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Original Article

# *Dendrobium* orchid polysaccharide extract: Preparation, characterization and *in vivo* skin hydrating efficacy

Mayuree Kanlayavattanakul[a,b,*], Tamonpatch Pawakongbun[a], Nattaya Lourith[a,b]

[a] School of Cosmetic Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
[b] Phytocosmetics and Cosmeceuticals Research Group, Mae Fah Luang University, Chiang Rai 57100, Thailand

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ABSTRACT

*Objective:* *Dendrobium* spp., the major globally commercializing tropical orchid, has been continuously used in Chinese medicine. However, preparation and standardization of this therapeutic orchid including its clinical evidence for topical application are sparely to be exploited.
*Methods:* Maceration of the white orchid (*Dendrobium* cv. Khao Sanan) in water was varied on the extraction time. The extraction yields and total polysaccharide content of the extracts were compared. The best extract condition was selected, standardized, and evaluated on safety and skin hydrating efficacy in human volunteers.
*Results:* The extraction for 3 h gave the extract with polysaccharide content that significantly ($P < 0.001$) greater than the other extraction times with the following specification: yield [(35.60 ± 2.51)%], moisture content [(7.65 ± 0.21)%], total polysaccharide, sugar, reducing sugar and ash content [(72.95 ± 2.37)%, (34.38 ± 0.00)%, (16.28 ± 0.00)%, and (0.12 ± 0.00)%], pH (4.42 ± 0.01), viscosity [(15.07 ± 0.12) cps] swelling and water absorption capacities [(10.00 ± 0.00)%, (1.19 ± 0.24) g/g]. This antioxidative polysaccharide caused no skin irritation with a better skin hydrating efficacy than the untreated skin and the benchmark as examined in 22 Thai volunteers.
*Conclusion:* White *Dendrobium* is ready to be supplied as a specialty ingredient with a safe and efficient profile for skin dryness therapy. This innovative application of the identified traditional Chinese medicinal herb flows in the main stream of the consumers' preferences and demand upon natural derived products.


## 1. Introduction

*Dendrobium* spp. has been continuously used in Chinese medicine calling Shihu. Of which, the herbal actives with healthy benefits reported are stem polysaccharide (Pan et al., 2014; Xing et al., 2013). Polysaccharide is the important phytochemical for skin dryness treatment. Hydrating and/or moisturizing of skin accumulating in inflammation and aging of skin preventions. Thus, topical products containing skin hydrating polysaccharide is attracting an ever-growing interest especially those of herbal derived products (Kanlayavattanakul & Lourith, 2015; Lourith & Kanlayavattanakul, 2016). In addition, polysaccharides have been reported to exhibit anti-oxidant activity (Delattre et al., 2015; Petera et al., 2015) that are appointed for health promotion products.

*Dendrobium* is the global number 1 tropical orchid of the floriculture industry, where Thailand is reported as the major producer and exporter (94.7% to total orchid cut flower). However, only 40% of total orchid flower is qualified for marketing and the rest is abandoned (Thailand Ministry of Commerce, 2017). The low-grade flower of the farmed orchid is therefore worthy to be explored upon its potency of this traditional herb for different application and industry. In addition, accessibility of the neglected *Dendrobium* flower will strengthen sustainable utilization of this herb and able to make additional value for the available crop.

*Dendrobium* spp. is rich in polysaccharide with bioactivities applicable for health promotions. *Dendrobium* polysaccharide is therefore largely in focus among the researchers for specific health-enhancing functions but exclusively focus on stem and none of the flower polysaccharide is neglect. Although *Dendrobium* polysaccharide is water-extractable, the sample preparation and extraction condition are necessary to be concerned in an order to fabricate the polysaccharide extract for specific utilization. In spite of advancements of extraction methods, *i.e.* ultrasonication and microwave assisted extractions; These methods depolymerize the extracting polysaccharide (Xing et al., 2013). Thus, the concise and feasible preparation of *Dendrobium* orchid for an industrial practice alongside with eco-friendly and green solvent was therefore examined.

* Corresponding author.
*E-mail address:* mayuree@mfu.ac.th (M. Kanlayavattanakul).

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Skin care industry is attracting an ever-growing interest upon products derived from the natural sources especially those of herbs with pharmacological activities including the active polysaccharide (Kanlayavattanakul & Lourith, 2015; Lourith & Kanlayavattanakul, 2016). In a continuum of our attempt exploits the innovative utilization of red-purple *Dendrobium* (Kanlayavattanakul, Lourith & Chaikul, 2018), low quality flower of white orchid (*Dendrobium* cv. Khao Sanan) is objected to be investigated for eco-pharmaceutic application on the basis of its traditionally used. Preparation of the white orchid flower polysaccharide feasible for industrial practice with a suitable method in accordance with natural and clean practice without using ethanol and petrochemical solvents, is presented in this context. Specification of the polysaccharide is set with the quality control for routinely practice. Safety assessment necessary for topical application by means of *in vivo* skin irritation test was conducted as per its hydrating efficacy in human volunteers.

## 2. Materials and methods

### 2.1. Preparation of white orchid polysaccharides

Fresh low-grade *Dendrobium* cv. Khao Sanan flowers cultivated in Nakhon Pathom, the largest floriculture of Thailand. The plant was identified by botanist Dr. Nijsiri Ruangrungsri, Faculty of Pharmaceutical Sciences, Department of Pharmacognosy, Chulalongkorn University, Bangkok, Thailand. The voucher specimen (MKDKS NP16) was deposited for further reference at our laboratory herbarium at Mae Fah University, Chiang Rai. The flowers were dried (40 °C) and grinded (< 2 mm). The dried-power was soaked in water (1:15) for 3, 6, 12, and 24 h, separately, with shaking at 150 rpm at 30 °C. The extract was concentrated to dryness under vacuo. The extractive yield was calculated and each of the extraction condition was repeated for more than two times (Lourith & Kanlayavattanakul, 2017).

### 2.2. Quality control and characterization of white orchid polysaccharides

#### 2.2.1. Total polysaccharide, sugar and reducing sugar content

Total polysaccharide content (TPC) was examined by a phenol-sulfuring acid method in a comparison with the standard glucose (Lourith & Kanlayavattanakul, 2017). Total sugar content was analyzed by means of Lane and Eynon volumetric method as per reducing sugar content (AOAC, 2000).

#### 2.2.2. Total phenolic and tannin content

Total phenolic content (TPhC) was determined using Folin-Ciocalteu assay. The reagent was mixed with $Na_2CO_3$ and the absorbance was measured. The content was compared with the gallic acid and expressed as mg GAE (gallic acid equivalents) per g of extract. The procedure was repeated in triplicate (Kanlayavattanakul, Lourith & Chaikul, 2016). Total tannin content (TTC) of the polysaccharide in DMSO and water was determined by incubation with 5% $Na_2CO_3$ and 1N Folin-Ciocalteu for 60 min prior to an absorbance recorded. Of which, tannic acid was used as the standard and TTC was reported as mg tannic acid equivalent (TAE) per g of extract (Lourith & Kanlayavattanakul, 2017).

#### 2.2.3. Moisture and total ash content

The polysaccharide extract was additionally controlled in terms of its moisture content using a moisture analyzer (Ohaus MB45, USA) and total ash content was determinated (AOAC, 2000; Kong et al., 2015).

#### 2.2.4. pH and viscosity

The pH of the orchid extract (1%) saturated in water for 2 h was determined (Qis B200, the Netherlands) under ambient condition. Viscosity of the polysaccharide (0.3 g) was saturated in water (7.5 mL) for 24 h, adjusted to 10 mL, mixed thoroughly at 100 rpm under room temperature (RT) for 2 h and recorded with the viscometer (Brookfield DVII+ Pro, USA) at the ambient condition (spindle No. 21, 20 rpm) (Lourith & Kanlayavattanakul, 2017).

#### 2.2.5. In vitro hydration and swelling capacities

Water retaining capacity of the orchid polysaccharide was *in vitro* examined and delineated by the literature methods as per swelling capacity (Lourith & Kanlayavattanakul, 2017). In brief, the polysaccharide (100 mg) was mixed with water (6 mL) in a centrifuge tube and hydrated for 18 h. A centrifugation at 3000 g was undertaken for 20 min. The supernatant was decanted and the residue weight was recorded. The capacity was calculated as the amount of water retained by the pellet (g water/g sample dry weight). The swelling capacity was assessed by hydrating of sample (0.5 g) in a measuring cylinder with distilled water (10 mL) for 24 h, recorded the occupied volume (mL), and calculated as swelling capacity (%).

#### 2.2.6. FT-IR analysis

FT-IR spectrum of the orchid extract in KBr was recorded using Perkin Elmer Spectrum-GX FT-IR spectrometer in the range of 4000 to 400 $cm^{-1}$.

### 2.3. Anti-oxidant activities of white orchid polysaccharide

*In vitro* anti-oxidant activities of the water-soluble polysaccharide were assessed by means of ABTS and DPPH assays. Vitamin C was examined in parallel as the positive control and $IC_{50}$ of the polysaccharide and the standard were calculated. In addition, reducing ability was determined with FRAP (ferric reducing ability of plasma) assay and expressed as equivalent concentration (EC) to that of $FeSO_4$ (Kanlayavattanakul, Lourith, Tadtong & Jongrungruangchok, 2015).

### 2.4. Stability of white orchid polysaccharide

The stability of white orchid polysaccharide was studied by accelerated stability test under the storage at (4 ± 2) °C for 24 h and switched to (45 ± 2) °C for 24 h (counted as one cycle). The heating-cooling cycle was repeated for more than six times (totally seven cycles), and TPC was re-assessed (Kanlayavattanakul et al., 2016). In addition, long term stabilities of white orchid polysaccharide under 4 °C, RT, and 50 °C, separately for 90 d were undertaken in parallel.

### 2.5. In vivo skin hydrating efficacy

Healthy Thai volunteers aged between 20 and 40 years old having none of skin disease were enrolled in this study. Those of hypersensitive skin as well as allergy history were excluded including who were pregnant or lactating or dieting. All recruited subjects were informed about the study both in writing and verbally signed a written consent form which was approved by the ethical committee of the Mae Fah Luang University (REH-59110) prior to enrolment.

#### 2.5.1. Skin irritation test

A single application closed patch test was preliminary performed in 22 volunteers. Finn chambers (8 mm) were used for skin irritation observation of the test sample (0.1 mL) for a period of 24 h on volar forearms of the volunteers. Skin irritation severity was graded 0–4. The obtaining data were gathered for MII (Mean Irritation Index) calculation. The MII < 0.2 was interpreted as none irritation. The white orchid polysaccharide was examined at the concentration of 0.5% in a comparison with the commercialized natural polysaccharide extract of sea weed. This reference or benchmark polysaccharide extract was examined at 0.2% as recommended to be the highest applied dose by the supplier. Water was examined in parallel as the negative control, whereas 0.1% sodium lauryl sulfate was assessed as the positive control (Kanlayavattanakul et al., 2013, 2017).

*2.5.2. Evaluation of skin hydrating efficacy in human volunteers*

Skin hydrating efficacy of the white orchid flower extract was evaluated at the concentration of 0.5, 0.3, 0.2 and 0.1% in a comparison with the benchmark sea weed extract at 0.2%. The volunteers were requested not to use moisturizers, body lotions, soaps or occlusive cosmetic preparations on the tested area prior to 12 h of the *in vivo* study. All subjects were asked to rest in the controlled room at (25 ± 1) °C and 40%–60% relative humidity for 20 min prior to skin moist monitored by using of Moist Sense® (Moritex, Japan). Both sides of the inner upper forearms were randomly marked for seven positions (2 × 3 cm, each). There were marks for the orchid flower extract at four concentrations; The benchmark extract, water and control untreated skin occupied the other three positions. The base line skin capacitance of each marked position was recorded. The test samples (50 µL), were randomized-singly applied onto the volunteers' forearm. The volunteers were requested to relax in the environmentally controlled room during the examination period. Skin hydrating efficacy was firstly recorded following 15 min of the application and at 30, 45, 60, 90, 120, 150, 180 and 210 min, eventually. All of the measurements were done in triplicate. Skin hydration difference (%) was calculated as follows (Kanlayavattanakul et al., 2013, 2017; Lourith & Kanlayavattanakul, 2017):

Skin hydration difference (%) = $[(A_t - A_0)/A_0] \times 100$

Where $A_t$ = skin capacitance at a specified time; $A_0$ = skin capacitance of untreated skin.

*2.6. Statistical analysis*

Statistical analysis was performed using the SPSS program for Windows. Independent sample *t*-test was calculated and $P < 0.05$ were statistically significant considered. The *in vivo* efficacy evaluation was shown as the means ± SEM.

## 3. Results and discussion

*3.1. Preparation of white orchid polysaccharides*

The white orchid flower was extracted by maceration in water at various time points from 3 to 24 h. The extraction time was trialed starting at 3 h as it was reported to yield the greatest polysaccharide extract from vegetable extracted by the same practice, although the yield was decreased at 4–6 h (Lourith & Kanlayavattanakul, 2017). The duration time of white orchid flower extraction was increased as we expected that a longer time of extraction would improve the yield differed from spinach. The orchid soaking in water at different times giving the pale powder extracts of similar ($P \geq 0.285$) yields as shown in Fig 1, although that of 3 h was the greatest. Polysaccharide of white orchid flower might be degraded following a longer extraction time. TPC of the extracts obtained from four condition times was assessed thereafter. Maceration for 3 h afforded the greatest TPC that significantly ($P < 0.001$) higher than other extraction times (Fig. 1). This white orchid flower extract was quality controlled, characterized and examined on anti-oxidant activity consequently.

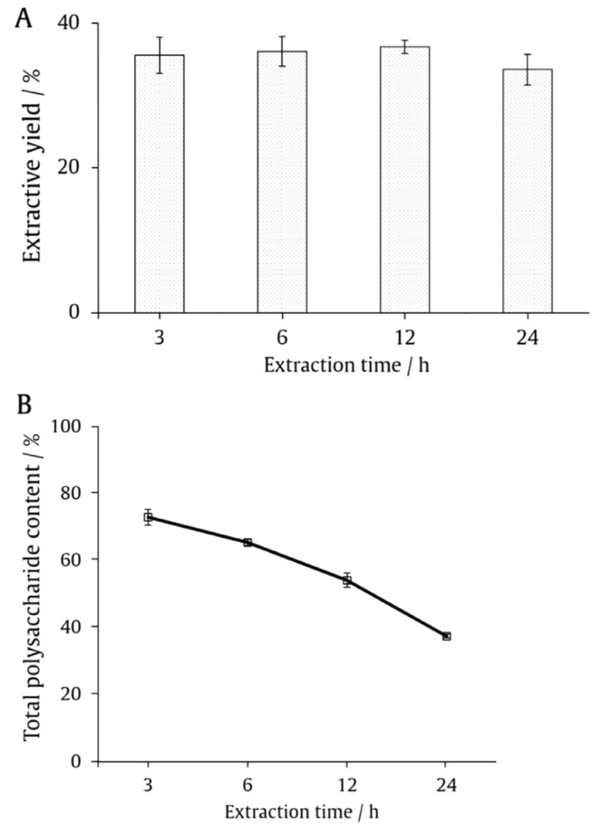


**Fig. 1.** Extractive yields (A) and total polysaccharides (B) of white *Dendrobium* polysaccharide extracted at different times.

*3.2. Quality control and characterization of white orchid polysaccharide*

Total sugar and reducing sugar contents of the prepared polysaccharides were analyzed as shown in Table 1. In addition, its TTC was quantified to be (36.22 ± 0.15) mg TAE/g extract that was higher than that of Ceylon spinach polysaccharide prepared with the same practice (Lourith & Kanlayavattanakul, 2017). Accordingly, absorptivity of the orchid polysaccharide would be better than the spinach. TPhC of the orchid polysaccharide was additionally analyzed to be (37.61 ± 0.63) mg GAE/g extract, although there were phenolic constituents in orchid polysaccharide but at a less content that rice panicle and fruit residues extracts that were active principles selectively extracted for the phenolic-rich extracts (Kanlayavattanakul et al., 2016; Lourith, Kanlayavattanakul, Chaikul, Chansriniyom & Bunwatcharaphansakun, 2017). Total

**Table 1**
Physicochemical properties of white *Dendrobium* polysaccharide.

| Properties | Values |
|---|---|
| Extractive yield (%) | 35.60 ± 2.51 |
| Moisture content (%) | 7.65 ± 0.21 |
| Total polysaccharide content (%) | 72.95 ± 2.37 |
| Total sugar content (%) | 34.38 ± 0.00 |
| Total reducing sugar content (%) | 16.28 ± 0.00 |
| Total phenolic content (mg GAE/g extract) | 37.61 ± 0.63 |
| Total tannic acid content (mg TAE/g extract) | 36.22 ± 0.15 |
| Total ash content (%) | 0.12 ± 0.00 |
| pH | 4.42 ± 0.01 |
| Viscosity (cps) | 15.07 ± 0.12 |
| Swelling capacity in water (%) | 10.00 ± 0.00 |
| Water absorption (g/g) | 1.19 ± 0.34 |

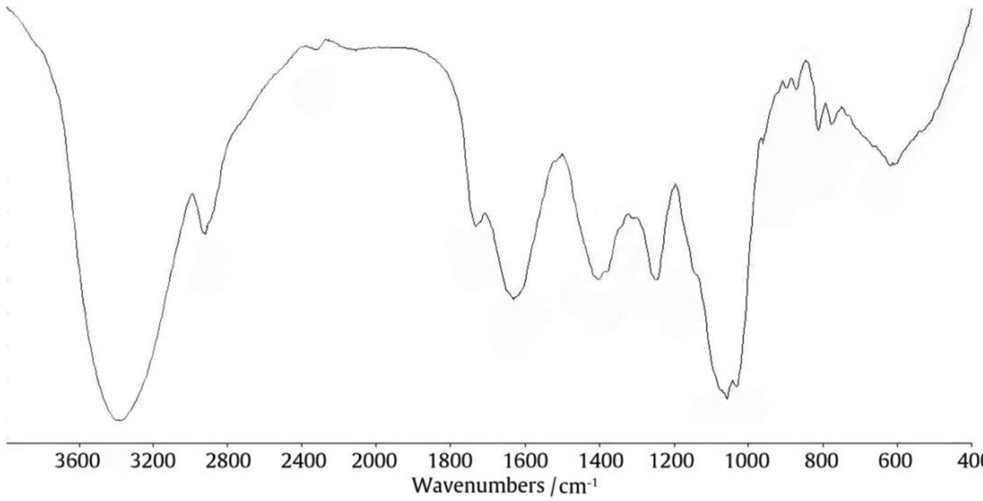


**Fig. 2.** IR spectrum of white *Dendrobium* polysaccharide.

ash and moisture content of the polysaccharide were shown to be less than 1.5% and 15% confirming its quality addressed in US Phamacopeia (2007). pH and swelling capacity of white *Dendrobium* was examined and were shown to be applicable for cosmetics (Kanlayavattanakul et al., 2016). Viscosity of the white orchid polysaccharides was less than Ceylon spinach polysaccharide (Lourith & Kanlayavattanakul, 2017) as per this presenting biopolymer was more swelled and higher water absorbed. Its greater swelling capacity increases hydrophilicity of the hydrogen network (Archana et al., 2013), and should enhances skin hydration consequently (Kanlayavattanakul & Lourith, 2015).

*Dendrobium* cv. Khao Sanan extract was consequently confirmed upon its polysaccharide nature with FT-IR (Fig. 2). This spectroscopic technique is widely used for polysaccharide analysis (Coimbra, Barros, Barros, Rutledge & Delgadillo, 1998; Mzoughi et al., 2017; Wiercigroch et al., 2017; Xing et al., 2014) in addition to NMR (Delattre et al., 2015; Petera et al., 2015). The characteristic O–H, C–H, –COOR, COO–, O–H and C=O were shown at 3380, 2922, 1731 and 1633, 1406, 1379, and 1248 $cm^{-1}$. In addition, there were bands at 1058 and 1031 $cm^{-1}$ attributed to $CH_2$–O–$CH_2$ including a low energy C=O absorption at the fingerprint region of 620 $cm^{-1}$. This polysaccharide should be acidic in nature (1731 $cm^{-1}$), which correspondence with its determined pH as shown in Table 1, with $\beta$-dominating configuration in pyranose form of mannan and glucose at around 870 and 811 $cm^{-1}$ (Luo et al., 2016; Xing et al., 2014). The molecular absorptions of glycosidic linkage and acetylation (1058 and 1031, and 1248 $cm^{-1}$) revealed that the orchid polysaccharide is pectin Yilmaz and Tavman, (2015). Furthermore, degree of esterification (DE) determination of this pectin based on the band areas at 1700–1750 $cm^{-1}$ (methyl esterified uronic acids) and 1600–1630 $cm^{-1}$ was calculated to be 34.43% (Guo et al., 2015; Mzoughi et al., 2017). *Dendrobium* flower polysaccharide is therefore conformed to that derived from stem (Xing et al., 2013). In addition, the presences of uronic acid is strongly confirmed its potential for skin hydration enhancement (Kanlayavattanakul & Lourith, 2015). Furthermore, this spectroscopic technique is feasible for the quality control and standardization of the polysaccharide for the industrial production (Kanlayavattanakul, Fungpaisalpong, Pumcharoen & Lourith, 2017; Mellal et al., 2008).

### 3.3. Anti-oxidant activities of white orchid polysaccharide

In an attempt to widen application of this polysaccharide as multifunctional ingredient (Petera et al., 2015) confirming antioxidative nature of polysaccharide (Delattre et al., 2015), the ability of the polysaccharide extracts to terminate radical was assessed by three assays. The anti-oxidant activity by means of DPPH and ABTS radicals scavenging effects in a comparison with the positive control, vitamin C or ascorbic acid was undertaken. The polysaccharide was noted to scavenge cation radical of $ABTS^{\bullet+}$ better than neutral radical of $DPPH^{\bullet}$ (Table 2) due to a macromolecule polysaccharide, and conforming to the orchid's reducing power examined by FRAP assay. Anti-oxidant activity of the white orchid polysaccharide was shown to be weaker than the positive control and less potent than the previous report upon xanthan and its modified derivative, xanthouronan (Delattre et al., 2015) and that of the semi-purified arabinogalactan-rich fraction of *Cereus triangularis* (Petera et al., 2015). These antioxidant activities may be therefore sufficient for the white orchid polysaccharide to function as a self-preservative ingredient. Semi-purification step would be encouraged to boost up the activity. Nevertheless, the additional step should not be very costly and feasible for the industrial production (Mellal et al., 2008), and corrective with green solvent preparation procedure.

### 3.4. Stability of white orchid polysaccharides

According to physicochemical properties of the prepared biopolymer suitable for cosmetic products (Kanlayavattanakul & Lourith, 2015; Lourith & Kanlayavattanakul, 2016), stability of this sustainable ingredient was therefore examined in order to

**Table 2**
Anti-oxidant activity of white *Dendrobium* polysaccharide.

| Groups | Assay ABTS ($IC_{50}$, mg $mL^{-1}$) | DPPH ($IC_{50}$, mg $mL^{-1}$) | FRAP (EC, µg $FeSO_4$•$mg^{-1}$) |
|---|---|---|---|
| Orchid | 90.19 ± 3.20 | 122.67 ± 1.62 | 46.00 ± 0.70 |
| Vitamin C | 3.15 ± 0.05 | 2.98 ± 0.13 | – |

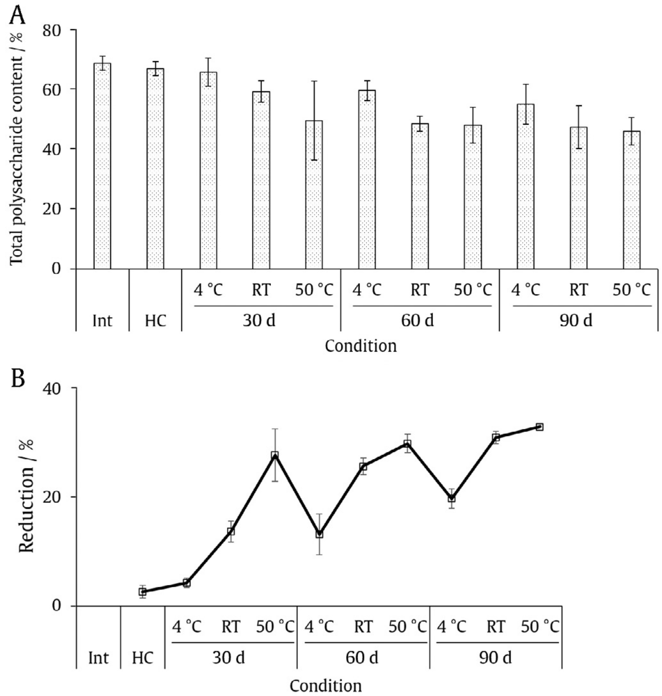


**Fig. 3.** Stability of white *Dendrobium* polysaccharide in terms of TPC (A) and reduction of TPC (B).

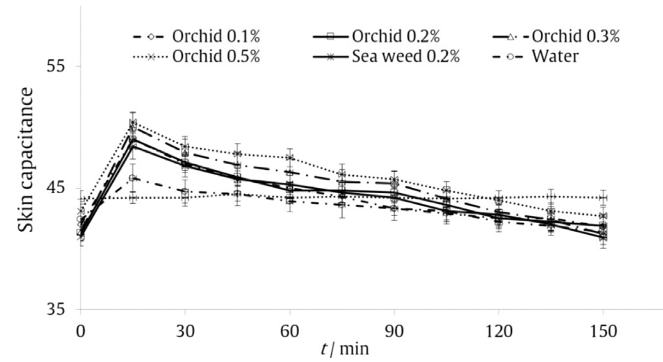


**Fig. 4.** Skin capacitance followings application of white *Dendrobium* polysaccharide, benchmark, water and control untreated skin.

ensure its potential uses (Antignac, Nohynek, Re, Clouzeau & Toutain, 2011). Following accelerated stability test, the white orchid polysaccharide was exhibited to be stable with an insignificant ($P > 0.05$) reduction of TPC [$(2.67 \pm 1.37)$%] as shown in Fig. 3. The stability would be regarded by its antioxidant activities, and function as self-preservative accordingly. Long term storage of the extract up to two months without preservative was recommended at 4 °C due to the insignificant reduction of TPC ($p_{30D} \leq 0.23$, $p_{60D} \leq 0.112$). In contrary, storage under ambient temperature and 50 °C decreases the quality of this bio-polysaccharide.

### 3.5. In vivo *skin hydrating efficacy*

Regarding to the quality parameters of the prepared white orchid polysaccharide as discussed above, this biopolymer was thereafter assessed upon its specific application for skin hydrating products. Skin compatibility was firstly examined (Antignac et al., 2011; Kanlayavattanakul et al., 2015), although the *Dendrobium* polysaccharide is traditionally oral administrated as tonic (Pan et al., 2014; Xing et al., 2013) according to its extraction using water. Single application closed patch test was examined in 22 Thai volunteers. Both of the white orchid flower and the benchmarked sea weed polysaccharides were negatively skin irritated with the MII of 0 in similar to water, the negative control. Thereafter, skin hydrating efficacy was examined. The prepared orchid polysaccharide was analyzed at various concentrations, whereas that of the benchmark was at 0.2% as per recommended. Seaweed polysaccharide had been included as the benchmark herbal skin hydrating polysaccharide because of its popularly and well-known used as an active in skin moisturizing product. In addition to the reference commercializing polysaccharide, water was studied in parallel, of which the untreated skin was set as a control.

The skin water content in term of stratum corneum (SC) hydration reflecting skin barrier is measured on the basis of electrical capacitance, conductance or impedance. These fundamental relies on the dielectric medium nature of SC. The instrument is therefore developed on the basis of this electrical concept of skin. Measurement of skin permeability to alternating electric current (impedance) reflects electromagnetic interaction with skin dipoles and electrolytes. A low resistance referring high impedance correlates with a greater skin hydration (water content). In the meantime, the conductance instrument consists of the concentric interdigital electrodes liberating a direct galvanic contact between the probe and skin surface. The non-invasive capacitance based devices are therefore examine skin hydration by the difference of the dielectric constant of water and other substances in skin brought in the electrical measurement field, which be able to monitor using low operating frequency (up to 1 MHz), and reported in arbitrary

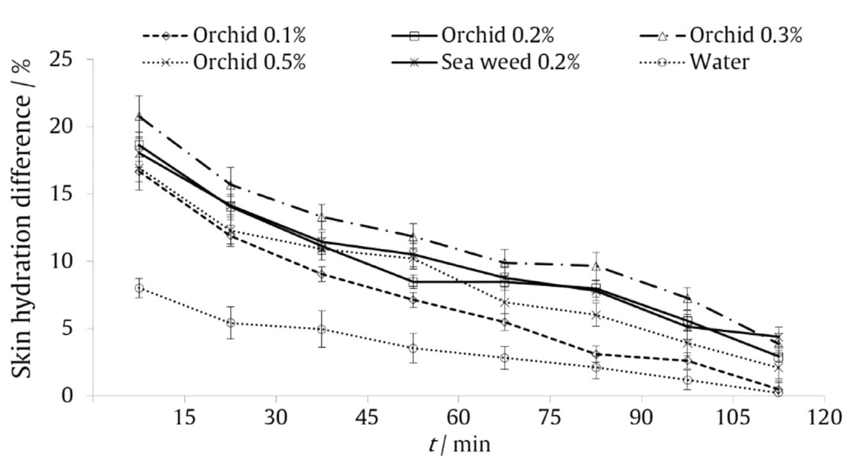


**Fig. 5.** Skin hydrating efficacy of white *Dendrobium* polysaccharide in a comparison with benchmark and water.

unit (AU) referring skin moisture value. Skin hydration measurement is therefore assessable by capacitance and conductance based device and they are correlated, although the instrumental evaluation based on capacitance is more popular in skin hydration assessments. (Kanlayavattanakul & Lourith, 2015). In this study, skin hydrating efficacy was monitored by skin capacitance.

All of the polysaccharides were all shown to retain skin hydration better than water and the control untreated skin (Fig. 4). Short term skin hydrating efficacy was last for 150 min as per the monitoring hydration was declined to the control skin. Skin hydrating efficacy of the white orchid of the same concentration with the benchmarked was shown to be comparable. Skin hydration difference of each test sample was compared with the untreated skin. Skin hydrating efficacy of the polysaccharide was confirmed, and the efficacy was prolonged to 120 min following the single application (Fig. 5). The efficacy of white orchid polysaccharide at 0.3% was noted to be superior over the benchmark at 0.2% and the orchid at 0.5%. The greater content of orchid polysaccharide more than 0.3% reverses skin hydration efficacy. The hydrogel at a higher content would better retain the hydrate molecules in its network. Furthermore, this white orchid polysaccharide was shown to be superior in skin hydrating efficacy than okra moisturizing pectin (Kpodo et al., 2017) with 0.225% of polysaccharide (Kanlayavattanakul, Rodchuea & Lourith, 2012).

## 4. Conclusions

Flower of *Dendrobium* cv. Khao Sanan, the traditional Chinese medicinal herb, is confirmed as the safe and efficient source of skin hydrating polysaccharide. The concise and feasible practice for preparation without pretreatment steps (Pan et al., 2014; Xing et al., 2013) using water as the green solvent is presented. The standardization protocol with its specification available for industrial uses is offered. Polysaccharide of this traditionally used health remedies orchid is clinically evidenced as a potential candidate natural derived agent for skin care product industry. Orchid is the important crops resulting in less risk of availability lacking. In addition, those of low-grade flowers rejected from the floriculture industry are used to prepare the specialty skin hydrating agent with the concise preparation and inexpensive method. This innovative application of the traditionally used herb identified flows in the main stream of the consumers' preferences and demand upon natural derived and sustainable products. Application of *Dendrobium* polysaccharide in topical products for skin dryness treatment is encouraged accordingly.

## Declaration of Competing Interest

The authors declare no conflicts of interest.

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