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Effect of drying methods on phenolics, flavonoids and antioxidant activities in yellow bell flower (*Tecoma stans* (L.) Juss. ex Kunth) powder

Amornrat Wongklom *, Temsiri Tharakhachat, and Thatdawan Khamphachat

Department of Chemistry, Faculty of Science, Ubon Ratchathani Rajabhat University, Ubon Ratchathani, 34000 Thailand

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Abstract

The objective of this research is to study the effect of different drying methods on phenolics, flavonoids and antioxidant activities in yellow bell flower (*Tecoma stans* (L.) Juss. ex Kunth) powder. These methods include sun and hot air drying at 60 °C for 6 h and 7 h. The flower powder was extracted by water under temperature at 70 °C for 7 min. The extract was analyzed for phenolics, flavonoids, and antioxidant activities. The results found that the powder of hot air drying at 60° C for 6 h has antioxidant activity higher than that of the powder of hot air drying at 60 °C for 7 h and sun drying, respectively. The powder has total phenolics and flavonoids as 16.381±0.836 mg GAE g^{-1} powder and 4.920±0.154 mg CE g^{-1} powder, respectively. DPPH free radical scavenging activity is 0.520±0.039 mg AAE g^{-1} powder. ABTS free radical scavenging activity is 6.186±0.046 mg AAE g^{-1} powder). Ferric reducing antioxidant power is 17.582±0.682 µmol Fe^{2+} E g^{-1} powder. Total antioxidant capacity is 71.030±0.902 mg AAE g^{-1} powder. These results indicated that the sun and hot air drying under different temperature and time, affected on content of phenolics, flavonoids and antioxidant activities in yellow bell flower (*T. stans*) powder.

*** Corresponding author** : amornrat.a@ubru.ac.th

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1. Introduction

The yellow bell flower, the scientific name of *Tecoma stans* (L.) Juss. ex Kunth (*T. stans*) is in the Bignoniaceae family and is also known by other names such as Phuang Urai, Soi Thong or Dok Lakorn. The presence of several bioactive compounds in *T. stans* has been reported, which include polyphenol, flavonoids, alkaloids, phytosterols, glycosides, saponins, and tannins. In the flower, it is reported that active compounds are found, including flavonoids, subgroup of flovones and flovonols, monoterpene alkaloids, and phenylethanoid glycosides. These compounds have been shown antioxidant, antibacterial and antifungal activities. These bioactive compounds may be responsible for the capacity of *T. stans* teas to treat of digestive problems [1, 2].

Moreover, the flower has been used in traditional medicine. The leaves of the flower are used to treat diabetes, antifungal, and as a tonic, diuretic and anthelmintic. The flowers and leaves are often used to treat diabetes, gastrointestinal problems and relieve stomachache. The bioactive compounds of the naturally flower, act to slow or prevent the oxidation of precursors and prevent the formation of free radicals, which lead to certain diseases such as cancer, diabetes and cardiovascular problems [1 – 4].

The processing of herbs into herbal tea products often involves drying processes such as sun drying, hot air drying, shade drying, etc. These drying methods and conditions may affect the bioactive compounds, including saponins, flavonoids, alkaloids, phenols, steroids, anthraquinones, tannins, terpenes, hydrocarbons, volatile oils, glycosylated flavonoids and phenolic acids [4]. These compounds exhibit antioxidant and antibacterial activities and antifungal [5]. The bioactive constituents have been used to treat gastrointestinal tract [5, 6]. Phenolic compounds are important bioactive compounds due to their ability to trap oxygen and are the major constituents in yellow bell flower. Currently, yellow bell flower is processed into tea products, and herbal drinking water.

In particular, it is processed into herbal tea in flower, leave and powder form by a simple process. The tea is produced by simple drying methods such as sun, shade and hot air drying [7 – 10]. These drying methods are simple for drying may be not able to enough eliminate the percentage of moisture content and water activity lower than 10 and 0.6, respectively. There are growing microorganism such as yeast, fungi and bacteria which pathogenic microorganism in flower, leaves or powder tea, resulting reduced quality of the tea. Therefore, studying on the drying methods that affects the moisture contents, water activities, phenolics, flavonoids and antioxidant activities of the yellow bell

flower (*T. stans*) powder were investigated. It's obtained the information on the efficiency and value of the yellow bell flower. These data can be used as guideline for the further development such as a commercial the yellow bell flower tea product.

2. Materials and Methods

Preparation of the yellow bell flower powder

The yellow bell flower (*Tecoma stans* (L.) Juss. ex Kunth) was sampled from Faculty of Science, Ubon Ratchathani Rajabhat University. It was washed by tap water, and allowed to drain. All of them were divided into three parts and weighed to 300 g of them to be dried in the three different drying methods. The drying methods included sun drying (15 h; 37±2 °C) and hot air drying at 60 °C for 6 h and 7 h. After drying, the dried flower was ground by grinder machine, Bos Mall 4500A and sieved through a 63–mesh standard test sieve. All of them were divided into two parts. The first part of powder was analyzed for moisture content and water activity, and the second part of powder was stored in a desiccator for analysis of the active substances and antioxidant activities. The procedure for preparing the yellow bell flower powder was shown in Fig. 1.

Moisture content and water activity analysis

Moisture content was analyzed by moisture analyzer, Leco/TGA701 and was calculated follow by AOAC (2000). Water activity was analyzed by water activity meter, Novasina AG, Lab Master aw neo [11].

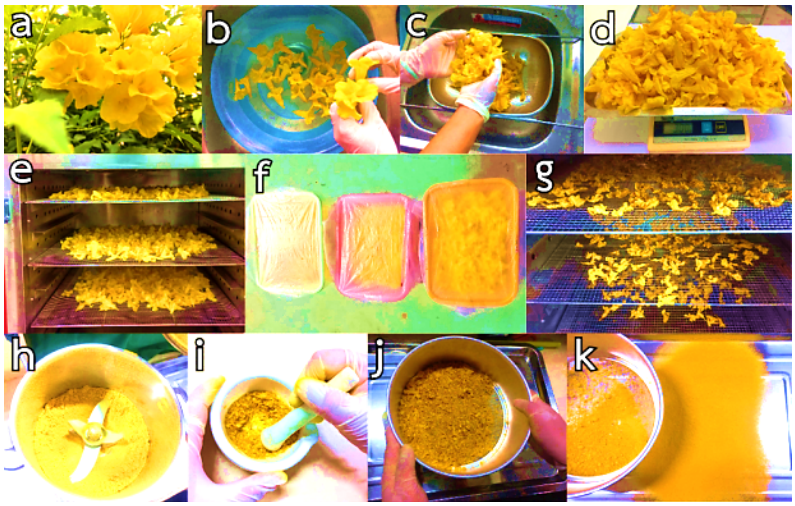

Fig. 1 Preparation of the yellow bell flower (*T. stans*) powder; fresh yellow bell flower (a), wash (b), drain (c), weigh (d), hot air drying (e), sun drying (f), dried flower (g), grind by grinder (h), grind by mortar (i), sieve (j), and yellow bell flower powder (k).

Preparation of the extract

The 0.5 g of the yellow bell flower (*T. stans*) powder was extracted by 50 mL water for 7 min at 70 °C [12 – 15]. Then each sample was extracted for 5 times. The water extract was filtered through filter paper NO 1. The extract was a yellowish–brown color. All of them were kept under 4 °C before the further experiments. The preparation of the yellow bell flower extract was shown in Fig. 2.

Determination of total phenolics content

Total phenolics content (TPC) in the yellow bell powder extract was determined by the Folin–Ciocalteu colorimetric method with modified by Zheng *et al*. [14]. A 1 mL of extract and gallic acid standard solution were mixed into a vial with 0.5 mL Folin–Ciocalteu reagent. After shaking for 30 sec and sitting for 1 min, the mixture was added with 5 mL of 5% w v^{-1} Na_2CO_3, then shaked and placed for 60 min at room temperature. The absorbance was measured spectrophotometrically at 760 nm. TPC was expressed as milligrams of gallic acid equivalents per gram of powder (mg GAE g^{-1} powder).

Determination of total flavonoids content

Total flavonoids content (TFC) of the powder extract was determined by the formation of an aluminum flavonoid complex with modified by Silva *et al*. [16]. Briefly, 100 µL of the extract and catechin standard solution were mixed into 4 mL distill water, 300 µL of 5% w v^{-1} $NaNO_2$ and shaked well. After sitting for 5 min, 300 µL of 10% w v^{-1} $AlCl_3$ was added into the mixture. Next, the mixture was added 2 mL of 1 M NaOH and 2.40 mL of distill water, then shaked well. After sitting for 5 min, the absorbance was measured at 510 nm and TFC was expressed in milligrams of catechin equivalents per gram of powder (mg CE g^{-1} powder).

DPPH free radical scavenging activity assay

DPPH free radical scavenging activity of the powder extract was determined following the method reported by Zheng *et al.* [14]. Aliquot (0.20 mL) of the extract and

ascorbic acid standard solution were mixed to 5 mL of 0.20 g L^{-1} dilute DPPH solution (1:7). After being energetically mixed, the mixture was placed in the dark for 30 min. Then, the absorbance was measured at 517 nm. The percentage of inhibition (%I) of DPPH free radical was calculated using the formula:

$$\%I = [(A_{blank} - A_{sample}) / A_{blank}] \times 100$$

DPPH free radical scavenging activity was expressed as milligrams of ascorbic acid equivalents per gram of powder (mg AAE g^{-1} powder).

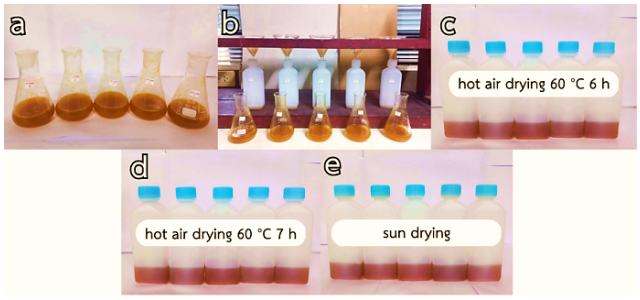

Fig. 2 Preparation of the yellow bell flower powder extract; extract by hot water at 70 °C (a), filter by filter paper (b), and the extract (c, d, e).

Total antioxidant capacity assay

Total antioxidant capacity was assayed by Wongklom *et al.* [13] base on reduction of Mo (VI) to Mo (V). A 0.30 mL of the flower powder extract and ascorbic acid standard solution were mixed to 3 mL of TAC reagent, mix solution of sulphuric acid 0.60 mol L^{-1}, sodium phosphate 28 mmol L^{-1} and ammonium molybdate 4 mmol L^{-1} (1:1:1) and shaked for 30 sec. The mixture was incubated at 95 °C for 90 min and then kept to room temperature. The absorbance was measured at 695 nm [6, 13]. The total antioxidant capacity, calculation was expressed as milligrams of ascorbic acid equivalents per gram of powder (mg AAE g^{-1} powder).

Ferric reducing antioxidant power (FRAP) assay

FRAP assay was estimated according to the report of Dravie *et al.* [17]. The 100 µL extract and ferrous ion standard solution were mixed into 3 mL FRAP reagent, shaked and incubated at 37 °C for 30 min. After setting for 5 min, the absorbance was measured at 593 nm [17]. FRAP value was expressed as micromol ferrous ion equivalents per gram of powder (µmol Fe^{2+} E g^{-1} powder).

ABTS free radical scavenging activity assay

ABTS cation free radical activity was assayed by the method of Wongklom *et al.* [13]. ABTS cations radical was generated by reacting 7 mM ABTS with 2.45 mM potassium persulfate (1:1, v v^{-1}) for 14 h. Then the mixture was diluted to give an absorbance of 0.70±0.20 at 734 nm. The 600 µL of extract and ascorbic acid standard solution were mixed into 5.4 mL diluted $ABTS^{+\bullet}$ solution, shaked for 30 sec and kept in dark for 6 min. The absorbance was measured at 734 nm using a spectrophotometer [13, 15]. The percentage of inhibition (%I) of ABTS free radical was calculated using the formula:

$$\%I = [(A_{blank} - A_{sample}) / A_{blank}] \times 100$$

ABTS free radical scavenging activity was calculated and expressed as milligrams of ascorbic acid equivalents per gram of powder (mg AAE g^{-1} powder).

Statistical analysis

Sample test was utilized to evaluate the statistical difference between the control group and the group exposed to powder of *T. stans*. A p value < 0.05 was considered statistically significant.

3. Results and Discussion

Moisture content and water activity of the yellow bell flower powder

The yellow bell (*T. stans*) flower was dried by different drying methods, including 1) sun drying (15 h; 37±2 °C) and 2) hot air drying at 60 °C for 6 h and 7 h. These conditions made the flower completely dry and crisp, suitable for grinding into powder. We found that it takes less than 6 h, fresh flower will not dry properly and are not suitable for grinding. Then the dry flower was ground to fine for analysis of the moisture content and water activity.

Moisture content is the amount of water present in a flower powder, usually expressed as a percentage of the material's dry weight. It's a crucial factor for product quality, process control, and material properties, influencing factors like shelf life, usability, and physical characteristics. Moisture content is measured by moisture analyzer or thermogravimetric analyzer. Water activity (a_w) is a measure of the free or unbound water in a system, defined as the ratio of the water's vapor pressure to that of pure water at the same temperature. It indicates to how much water is available for chemical reactions, microbial growth, and physical processes. Water activity is measured by water activity meter.

Table 1 Moisture content and water activity of the yellow bell flower powder from the different drying methods.

Drying method	Moisture content (%)	Water activity (a_w)
Fresh flower	82.55	0.954
Hot air drying 60 °C 6 h	7.747	0.367
Hot air drying 60 °C 7 h	7.540	0.305
Sun drying	8.913	0.454

The moisture content and water activity in the yellow bell flower powder from different drying methods were showed in Table 1. The results indicated that drying temperature and time affected on moisture content and water activity [12 – 15]. Fresh *T. stans* flower had a percentage of moisture content as 82.55 and water activity (a_w) was 0.954. These flowers were processed by different drying methods, until the moisture contents reduced and dry. The percentage of moisture contents were 7.540–8.913 with lower than 10. The water activities were 0.305–0.454 which lower than 0.6, which can protect growing of yeast, fungi and bacteria in dried leaves and powder [12 – 15].

The flower powder from hot air–drying methods (60 °C 6 h; 60 °C 7 h) and sun drying (15 h; 37±2 °C) had a percentage of moisture content lower than 10 as 7.747, 7.540 and 8.913, respectively. The hot air–dried powder had moisture content lower than the sun–dried powder due to hot air drying used oven which control a stable temperature and time at 60 °C for 6–7 h, but efficiency of sun drying method is depending on environment weather condition which cannot control the temperature to stable. The drying temperature was average 37± 2 °C and long time for drying (15 h), resulting in difficulty to control the quality and moisture content of dried flower. In addition, the dried flower may be absorbed by the moisture content in the air around the area, resulting in higher moisture content. This research corresponds to Chen *et.al.* [7], who found that the hot air–dried samples had moisture content (9.71±0.46%) lower than those of the air dried (10.39±0.32%) and freeze–dried sample (11.78±0.90%), respectively [7]. The research indicated that temperature and time required for drying affected on moisture content and water activity when high temperature and long drying times, a moisture content and water activity will be reduced [12 – 15].

Total phenolics and flavonoids contents

The water soluble phenolics and flavonoids contents in the yellow bell flower powder determined by three different drying methods were shown in Table 2. The highest of the water soluble phenolics and flavonoids contents existed in the powder at 60 °C for 6 h (16.381±0.836 mg GAE g^{-1} powder, 4.920±0.154 mg CE g^{-1} powder) among the powder at 60 °C for 7 h (15.951±0.890 mg GAE g^{-1} powder, 4.721±0.190 mg CE g^{-1} powder) and sun dried powder (14.55±0.318 mg GAE g^{-1} powder, 4.360 ± 0.092 mg CE g^{-1} powder) because the sun dried powder has a higher moisture content than that of the powder of hot air drying (60 °C 6 h and 7 h). Hot air drying is method which controls temperature at 60 °C and time for 6 h and 7 h, resulting in lower moisture content than the sun–drying method. The drying time is longer; the moisture content is reduced. The flower received high temperature for longer time, then the water soluble phenolics and flavonoids decomposed in the drying process, resulting in the flower powder of hot air drying (60 °C 7 h) had lower phenolics and flavonoids contents than the powder of hot air drying (60 °C 6 h). The hot–air drying process requires high temperature and increase airflow, which is needed to promote water evaporation and reduce the relative humidity, and the deterioration of active substances in raw materials. The sun drying is dry in the open air, not be control temperature and received uneven heat from the sun for a long time. The active components may be more decompose in drying process.

The sun–dried powder had a lower phenolics and flavonoids contents than the hot air–dried powder. Some antioxidant substances will decompose through the mechanism of hydrolysis of esters or glycosides such as rutin (quercetin–3–orutinoside) may be decompose into protocatechuic acid [16, 18, 19]. Flavonoids without an enone structure are more stable. Flavonoids with a hydroxyl group at position 3 are the most sensitive to UV light. UV light can cause the decomposition of flavonoids, which breaks them down into different compounds. The extent and pathway of this decomposition depend on the specific flavonoid's structure, with molecules lacking an enone structure being more stable and those with a 3–hydroxyl group being more sensitive. This degradation can alter their antioxidant activity.

The specific rate and extent of degradation depend on the heating temperature, the flavonoid's molecular structure, and other factors like pH and oxygen availability. While high temperatures and UV light exposure can lead to a loss of original flavonoids, some degradation products may have similar or even superior antioxidant properties [3, 4]. These results were corresponding to Miao *et al*. [18] who reported that the hot dried *Coreopsis tinctorial* powder (50 °C 4 h) (46.45±0.46 mg GAE g^{-1} dry weight) had more phenolics and flavonoids contents than the sun–dried powder (3 days) (46.00±1.00 mg GAE g^{-1} dry weight). Kolla *et al*. [19] reported that the hot air dried *Hyphaene thebaica* powder (60 °C) (4.08±0.04 g 100g^{-1}) had more phenolics and flavonoids contents than the sun dried *Hyphaene thebaica* powder (3 days) (3.46±0.03 g 100g^{-1}). These results indicated that UV light affected on the active components. Exposed to light, especially over a long duration, flavonoids can break down. Drying using higher temperature and longer period of time also increase the chance of degradation of active compound in powder.

DPPH free radical scavenging activity, ABTS free radical scavenging activity, ferric reducing antioxidant power and total antioxidant capacity

DPPH radical is a stable free radical that can donate hydrogen when reacts with antioxidant compounds and reduce to diphenyl picryhydrazine [14]. These showed the ability of extract to neutralize free radicals which possess unpaired electrons. The DPPH free radical scavenging activity in the yellow bell flower powder by different drying methods were showed in Table 3. The hot air–dried powder (60 °C for 6 and 7 h) had DPPH free radical scavenging activity more than the sun–dried powder.

The highest of DPPH free radical scavenging activity existed in the powder of hot air at 60 °C 6 h (0.520±0.039 mg AAE g^{-1} powder) among the powder of hot air dry at 60 °C 7 h (0.497±0.054 mg AAE g^{-1} powder), and sun dried for 15 h

(0.422±0.016 mg AAE g^{-1} powder), respectively. The flower powder that has been dried by sun drying (37±2 °C) for 15 h as long–term drying, total phenolics and flavonoids evaporate with water and exposed an UV light during drying process, causing the amount of these components decreased. As a result, the DPPH antioxidant activity was reduced as well [14]. The scavenging ability of DPPH radicals increases by antioxidant due to hydrogen donation. The flower powder extract was active with relation to the phenolics, flavonoids and phytochemicals in the powder. Therefore, it can be deduced that drying methods, drying temperature and time had effect on the antioxidant activities of the yellow bell flower powder. The DPPH antioxidant activity was related to the phenolics and flavonoids contents. This is because these active components capable of contributing a hydrogen radical to free radicals. DPPH is not radical. In addition, drying has an effect on the DPPH antioxidant activity. Long–term drying results in lower the DPPH antioxidant activity.

Table 2 Total phenolics and flavonoids contents of the yellow bell flower powder from the different drying methods.

Drying method	Total phenolics content (mg GAE g^{-1} powder; n = 5)	Total flavonoids content (mg CE g^{-1} powder; n = 5)
Hot air drying 60 °C 6 h	16.381±0.836	4.920±0.154
Hot air drying 60 °C 7 h	15.951±0.890	4.721±0.190
Sun drying (15 h)	14.553±0.318	4.360±0.092

Table 3 DPPH free radical scavenging activity, ABTS free radical scavenging activity, FRAP value and total antioxidant capacity of the yellow bell flower powder from the different drying methods.

Drying method	DPPH free radical scavenging activity (mg AAE g^{-1} powder; n = 5)	ABTS free radical scavenging activity (mg AAE g^{-1} powder; n=5)	FRAP (μmol Fe^{2+} E g^{-1} powder; n=5)	total antioxidant capacity (mg AAE g^{-1} powder; n = 5)
hot air drying 60 °C 6 h	0.520±0.039	6.186±0.046	17.582±0.682	71.030±0.902
hot air drying 60 °C 7 h	0.497±0.054	6.149±0.048	17.581±0.913	66.525±4.398
sun drying (15 h)	0.422±0.016	5.978±0.106	15.261±0.260	61.186±2.051

The $ABTS^+$ free radical activity was determined hydrogen donation ability which generated by potassium persulfate [13, 15, 17]. The $ABTS^+$ radical scavenging activity in the yellow bell flower powder was showed in Table 3. The highest of $ABTS^+$ radical scavenging activity existed in the flower powder of hot air dry at 60 °C for 6 h (6.186±0.046 mg AAE g^{-1} powder) among the powder of hot air dry at 60 °C for 7 h (6.149±0.048 mg AAE g^{-1} powder), and the sun–dried powder (5.978±0.106 mg AAE g^{-1} powder), respectively. The hot air–dried powder had higher phenolics and flavonoids contents, compared with the sun–dried powder. The powder of hot air dry at 60 °C for 7 h had a slightly $ABTS^+$ free radical activity lower than the powder at 60 °C for 6 h because phenolics and flavonoids may be decomposed in drying stage. $ABTS^+$ free radical activity decreased. The results were found $ABTS^+$ radical scavenging activity related to the water soluble phenolics, flavonoids and phytochemicals contents. Because active compounds can give hydrogen radical to ABTS free radicals that ABTS is not free radicals [15, 17].

The ferric reducing antioxidant power (FRAP) was measured the reduction of Fe^{3+}–ligand to Fe^{2+} complex in the intensely blue–colored form by acidic medium. Antioxidant activity is determined as increase of absorbance at 593 nm, and results are calculated by expressed as μmol Fe^{2+} equivalents or relative to an antioxidant standard [17, 20, 21]. The potent hydroxyl radical can be generated through the Fenton reaction in cells. The radical chain reaction mediated by the hydroxyl radical depends on Fe^{3+}. Thus, the ability of a compound to reduce Fe^{3+} to Fe^{2+} could contribute to its antioxidant potential. The FRAP assay is used to determine the ability of a compound to reduce Fe^{3+} to Fe^{2+} [17]. That in the yellow bell flower powder was showed in Table 3.

The FRAP value existed in the yellow bell flower powder of hot air dry at 60 °C for 6 h (17.582±0.682 μmol Fe^{2+}E g^{-1} powder) and 60 °C for 7 h (17.581±0.913 μmol Fe^{2+}E g^{-1} powder) slightly higher than the powder of sun dry (15.261±0.260 μmol Fe^{2+}E g^{-1} powder). Since the sun drying method is an open–air drying method without temperature control, the flower exposed UV light but not consistently and took a longer of period of drying time. Phenolics and flavonoids substances were more likely to degrade during the drying process, which results in a decrease in the reducing ability as well. The FRAP value is related to total phenolics, flavonoids and phytochemicals contents. These antioxidants that can give free electrons in the reduction reaction, the antioxidants give electrons to ferric ion [17, 20, 21].

The antioxidant capacity assay based on the reduction of Mo (VI) to Mo (V) by the formation of a green phosphate Mo (V) complex at acid pH [12, 13, 15]. The total antioxidant capacity in the yellow bell flower powder was showed in Table 3. The highest of total antioxidant capacity existed in the powder of hot air dry at 60 °C for 6 h (71.030±0.902 mg AAE g^{-1} powder) among the powder of hot air dry at 60 °C for 7 h (66.525±4.398 mg AAE g^{-1} powder), and the sun–dried powder (61.186±2.051 mg AAE g^{-1} powder), respectively. An increase in the total antioxidant capacity relates to the water soluble phenolics, flavonoids, and phytochemicals contents in the flower powder than base on conditions of drying, include temperature, period of time and UV light. These results were corresponded to Wongklom *et al.* [12, 13, 15] reported that an

increase in the total antioxidant capacity caused by antioxidant might be due to the phenolics and flavonoids contents.

In these results, it showed no significant difference in the total phenolics and flavonoids contents between hot–air and sun drying. The antioxidant activities, including DPPH free radical scavenging activity, ABTS free radical scavenging activity, FRAP value and total antioxidant capacity of *T. stans* flower powder, were also found to be comparable. The specific chemical structure of a total flavonoids and phenolics such as the presence and position of hydroxyl groups, determines its antioxidant power. These effects are mainly due to the antioxidant properties that depend on the presence and the localization of functional groups on the phenolics and flavonoids skeleton [22]. The activity of antioxidants is linked to their capacity to scavenge radical species. The configuration and the number of phenoxy groups are an important parameter to improve antioxidant activity. A catechol structure (phenols in position 3′ and 4′) and an enol group in position 3 lead to a better free radical scavenging. Moreover, the presence of an enone moiety contributes to increase further antioxidant properties. Phenolics and flavonoids are sensitive to their environmental conditions, including temperature, light, oxygen, and pH [23]. Heat treatment and light exposure affected on antioxidant activities of active compounds. Thus, the processes of drying can lead to a change of the flavonoid structure and, therefore, on their antioxidant activities.

4. Conclusion

The drying methods include sun and hot air drying (60 °C for 6 h and 7 h) methods affected on total phenolics, flavonoids, phytochemicals, and antioxidant activities of the yellow bell flower powder. The flower powder of hot air drying (60 °C 6–7 h) had total phenolics, flavonoids, and antioxidant activities higher than those of the powder of sun. The UV light exposure is more affected on the content of phenolics, flavonoids and antioxidant activities in the yellow bell flower powder than a hot air drying at 60ºC for 6–7 h.

5. Suggestions

Future studies should examine the different drying technologies, such as microwave and freeze drying, on the preservation of active compound, antioxidant and antimicrobial. In addition, it would be beneficial to analyze the active ingredients and biological activities (e.g., antioxidant or antimicrobial properties) of the dried *T. stans* products to confirm the functional stability of the bioactive compounds after processing.

6. Acknowledgement

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7. Declaration of generative AI in scientific writing

In this study, data or primary research results were not generated by AI. All experimental design, data collection, and analysis were conducted by the authors, in accordance with recognized scientific protocols and ethical guidelines.

8. CRediT author statement

Amornrat Wongklom: Conceptualization, Methodology, Data Curation, Writing – Original Draft, Writing – Review & Editing.

Temsiri Tharakhachat: Methodology, Investigation

Thatdawan Khamphachat: Methodology, Investigation

9. Research involving human and animals rights

This study did not involve any experiments on human participants or animals conducted by any of the authors.

10. Ethics Approval and Consent to Participate

This study did not involve human participants or animals.

11. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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