 12 hour (A) and 24 hours (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

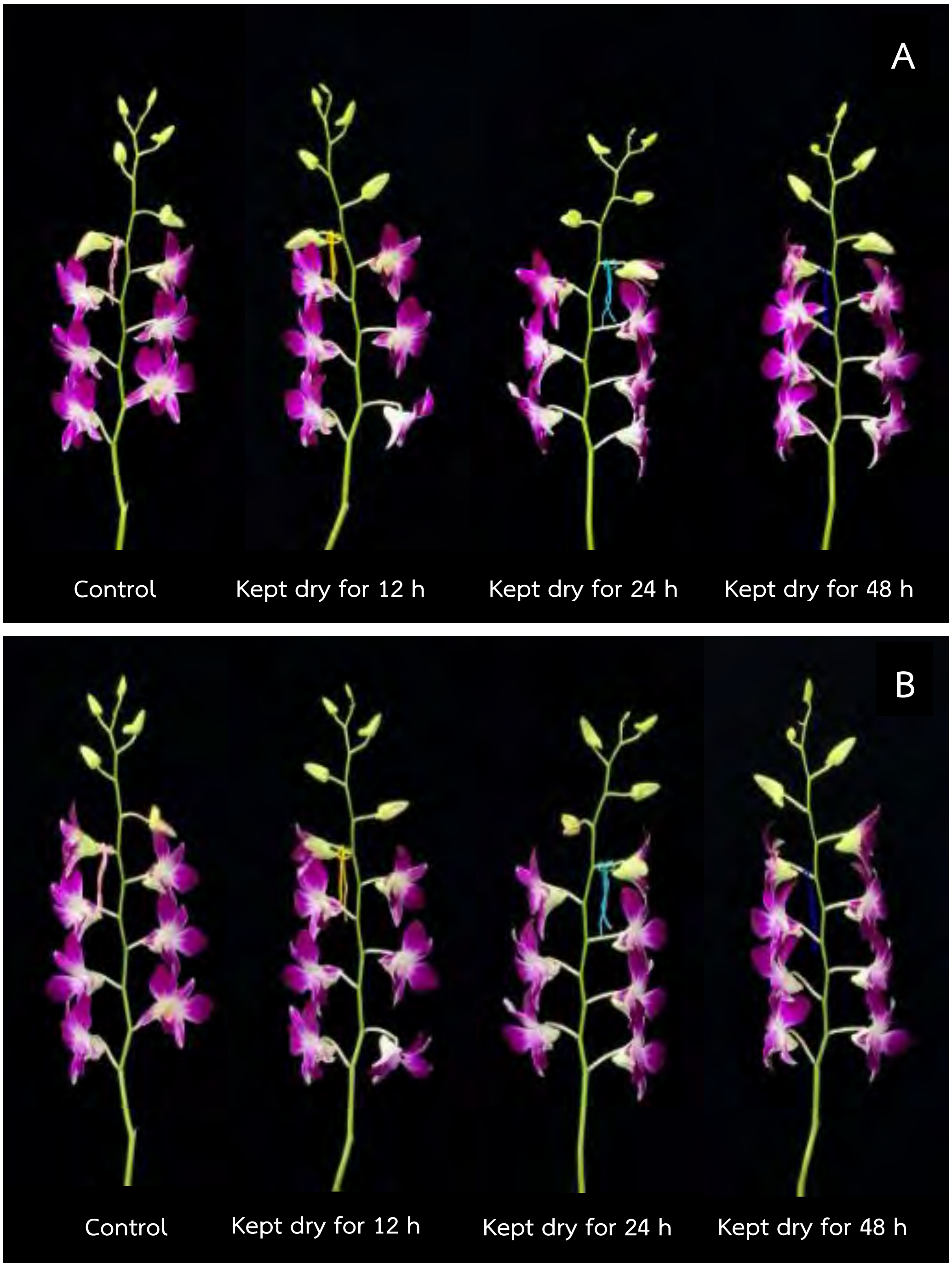

Figure 33 Inflorescences of cut *Dendrobium* 'Eia Sakul' flowers after placing in water 48 hours (A) and 96 hours (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

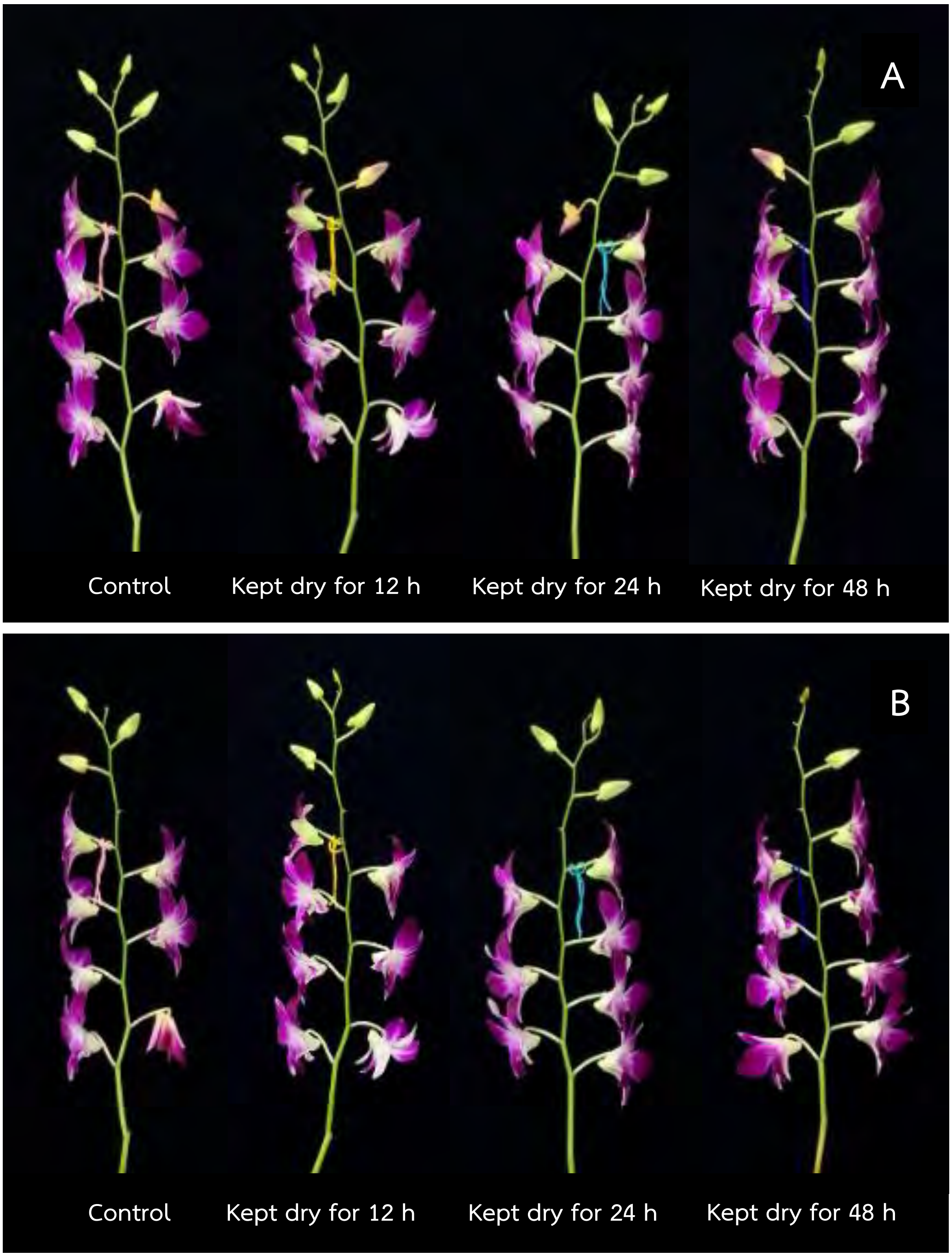

Figure 34 Inflorescences of cut *Dendrobium* 'Eia Sakul' flowers after placing in water 144 hours (6 days) (A) and 192 hours (8 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

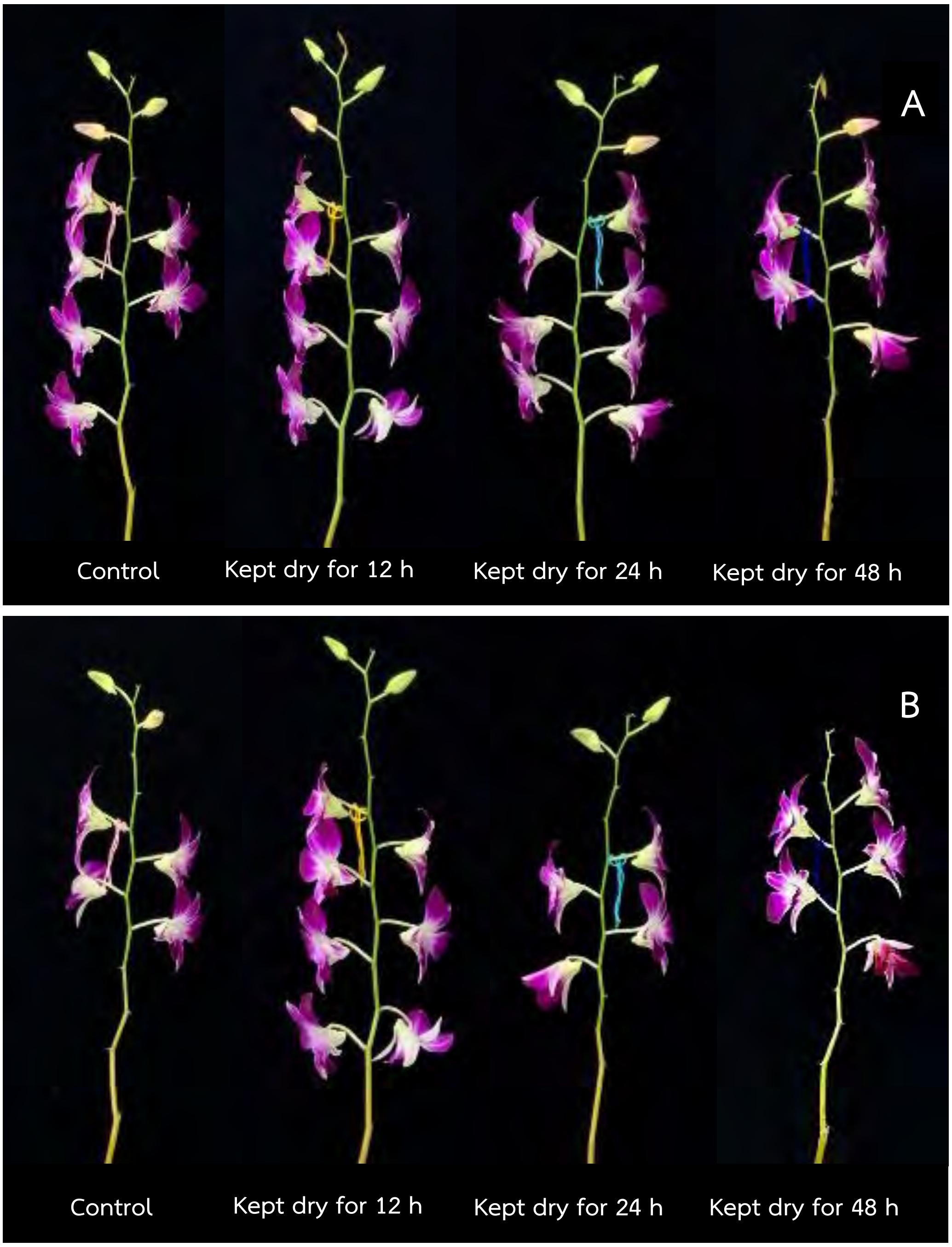

Figure 35 Inflorescences of cut *Dendrobium* 'Eia Sakul' flowers after placing in water 240 hours (10 days) (A) and 288 hours (12 days) (B) of control and the treatments which kept dry for 12, 24 and 48 hours respectively.

CHAPTER 5
DISCUSSION

1. Petal color

Our results revealed that water deficit of cut *Dendrobium* 'Suree Peach' and 'Supinya' flowers after harvest had little effect on petal color. Whereas, in *Dendrobium* 'Eia Sakul' flowers, water deficit had no effect on petal color. Water deficit had different effects on all cultivars could be because *Dendrobium* 'Eia Sakul' was more tolerant to water deficit than *Dendrobium* 'Suree Peach' and "Supinya'. However, water stress may affect petal color due to ethylene which was produced when flowers were exposed to water stress. In addition, Khunmuang et al. (2019) reported that ethylene could induce a rapid anthocyanin degradation of petal of cut *Vanda* 'Sansai Blue' flowers, eventually led to petal color change and flower senescence. Along with the study on *Brunfelsia calycina*, anthocyanin was degraded, resulting in a change of flower color from dark purple to white (Oren-Shamir, 2009).

2. Flower bud opening

In this study, the results showed that water deficit of *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers had affected flower bud opening. The flower buds which were exposed to water deficit for 48 hours had significantly higher percentages of flower bud opening than the flowers which were exposed to water deficit for 24 and 12 hours in all cultivars. The opening of flower buds in all *Dendrobium* orchid cultivars could be ethylene-stimulated due to water stress. These results were along with Reid et al. (1989), and Yamamoto (1994) studies, which suggested that the flower opening was affected by ethylene caused by water stress and that the effects of ethylene depended on cultivars.

Additionally, Ketsa and Thampitakorn (1995) reported that flower buds of *Dendrobium* orchid flower produced more ethylene than the opened florets.

3. Floret abscission

This study indicated that water deficit had an effect on the abscission of florets in all cultivars; cut flowers of *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul'. The highest percentages of florets abscission were observed on the inflorescences which were exposed to water deficit for 48 hours in all cultivars. According to early studies, water stress caused ethylene to be produced in flowers such as carnation and valencia orange flowers, eventually led to the abscission of flowers (Ben-Yehoshua and Aloni, 1974; Yakimova and Woltering, 1997). This occurrence was after rehydration of the flowers or other plant organs (Tudela and Primo-Millo, 1992). Furthermore, Woltering and van Doorn (1988) further reported that ethylene controlled floret abscission and petal life of roses is usually limited by abscission that is controlled by ethylene.

4. Open flowers quality scores

The results of this study represented that water deficit had affected open flower quality scores of cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers. Inflorescences which were exposed to water deficit for 12 and 48 hours were observed in all cultivars with the highest and lowest open flower quality scores respectively. Nonetheless, the inflorescences of cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers could recover from water deficit within 12 hours of rehydration with open flower quality scores. These results were along with early studies of Wangstaff et al. (2010) on cut alstroemeria flowers, which suggested that the flowers were able to recover with full turgor from water stress after being refreshed in water.

5. Vase life of cut *Dendrobium* flowers

The longest vase life and the best flower quality of cut *Dendrobium* flowers in all cultivars was observed in the flowers which were exposed to water deficit for 12 hours. In contrast, the shortest vase life was observed in the flowers that were exposed to water deficit for 48 hours in all cultivars. However, no significant differences were found in all treatments of all cultivars. Consequently, the results showed that water deficit has little effect on the vase life of cut *Dendrobium* orchid flowers.

The effect of water deficit on quality and vase life of cut *Dendrobium* flowers, petal color, flower bud opening, florets abscission, and open flower quality scores were observed. The flowers in all cultivars; *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' were responded to water deficit by increasing the percentages of flower bud opening and floret abscission which could be a result of high ethylene production, eventually led to early senescence of the flowers, and decreased open flower quality scores resulting in the end of their vase life.

CHAPTER 6
CONCLUSION

In conclusion, water deficit affected quality and vase life of postharvest cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers by increasing flower bud opening and floret abscission and decreasing open flower quality scores. Whereas, water deficit had only a small effect on petal color changes of the flowers. However, in the flowers which were exposed to water deficit for 12 hours in all cultivars had the longest vase life and the best flower quality compared with the flowers which exposed to water deficit for 24 and 48 hours. Therefore, keeping the inflorescences dry if needed after harvest up to 12 hours before packing in water tube for transport or export to local market could be considered as one way to maintain quality and vase life of cut *Dendrobium* 'Suree Peach', 'Supinya' and 'Eia Sakul' flowers.

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Appendix

1. **The vase life of cut *Dendrobium* flowers was terminated when these senescence symptoms occur 50% of the open florets (In et al., 2017).**

Figure A1 Bending of the pedicel (bent-neck; neck angle greater than 45°) and wilting of floret

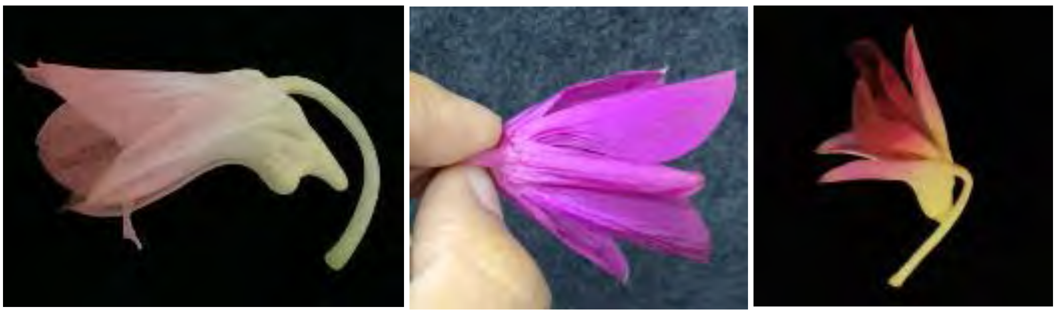

Figure A2 Closed flower or floret dropped

Figure A3 Obvious line on petal and sepal

Table A1 *L** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*L** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	68.61 ± 0.73	69.78 ± 0.61	68.53 ± 0.48	68.55 ± 0.61	ns
12 h	67.98 ± 0.91^{a}	68.93 ± 0.61^{ab}	68.93 ± 0.44^{ab}	70.00 ± 0.42^{b}	*
24 h	67.53 ± 0.88^{a}	68.85 ± 0.66^{ab}	69.19 ± 0.26^{ab}	69.63 ± 0.54^{b}	*
48 h	69.66 ± 0.49^{a}	67.89 ± 0.40^{b}	68.81 ± 0.18^{ab}	68.99 ± 0.73^{ab}	*
96 h	69.05 ± 0.58	69.03 ± 0.61	69.89 ± 0.44	68.38 ± 0.85	ns
144 h	68.61 ± 0.64^{a}	70.73 ± 0.40^{b}	70.29 ± 0.35^{b}	69.11 ± 0.41^{a}	*
192 h	69.18 ± 0.39^{a}	70.50 ± 0.35^{b}	70.49 ± 0.08^{b}	69.46 ± 0.46^{a}	*
240 h	68.71 ± 0.70^{a}	70.81 ± 0.38^{b}	69.99 ± 0.21^{b}	69.66 ± 0.10^{ab}	*
288 h	70.02 ± 0.09^{ac}	70.40 ± 0.12^{a}	71.42 ± 0.38^{b}	69.50 ± 0.27^{c}	*
336 h	69.94 ± 0.36^{a}	70.82 ± 0.25^{ab}	71.24 ± 0.35^{b}	71.50 ± 0.15^{b}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A2 *a** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	***a** value**				
	control	**Kept dry for 12 h**	**Kept dry for 24 h**	**Kept dry for 48 h**	
0 h	14.00 ± 0.76	14.33 ± 0.69	14.14 ± 0.48	14.44 ± 0.51	ns
12 h	14.84 ± 0.77[a]	13.93 ± 0.42[a]	14.21 ± 0.58[a]	13.24 ± 0.30[b]	*
24 h	13.90 ± 0.76	12.85 ± 0.43	13.23 ± 0.50	14.33 ± 0.44	ns
48 h	13.08 ± 0.52	13.54 ± 0.44	13.30 ± 0.54	13.04 ± 0.37	ns
96 h	13.54 ± 0.53	13.55 ± 0.43	12.54 ± 0.55	12.84 ± 0.21	ns
144 h	12.38 ± 0.38	11.70 ± 0.35	11.85 ± 0.40	12.36 ± 0.16	ns
192 h	12.48 ± 0.27[a]	11.19 ± 0.32[b]	11.66 ± 0.21[ab]	12.26 ± 0.38[a]	*
240 h	12.86 ± 0.21[a]	11.47 ± 0.15[b]	11.53 ± 0.26[b]	12.07 ± 0.21[b]	*
288 h	12.28 ± 0.40[a]	11.77 ± 0.21[ab]	11.28 ± 0.10[b]	11.88 ± 0.22[ab]	*
336 h	11.80 ± 0.18[a]	11.94 ± 0.30[a]	11.52 ± 0.27[a]	12.60 ± 0.12[b]	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A3 *b** value of petal of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*b** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	3.38 ± 0.20^{a}	3.89 ± 0.18^{a}	4.51 ± 0.20^{b}	3.36 ± 0.21^{a}	*
12 h	4.04 ± 0.18^{ab}	4.36 ± 0.23^{a}	3.90 ± 0.15^{ab}	3.66 ± 0.20^{b}	*
24 h	3.80 ± 0.27	3.80 ± 0.15	3.43 ± 0.30	3.55 ± 0.13	ns
48 h	3.50 ± 0.21	3.61 ± 0.12	3.35 ± 0.13	3.23 ± 0.18	ns
96 h	3.05 ± 0.15^{a}	3.05 ± 0.15^{a}	2.89 ± 0.15^{a}	3.61 ± 0.15^{b}	*
144 h	3.84 ± 0.21	3.03 ± 0.17	3.45 ± 0.15	4.01 ± 0.22	ns
192 h	4.13 ± 0.22^{ac}	3.50 ± 0.17^{b}	3.48 ± 0.14^{ab}	4.16 ± 0.27^{c}	*
240 h	4.01 ± 0.27	4.07 ± 0.22	4.39 ± 0.18	4.56 ± 0.04	ns
288 h	3.62 ± 0.29	3.67 ± 0.10	3.92 ± 0.21	3.68 ± 0.31	ns
336 h	3.36 ± 0.30^{a}	3.84 ± 0.15^{ab}	3.30 ± 0.09^{a}	4.30 ± 0.06^{b}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A4 Flower bud opening of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Flower bud opening (%)				
	control	**Kept dry for 12 h**	**Kept dry for 24 h**	**Kept dry for 48 h**	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
12 h	0.00 ± 0.00	0.00 ± 0.00	2.09 ± 2.09	2.09 ± 2.09	ns
24 h	0.00 ± 0.00[a]	0.00 ± 0.00[a]	12.04 ± 2.71[b]	5.96 ± 2.92[c]	*
48 h	12.94 ± 2.85	16.63 ± 0.83	14.11 ± 3.80	10.14 ± 2.98	ns
96 h	15.03 ± 2.18	18.41 ± 1.64	16.20 ± 3.22	15.56 ± 4.19	ns
144 h	17.53 ± 0.54	20.91 ± 3.18	16.20 ± 3.22	21.70 ± 3.90	ns
192 h	22.10 ± 3.26	24.78 ± 3.26	17.99 ± 3.55	26.29 ± 5.48	ns
240 h	22.10 ± 3.26	27.28 ± 3.67	22.28 ± 4.51	30.45 ± 6.00	ns
288 h	22.10 ± 3.26	29.06 ± 3.17	22.28 ± 4.51	30.45 ± 6.00	ns
336 h	22.10 ± 3.26	29.06 ± 3.17	24.78 ± 6.26	30.45 ± 6.00	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \le 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \le 0.05$, respectively.

Table A5 Floret abscission of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Floret abscission (%)				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
12 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
24 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
48 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.28 ± 2.28	ns
96 h	0.00 ± 0.00	0.00 ± 0.00	1.25 ± 1.25	2.43 ± 1.61	ns
144 h	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]	13.20 ± 4.05[b]	*
192 h	0.00 ± 0.00[a]	0.00 ± 0.00[a]	6.05 ± 2.48[a]	15.50 ± 4.44[b]	*
240 h	3.75 ± 2.63[a]	5.94 ± 3.46[a]	14.71 ± 4.17[ab]	24.99 ± 5.25[b]	*
288 h	29.30 ± 4.23	20.76 ± 3.90	24.04 ± 5.18	33.63 ± 5.58	ns
336 h	39.30 ± 2.37[a]	27.81 ± 4.16[b]	34.64 ± 3.55[ab]	42.01 ± 3.10[a]	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A6 Open flower quality scores of cut *Dendrobium* 'Suree Peach' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Open flower quality score				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	5.00 ± 0.00^{a}	4.00 ± 0.00^{b}	4.00 ± 0.00^{b}	3.25 ± 0.16^{b}	*
12 h	5.00 ± 0.00	4.75 ± 0.16	4.75 ± 0.16	4.38 ± 0.18	ns
24 h	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00	4.88 ± 0.13	ns
48 h	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00	4.88 ± 0.13	ns
96 h	4.88 ± 0.13	5.00 ± 0.00	5.00 ± 0.00	4.63 ± 0.18	ns
144 h	4.88 ± 0.13^{ab}	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}	4.00 ± 0.33^{b}	*
192 h	4.88 ± 0.13^{ab}	4.88 ± 0.13^{a}	4.75 ± 0.16^{a}	3.38 ± 0.50^{b}	*
240 h	3.75 ± 0.49	4.13 ± 0.52	4.00 ± 0.57	2.50 ± 0.60	ns
288 h	3.13 ± 0.52	3.00 ± 0.53	3.00 ± 0.76	1.88 ± 0.58	ns
336 h	2.63 ± 0.50	2.50 ± 0.53	2.25 ± 0.49	1.88 ± 0.58	ns

Means within a row followed by different letters indicate significant differences between treatments, using Kruskal-Wallis test. Means were compared using least significant difference (LSD) at $P \leq 0.05$.

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively (Kruskal- Wallis test).

Table A7 *L** value of petal of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*L** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	26.86 ± 0.09^{a}	28.29 ± 0.16^{b}	31.54 ± 0.07^{c}	30.84 ± 0.32^{d}	*
12 h	28.30 ± 0.27^{a}	31.08 ± 0.34^{b}	31.34 ± 0.18^{b}	31.15 ± 0.30^{b}	*
24 h	29.94 ± 0.17^{a}	30.44 ± 0.22^{a}	31.28 ± 0.22^{b}	32.24 ± 0.24^{c}	*
48 h	30.68 ± 0.21^{a}	31.59 ± 0.33^{b}	32.29 ± 0.17^{c}	32.66 ± 0.12^{c}	*
96 h	31.64 ± 0.18^{a}	32.40 ± 0.25^{b}	32.29 ± 0.32^{ab}	32.86 ± 0.09^{b}	*
144 h	32.75 ± 0.27	32.99 ± 0.31	33.02 ± 0.13	32.28 ± 0.34	ns
192 h	35.16 ± 0.15^{a}	32.68 ± 0.21^{b}	34.18 ± 0.40^{c}	32.60 ± 0.21^{b}	*
240 h	35.30 ± 0.48^{a}	32.93 ± 0.38^{b}	32.33 ± 0.09^{b}	30.77 ± 0.15^{c}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A8 *a** value of petal of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*a** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	49.55 ± 0.52^{a}	49.74 ± 0.38^{a}	42.50 ± 0.44^{b}	39.24 ± 0.31^{c}	*
12 h	49.04 ± 0.55^{a}	46.11 ± 0.73^{b}	42.80 ± 0.19^{c}	39.06 ± 0.23^{d}	*
24 h	40.01 ± 0.23^{a}	44.09 ± 0.30^{b}	40.73 ± 0.34^{a}	38.84 ± 0.19^{c}	*
48 h	38.85 ± 0.54^{a}	42.93 ± 0.58^{b}	40.94 ± 0.43^{c}	36.46 ± 0.12^{d}	*
96 h	37.71 ± 0.12^{a}	40.60 ± 0.29^{b}	39.64 ± 0.19^{c}	35.55 ± 0.30^{d}	*
144 h	37.75 ± 0.17^{a}	40.26 ± 0.33^{b}	40.26 ± 0.23^{c}	36.63 ± 0.19^{d}	*
192 h	33.40 ± 0.16^{a}	37.85 ± 0.20^{b}	35.65 ± 0.25^{c}	37.50 ± 0.25^{b}	*
240 h	33.88 ± 0.19^{a}	40.43 ± 0.39^{b}	38.87 ± 0.09^{c}	37.57 ± 0.20^{d}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \le 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \le 0.05$, respectively.

Table A9 *b** value of petal of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*b** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	17.51 ± 0.41^{a}	18.24 ± 0.19^{b}	15.66 ± 0.16^{c}	15.08 ± 0.14^{c}	*
12 h	16.59 ± 0.26^{a}	16.79 ± 0.18^{a}	15.63 ± 0.10^{b}	15.31 ± 0.13^{b}	*
24 h	15.14 ± 0.20^{a}	16.48 ± 0.11^{b}	15.55 ± 0.15^{a}	14.75 ± 0.12^{a}	*
48 h	15.59 ± 0.14^{a}	17.09 ± 0.16^{b}	16.73 ± 0.36^{b}	14.05 ± 0.12^{c}	*
96 h	14.39 ± 0.47^{a}	16.83 ± 0.19^{b}	16.30 ± 0.38^{b}	14.31 ± 0.12^{b}	*
144 h	13.80 ± 0.13^{a}	16.14 ± 0.31^{b}	14.98 ± 0.19^{c}	13.98 ± 0.09^{a}	*
192 h	13.06 ± 0.25^{a}	14.82 ± 0.12^{b}	14.50 ± 0.15^{b}	14.33 ± 0.09^{b}	*
240 h	13.45 ± 0.13^{a}	14.60 ± 0.13^{b}	15.27 ± 0.22^{c}	14.53 ± 0.35^{b}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A10 Flower bud opening of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Flower bud opening (%)				
	control	**Kept dry for 12 h**	**Kept dry for 24 h**	**Kept dry for 48 h**	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
12 h	0.00 ± 0.00	1.56 ± 1.56	1.56 ± 1.56	2.09 ± 2.09	ns
24 h	3.88 ± 2.55	2.95 ± 1.94	10.88 ± 2.44	11.21 ± 4.04	ns
48 h	9.84 ± 2.90^{ac}	5.59 ± 2.13^{a}	15.79 ± 1.43^{abc}	20.38 ± 3.01^{b}	*
96 h	18.59 ± 1.53^{a}	15.90 ± 2.96^{a}	24.34 ± 3.08^{ab}	27.43 ± 3.78^{b}	*
144 h	25.29 ± 3.97^{a}	25.61 ± 2.55^{a}	32.83 ± 3.72^{ab}	41.56 ± 5.00^{b}	*
192 h	33.73 ± 3.73^{ab}	27.00 ± 2.66^{a}	36.48 ± 5.26^{ab}	45.45 ± 5.27^{b}	*
240 h	49.05 ± 5.98	35.09 ± 2.46	43.99 ± 4.81	49.30 ± 6.74	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A11 Floret abscission of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Floret abscission (%)				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.04 ± 1.04	ns
12 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
24 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
48 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.23 ± 2.23	ns
96 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.23 ± 2.23	ns
144 h	0.96 ± 0.96^{a}	1.80 ± 1.18^{ab}	7.58 ± 2.09^{b}	19.56 ± 3.70^{c}	*
192 h	4.39 ± 1.67^{a}	11.45 ± 2.54^{a}	25.03 ± 4.54^{b}	33.19 ± 4.87^{b}	*
240 h	18.56 ± 5.09^{a}	23.75 ± 3.70^{a}	41.48 ± 7.18^{b}	42.70 ± 2.41^{b}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \le 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \le 0.05$, respectively.

Table A12 Open flower quality scores of cut *Dendrobium* 'Supinya' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Open flower quality score				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	5.00 ± 0.00^{a}	4.00 ± 0.00^{b}	3.88 ± 0.13^{b}	3.63 ± 0.18^{b}	*
12 h	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}	4.88 ± 0.13^{ab}	4.38 ± 0.26^{b}	*
24 h	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}	4.75 ± 0.16^{ab}	4.25 ± 0.16^{b}	*
48 h	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}	4.38 ± 0.18^{ab}	3.88 ± 0.30^{b}	*
96 h	4.88 ± 0.13^{a}	4.63 ± 0.18^{a}	3.50 ± 0.33^{b}	3.50 ± 0.33^{b}	*
144 h	4.50 ± 0.27^{a}	4.00 ± 0.33^{a}	2.38 ± 0.53^{b}	2.25 ± 0.53^{b}	*
192 h	3.25 ± 0.56^{a}	3.00 ± 0.65^{a}	1.75 ± 0.31	1.75 ± 0.49	ns
240 h	2.50 ± 0.60^{a}	2.00 ± 0.65^{a}	1.38 ± 0.26	1.25 ± 0.16	ns

Means within a row followed by different letters indicate significant differences between treatments, using Kruskal-Wallis test. Means were compared using least significant difference (LSD) at $P \leq 0.05$.

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively (Kruskal- Wallis test).

Table A13 *L** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*L** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	23.83 ± 1.18	23.46 ± 0.54	23.09 ± 0.43	22.81 ± 0.66	ns
12 h	23.58 ± 1.58	23.48 ± 0.79	23.59 ± 0.12	23.29 ± 0.34	ns
24 h	23.41 ± 0.46	23.53 ± 0.48	23.20 ± 0.16	23.11 ± 0.45	ns
48 h	23.95 ± 1.38	23.80 ± 0.45	23.45 ± 0.27	23.33 ± 0.34	ns
96 h	23.65 ± 0.84	23.46 ± 0.40	23.30 ± 0.23	23.55 ± 0.58	ns
144 h	23.83 ± 0.56	23.93 ± 0.83	23.81 ± 0.69	24.01 ± 0.53	ns
192 h	23.84 ± 0.39	23.70 ± 0.63	20.60 ± 2.96	17.98 ± 3.93	ns
240 h	18.01 ± 3.98	17.88 ± 3.92	14.98 ± 4.40	15.09 ± 4.44	ns
288 h	14.99 ± 4.39	14.86 ± 4.40	8.88 ± 4.34	9.03 ± 4.41	ns
336 h	15.40 ± 4.52	12.08 ± 4.60	9.18 ± 4.48	9.13 ± 4.45	ns
384 h	15.04 ± 4.41	5.99 ± 3.92	12.15 ± 4.59	9.21 ± 4.50	ns
432 h	12.29 ± 4.68	15.20 ± 4.45	12.30 ± 4.65	9.08 ± 4.45	ns
480 h	9.05 ± 4.42	3.06 ± 3.06	3.04 ± 3.04	3.00 ± 3.00	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A14 *a** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*a** value				
	control	Kept dry for 12 h	Kept dry for 24 h	Kept dry for 48 h	
0 h	70.05 ± 1.68	68.18 ± 1.74	67.30 ± 1.60	65.85 ± 2.19	ns
12 h	66.65 ± 2.32	64.46 ± 1.29	62.71 ± 1.98	65.96 ± 0.56	ns
24 h	62.71 ± 1.49	64.03 ± 0.59	64.85 ± 0.83	64.31 ± 1.51	ns
48 h	63.31 ± 1.40	64.38 ± 0.46	65.01 ± 2.37	64.49 ± 1.53	ns
96 h	65.24 ± 1.38	65.51 ± 0.73	64.31 ± 1.23	65.09 ± 1.33	ns
144 h	63.39 ± 1.57	64.11 ± 2.41	63.86 ± 1.03	62.99 ± 0.93	ns
192 h	62.70 ± 0.82	63.74 ± 2.70	63.36 ± 1.65	62.73 ± 0.84	ns
240 h	64.20 ± 2.09	65.13 ± 1.32	65.28 ± 1.90	64.96 ± 5.35	ns
288 h	62.88 ± 1.47	63.32 ± 2.42	64.45 ± 3.48	64.10 ± 6.78	ns
336 h	63.16 ± 1.53	62.73 ± 1.30	64.13 ± 3.24	63.50 ± 1.32	ns
384 h	64.02 ± 1.23	63.00 ± 0.00	65.20 ± 0.20	65.87 ± 0.97	ns
432 h	61.64 ± 1.52	60.50 ± 3.50	64.00 ± 1.00	65.50 ± 1.39	ns
480 h	63.17 ± 0.83	60.00 ± 0.00	58.40 ± 0.00	60.85 ± 1.15	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A15 *b** value of petal of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	*b** value				
	control	**Kept dry for 12 h**	**Kept dry for 24 h**	**Kept dry for 48 h**	
0 h	24.45 ± 2.20	22.91 ± 0.92	20.21 ± 0.55	22.55 ± 1.69	ns
12 h	23.75 ± 2.14	21.86 ± 2.29	20.45 ± 0.52	20.35 ± 0.90	ns
24 h	19.61 ± 0.69	20.73 ± 0.92	18.91 ± 0.50	19.50 ± 1.03	ns
48 h	20.23 ± 1.33	21.44 ± 1.05	21.26 ± 1.17	21.49 ± 0.89	ns
96 h	23.63 ± 1.32	21.53 ± 1.10	21.69 ± 0.87	21.96 ± 0.91	ns
144 h	24.73 ± 1.16	21.21 ± 0.66	23.90 ± 2.35	22.48 ± 1.21	ns
192 h	22.55 ± 1.06	21.60 ± 1.73	20.30 ± 1.69	20.62 ± 1.16	ns
240 h	22.47 ± 2.65	23.93 ± 1.37	24.58 ± 4.06	22.12 ± 2.68	ns
288 h	21.00 ± 1.39	23.48 ± 1.15	22.37 ± 0.32	24.27 ± 0.57	ns
336 h	21.74 ± 2.56	22.15 ± 1.52	22.17 ± 1.58	23.70 ± 1.01	ns
384 h	23.94 ± 2.61	22.43 ± 1.88	23.30 ± 2.63	24.67 ± 0.98	ns
432 h	23.04 ± 0.41	20.80 ± 0.45	22.20 ± 0.70	21.97 ± 1.80	ns
480 h	23.40 ± 1.82	21.83 ± 2.59	22.63 ± 0.63	22.03 ± 1.13	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A16 Flower bud opening of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Flower bud opening (%)				
	control	Kept dry for 12h	Kept dry for 24h	Kept dry for 48h	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
12 h	0.00 ± 0.00^{a}	2.50 ± 2.50^{ab}	2.50 ± 2.50^{ab}	8.76 ± 3.33^{b}	*
24 h	0.00 ± 0.00^{a}	4.59 ± 3.02^{b}	7.50 ± 3.66^{ab}	13.76 ± 3.05^{b}	*
48 h	7.41 ± 3.76^{a}	9.59 ± 3.64^{b}	11.68 ± 3.45^{ab}	18.76 ± 0.60^{b}	*
96 h	13.68 ± 3.19^{a}	14.18 ± 3.13^{b}	14.18 ± 3.13^{a}	29.99 ± 3.08^{b}	*
144 h	13.68 ± 3.19^{a}	16.26 ± 2.39^{b}	19.18 ± 3.82^{a}	32.49 ± 2.94^{b}	*
192 h	13.68 ± 3.19^{a}	20.84 ± 1.86^{b}	21.68 ± 4.63^{a}	32.49 ± 2.94^{b}	*
240 h	13.68 ± 3.19^{a}	23.34 ± 3.02^{ab}	21.68 ± 4.63^{a}	32.49 ± 2.94^{b}	*
288 h	13.68 ± 3.19^{a}	30.43 ± 6.05^{b}	21.68 ± 4.63^{ab}	34.58 ± 3.67^{b}	*
336 h	13.68 ± 3.19^{a}	30.43 ± 6.05^{b}	21.68 ± 4.63^{ab}	34.58 ± 3.67^{b}	*
384 h	13.68 ± 3.19^{a}	32.93 ± 7.05^{b}	21.68 ± 4.63^{ab}	36.66 ± 5.20^{b}	*
432 h	13.68 ± 3.19^{a}	37.51 ± 9.40^{b}	24.18 ± 5.14^{ab}	36.66 ± 5.20^{b}	*
480 h	13.68 ± 3.19^{a}	42.09 ± 11.44^{b}	24.18 ± 5.14^{ab}	36.66 ± 5.20^{b}	*

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A17 Floret abscission of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Floret abscission (%)				
	control	Kept dry for 12h	Kept dry for 24h	Kept dry for 48h	
0 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
12 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
24 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	ns
48 h	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.28 ± 2.28	ns
96 h	0.00 ± 0.00	0.00 ± 0.00	1.14 ± 1.14	2.28 ± 1.49	ns
144 h	2.00 ± 1.31^{a}	1.14 ± 1.14^{a}	1.14 ± 1.14^{a}	7.68 ± 2.58^{b}	*
192 h	12.65 ± 2.64	9.85 ± 3.85	13.18 ± 3.25	19.90 ± 4.47	ns
240 h	28.39 ± 2.55	16.68 ± 5.60	25.59 ± 4.30	26.34 ± 5.90	ns
288 h	29.54 ± 1.50^{ab}	20.84 ± 4.68^{a}	25.40 ± 2.78^{ab}	29.75 ± 2.43^{b}	*
336 h	36.76 ± 1.83^{a}	25.20 ± 6.76^{b}	32.13 ± 3.45^{ab}	31.93 ± 1.66^{ab}	*
384 h	41.81 ± 3.30^{a}	27.48 ± 6.58^{b}	33.26 ± 3.41^{ab}	41.76 ± 3.61^{a}	*
432 h	44.76 ± 4.17	35.33 ± 3.97	37.70 ± 4.41	47.25 ± 4.96	ns
480 h	45.71 ± 4.32	35.51 ± 5.33	42.25 ± 3.85	48.39 ± 5.59	ns

Means within a row followed by different letters indicate significant differences between treatments at $P \leq 0.05$, least significant difference (LSD).

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively.

Table A18 Open flower quality scores of cut *Dendrobium* 'Eia Sakul' inflorescences after placing in water 0, 12, 24 and 48 hours and every 2 days. The inflorescences were kept in the laboratory room at 25°C under 70% relative humidity and cool-white fluorescent lights for 12 hours a day (mean ± SE).

	Open flower quality score				
	control	Kept dry for 12h	Kept dry for 24h	Kept dry for 48h	
0 h	5.00 ± 0.00[a]	4.00 ± 0.00[b]	4.00 ± 0.00[b]	3.00 ± 0.00[c]	*
12 h	5.00 ± 0.00	5.00 ± 0.00	4.88 ± 0.13	5.00 ± 0.00	ns
24 h	5.00 ± 0.00	5.00 ± 0.00	4.88 ± 0.13	5.00 ± 0.00	ns
48 h	5.00 ± 0.00	5.00 ± 0.00	4.88 ± 0.13	4.25 ± 0.37	ns
96 h	4.75 ± 0.16	4.13 ± 0.23	4.13 ± 0.30	3.63 ± 0.42	ns
144 h	4.50 ± 0.38	3.63 ± 0.32	3.63 ± 0.42	3.38 ± 0.53	ns
192 h	4.50 ± 0.38[a]	3.63 ± 0.32[ab]	2.75 ± 0.49[b]	2.63 ± 0.50[b]	*
240 h	3.13 ± 0.64	2.50 ± 0.46	2.00 ± 0.42	2.00 ± 0.42	ns
288 h	2.63 ± 0.63	2.00 ± 0.50	1.88 ± 0.35	1.75 ± 0.41	ns
336 h	2.63 ± 0.63	1.75 ± 0.37	1.88 ± 0.35	1.63 ± 0.38	ns
384 h	2.63 ± 0.63	1.63 ± 0.32	1.63 ± 0.26	1.50 ± 0.33	ns
432 h	2.25 ± 0.49	1.38 ± 0.18	1.25 ± 0.16	1.25 ± 0.16	ns
480 h	1.88 ± 0.48	1.13 ± 0.13	1.13 ± 0.13	1.00 ± 0.00	ns

Means within a row followed by different letters indicate significant differences between treatments, using Kruskal-Wallis test. Means were compared using least significant difference (LSD) at $P \leq 0.05$.

Means within a row followed by * or ns indicate significant or no significant difference at $P \leq 0.05$, respectively (Kruskal- Wallis test)