# Drying of Mint and Basil Leaves for The Herbal Blended Beverage Development

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**Abstract**

The objective of this study was to develop the herbal blended beverage made with 4 herbs: mint leaves, basil leaves, fennel seed and licorice root. Tray drying method was used for drying mint leaves and basil leaves at two different temperatures: 50ºC and 55ºC. Product quality was determined by measuring antioxidant activity by DPPH free radical method and total phenolic compound method. Drying kinetic, color and water activity were also analyzed. Results showed that drying mint leaves and basil leaves at 55ºC was better than drying at 50ºC. Sensory analysis was conducted to find appropriate proportion of ingredients. Herbal blended beverage with 40% of dried mint, 10% of dried basil, 30% of dried licorice root, and 20% of fennel seed was most accepted for all sensory attribute: appearance, color, odor, flavor, after taste, and overall.

**Key words:** Basil leaves, Mint leaves, Tray drying, Herbal blended beverage

## 1. Introduction

Nowadays, consumption trend is toward health-conscious food such as food ingredients, genetically modified food and organic foods (Horovitzs, 2015). Herbs are well known as containing potential of healing properties. Herbal tea has become popular due to its health benefits and unique flavors. Herbal blended beverage is usually mistakenly called herbal tea, which is incorrect since it is not made from tea. It is an infusion of leaves, seeds, roots or barks of herbs extracted in hot water, not actually made from tea leaves. Besides a beneficial effect on health, its taste is usually fragrant and appealing. Popular types of herbal tea include ginger tea, lemongrass tea, peppermint tea, and roselle tea, etc.

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Licorice root is an herb found in Greece, Turkey, and Asia countries. It is used as a dietary supplement for digestive problems, menopausal symptoms, cough, as well as bacterial and viral infections (NIH, 2016). It is often consumed as herbal beverage. However, some consumers find it is hard to drink due to its bland taste. Therefore, it is less popular than other herbal beverages. To increase the consumer satisfaction, this study developed the herbal blended beverage made with licorice root and other herbs (mint leaves, basil leaves, and fennel seeds). The objectives of this study were to investigate the appropriate drying condition of mint leaves and basil leaves and formulate herbal beverage that is most accepted by consumers.

## 2. Materials and Method

### 2.1 Materials and Equipment

Herbs used in this study included fresh mint leaves, fresh basil leaves, dried fennel seed and dried licorice root. Fresh mint and basil leaves were purchased from local market in Chiang Mai, Thailand. Dried fennel seed and dried licorice root were purchased from Royal Spice Company, Thailand. Chemicals used include Ethanol, 2,2-Diphenyl-1-picrylhydrazyl (DPPH), Anhydrous sodium carbonate, and Folin and Ciocalteu's Phenol Reagent. Equipment used in this study include colorimeter (Konica Minolta, Chroma Model CR-400, Japan), water activity analyzer (AquaLab, Decagon Devices, S36092, USA), tray dryer (Faculty of Agro-Industry, Thailand), thermometer, digital scale, desiccator, sonicator, microplate, tissue culture plate, and volumetric pipettes.

### 2.2 Experimental procedures

#### 2.2.1 Moisture content analysis of mint and basil leaves

The initial and final moisture content (% wet basis) of fresh mint leaves and fresh basil leaves were measured by the AOAC method (AOAC, 1999). Fresh leaves (3 g) were dried in the hot air oven for 24 h and cooled in the desiccator. Moisture content of mint leaves and basil leaves were calculated by equation.

$$\text{Moisture (\% wb)} = \frac{W1 - W2}{W1} \times 100 \quad (1)$$

where $W_1$ is sample weight before drying (g) and $W_2$ is sample weight after drying (g).

#### 2.2.2 Drying mint and basil leaves at 50ºC and 55ºC

Fresh mint leaves were uniformly spread on tray and placed in the drying cabinet. The average air velocity in the drying cabinet was at 0.5 m/s. Drying mint leaves were dried at 50ºC and 55ºC. The experiments were triplicated. Basil leaves were experimented in the same approach as mint leaves.

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### 2.2.3 Mathematical models of drying curves

Mathematical model to predict the dehydration of food products is important because it could affect the quality loss of products (Torki-Harchegani *et al.*, 2016). The use of inappropriate drying parameters resulted in loss of quality and nutritive constituents during drying (Babu *et al.,* 2018). Therefore, this present work studied the mathematical models of drying curves for mint and basil leaves. The moisture ratio of drying mint leaves and basil leaves using tray drying was calculated using equation (2) and the drying rate of drying mint leaves and basil leaves was calculated using equation (3) (Akpinar, 2002).

$$MR = \frac{M - M_e}{M_o - M_e} \quad (2)$$

$$\text{Drying rate} = \frac{M_{t+dt} - M_t}{dt} \quad (3)$$

where $M$, $M_e$, and $M_o$ are moisture content (% dry basis) at any time, moisture content in equilibrium, and initial moisture content, respectively, and $M_{t+dt}$, $M_t$, and t are moisture content at time *t+dt* (% dry basis), moisture content at time *t* (% dry basis), and time (min) respectively.

For mathematical models, the model equations shown in Table 1 were tested to select the best model for describing the drying curves of mint leaves and basil leaves.

**Table 1** Drying curves models

| Model no. | Model name | Model equation | References | Eq. |
|---|---|---|---|---|
| 1 | Henderson and Pabis | MR = $a$ exp(-$kt$) | Henderson and Pabis (1961) | (4) |
| 2 | Lewis | MR = exp(-$kt$) | Ayensu (1997) | (5) |
| 3 | Page | MR = exp(-$kt^n$) | Diamante and Munro (1993) | (6) |
| 4 | Modified page | MR = exp[-($kt$)$^n$] | White, *et al.* (1981) | (7) |
| 5 | Logarithmic | MR = $a$ exp(-$kt$) + c | Yagcioglu, *et al.* (1999) | (8) |
| 6 | Modified Henderson and Pabis | MR = $a$ exp(-$kt$) + $b$ exp(-$gt$) + $c$ exp(-$kat$) | Karathanos (1999) | (9) |

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The regression analysis was performed using Sigma Plot 12.5 statistical program. The choosing criteria for the best fit model consisted of the coefficient of determination ($R^2_{adj}$), the reduced chi–squares ($\chi^2$) and root mean square error analysis (RMSE). These parameters could be calculated using equations (10) and (11).

$$\chi^2 = \frac{\sum_{i=1}^{n}(MR_{exp,i} - MR_{pre,i})^2}{N - n} \quad (10)$$

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}\left(MR_{pre,i} - MR_{exp,i}\right)^2\right]^{1/2} \quad (11)$$

where $MR_{exp}$, $MR_{pre}$, N, n are moisture ratio of experiment, moisture ratio of predicted model, number of observations, and number of constants, respectively.

**2.2.4 The physical properties of dried mint and basil leaves**

Color and water activity ($a_w$) were measured as the physical properties of dried mint and basil leaves. Color was expressed its values for each coordinate L*, C*, h° where L* was lightness, C* was Chroma, h° was hue angle. Water activity was expressed as the ratio of vapor pressure in the sample to that of pure water.

**2.2.5 Determination of nutrition value**

Six samples (fresh mint, dried mint at 50ºC, dried mint at 55ºC, fresh basil, dried basil at 50ºC, and dried basil at 55ºC) were weighed approximately 1 g each. Five ml and 10 mL of 70% ethanol solution were dropped into each sample. The mixtures were sonicated for 1 h at 50ºC to extract bioactive compound, and then filtered. Each sample was initially diluted with ethanol as followed: 1:5 (g/mL) for fresh mint and fresh basil, and 1:10 (g/mL) for dried mint and dried basil. Five dilutions of fresh samples were 0.2, 0.15, 0.1, 0.05, 0.01 (g of sample/mL of ethanol) and five dilutions of dried samples were 0.1, 0.05, 0.01, 0.005, 0.001 (g of sample/mL of ethanol), respectively.

**a) Total phenolic compound (Cascant *et al.*, 2016)**

One hundred ml of 20% sodium carbonate solution was prepared from solid sodium carbonate. Distilled water (2.5 mL) was added to 2 mL sodium carbonate solution. In this experiment, dilution of 0.005 g/mL for dried samples and 0.05 g/mL for fresh samples were added into the solution, followed by 0.25 mL of Folin and Ciocalteu's Phenol Reagent. For each sample, 200 µL of final solution was dropped into a tissue culture plate and placed in the dark for 45 min at room temperature. The tissue culture plate with solution was then analyzed by the Micro plate. The absorbance of the mixture was measured at 765 nm. Gallic acid was used as standard substrate in this experiment.

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**b) DPPH (2,2-Diphenyl-1-picrylhydrazyl) radical–scavenging activity (Tai *et al.*, 2017)**

A 0.0047 mg of DPPH was added to 250 ml of 70% ethanol solution. The solution container was covered by aluminum wrap and stored in a refrigerator. Then, 1 mL of DPPH solution was added to each dilution with three replicates. One hundred μL of each final solution was dropped into a tissue culture plate and placed in the dark for 45 min at room temperature. The tissue culture plate with solution was then analyzed by Micro plate. The absorbance of the mixture was measured at 515 nm.

#### 2.2.6 Sensory analysis

Dried mint and basil leaves were selected according to the physical properties and nutrition value described above. Dried mint, dried basil, dried licorice root, and dried fennel seed were mixed according to the proportions in Appendix 1. Hot water was added to the mixed herbal and steeped for 2 min. The herbal blended beverage was sensory tested by 50 respondents. The most accepted proportion of herb ingredients was chosen using 9-points Hedonic scale.

### 2.3 Statistical analysis

Results were presented as the mean and standard deviation for each analysis, as well as inferential statistics. Differences were considered to be significant at $p \leq 0.05$. Data were analyzed by Sigma Plot 12.5. The physical properties and sensory analysis were analyzed using paired–samples t-test and one-way analysis of variance (ANOVA) using SPSS 17.0. Sensory data was analyzed by Design-Expert 7.0.

## 3. Results and Discussion

### 3.1 Drying curves models

The moisture content in wet basis of fresh mint leaves and fresh basil leaves were 86.18±0.1% and 84.28±0.1%, respectively. Drying leaves were started with the initial moisture content and continued drying until no further changes observed. The final moisture contents in wet basis were shown in Table 2.

**Table 2** Final moisture contents of different drying temperatures for mint and basil leaves

| Samples | Moisture content (% wb) | |
|---|---|---|
| | **50ºC** | **55ºC** |
| Mint | 6.77±0.10$^{ns}$ | 6.87±0.10$^{ns}$ |
| Basil | 6.77±0.01$^{ns}$ | 6.80±0.06$^{ns}$ |

**Note:** Data was expressed as the mean ± standard deviation from three replicates. Mean values in the same row were compared by paired-samples t-test with significant difference at $p \leq 0.05$. *ns* = non-significant

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Moisture content of food was very important. Inappropriate amount of moisture content could affect physical and chemical properties of food, directly correlated to the freshness and stability of food products for consumers. Results from Table 2 showed that there was no significant difference in final moisture content between drying at 50ºC and 55ºC for both mint leaves and basil leaves. The variations of moisture content and drying rate differences of drying mint leaves and basil leaves were showed from Figure 1 and Figure 2.

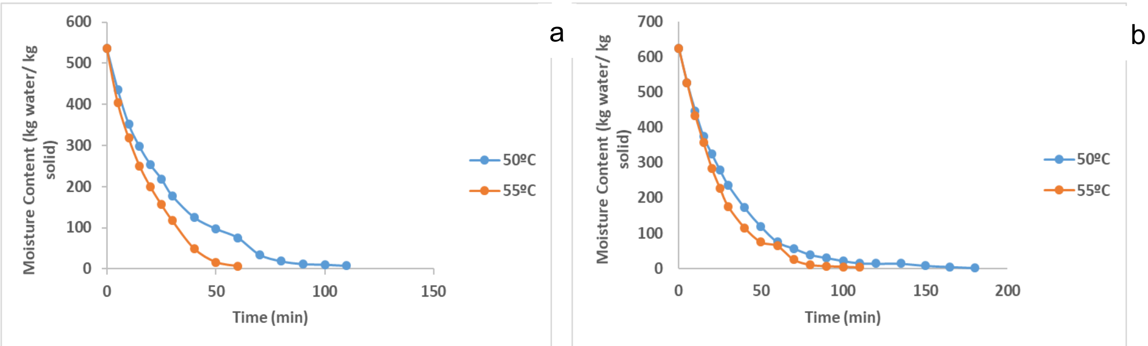


**Figure 1** Moisture content with drying time at 50ºC and 55ºC: a) mint leaves b) basil leaves

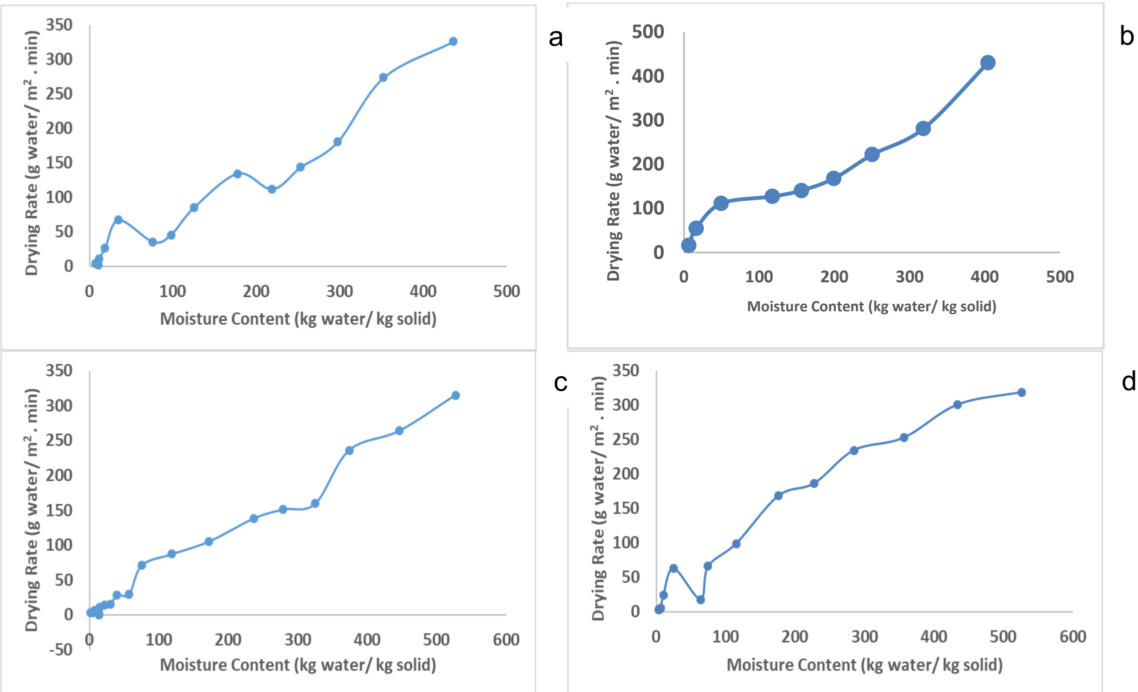


**Figure 2** Drying rate of sample vs moisture content, a) mint leaves at 50ºC, b) mint leaves at 55ºC, c) basil leaves at 50ºC, and d) basil leaves at 55ºC

From Figure 1-2, moisture content continuously decreased with drying time. The dehydration process completed when the moisture loss stopped. The drying rates were quite high at the beginning and continuously decreased with decreasing moisture content. The drying rates at 55ºC were higher than at 50ºC in first 30 min. After that, the drying rates of

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two different drying temperatures were not significantly different. It can also be noticed that an increase in air temperature significantly reduced the drying time of these leaves.

Generally, drying of food products occurs in 2 stages: the constant rate and falling rate (Babu *et al.*, 2018). The present study showed only the falling-rate period. This is in accordance with Lima-Correa *et al.* (2017), Doymaz *et al.* (2006), and Park *et al.* (2002) that drying curves of aromatic herbs under air temperatures from 30 to 60°C showed only the falling rate-drying period. For mint leaves, Doymaz (2006) and Etawil (2018) found that drying curves of mint leaves did not show a constant-rate period and showed only a falling-rate period. Lima-Correa *et al.* (2017) and Park *et al.* (2002) studied the drying characteristics for basil leaves and found similar results that drying curves of basil leaves showed only the falling-rate period.

Different prediction model would fit to different types of herbs and vegetables. In order to predict the drying, it is needed to find the model that best describes the drying. Drying models (shown in Table 1) were used to predict drying kinetic of mint leaves and basil leaves, and verified by root mean square error (RMSE), coefficient of determination ($R^2_{adj}$) and reduced chi-square, ($\chi^2$). The Sigma Plot 12.5 was used to analyze these models. Results were shown in Table 3.

**Table 3** Drying constant and coefficients of drying curve models

| Samples | Model names | Parameters | $R^2_{adj}$ | $\chi^2$ | RMSE |
|---|---|---|---|---|---|
| Dried mint at 50ºC | Henderson and Pabis | *a* = 1.0011, *k* = 0.0379 | 0.9920 | $368.28 \times 10^{-6}$ | 0.0497 |
| | Lewis | *k* = 0.0379 | 0.9920 | $337.25 \times 10^{-6}$ | 0.0479 |
| | Page | *k* = 1.0329, *y* = 0.0333 | 0.9925 | $468.98 \times 10^{-6}$ | 0.0481 |
| | Modified page | *k* = 0.0371, *y* = 1.0329 | 0.9925 | $468.98 \times 10^{-6}$ | 0.0481 |
| | Logarithmic | *a* = 0.9839, *k* = 0.0357, *c* = -0.0057 | 0.9974 | $297.29 \times 10^{-6}$ | 0.0173 |
| | Modified Henderson and Pabis | *a* = 0.0579, *k* = 0.2792, *b* = 0.4717, *g* = 0.0347, *c* = 0.4712, *ka* = 0.0347 | 0.9981 | $296.97 \times 10^{-6}$ | 0.0172 |
| Dried mint at 55ºC | Henderson and Pabis | *a* = 1.0702, *k* = 0.0610 | 0.9770 | $2147.54 \times 10^{-6}$ | 0.0947 |
| | Lewis | *k* = 0.0587 | 0.9737 | $1677.90 \times 10^{-6}$ | 0.0955 |
| | Page | *k* = 1.2250, *y* = 0.0265 | 0.9905 | $1364.85 \times 10^{-6}$ | 0.0610 |

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**Table 3** Drying constant and coefficients of drying curve models (Continue)

| Samples | Model names | Parameters | $R^2_{adj}$ | $\chi^2$ | RMSE |
|---|---|---|---|---|---|
| Dried mint at 55ºC | Modified page | *k* = 0.0516, *y* = 1.2250 | 0.9905 | $1364.85\times10^{-6}$ | 0.0610 |
| | Logarithmic | *a* = 1.0534, *k* = 0.0447, *c* = -0.0684 | 0.9982 | $245.11\times10^{-6}$ | 0.0157 |
| | Modified Henderson and Pabis | *a* = 0.3246, *k* = 0.0524, *b* = 0.3416, *g* = 0.0524, *c* = 0.3346, *ka* = 0.0524 | 0.9947 | $1268.00\times10^{-6}$ | 0.0356 |
| Dried basil at 50ºC | Henderson and Pabis | *a* = 0.9976 , *k* = 0.0330 | 0.9962 | $55.74\text{x}10^{-6}$ | 0.0317 |
| | Lewis | *k* = 0.0331 | 0.9962 | $52.06\times10^{-6}$ | 0.0308 |
| | Page | *k* = 0.9847 , *y* = 0.0352 | 0.9963 | $70.98\times10^{-6}$ | 0.0313 |
| | Modified page | *k* = 0.0334 , *y* = 0.9847 | 0.9963 | $70.97\times10^{-6}$ | 0.0313 |
| | Logarithmic | *a* = 0.9989, *k* = 0.0331, *c* = 0.0011 | 0.9995 | $58.33\times10^{-6}$ | 0.0077 |
| | Modified Henderson and Pabis | *a* = 0.3268 , *k* = 0.0330, *b* = 0.3398, *g* = 0.0330, *c* = 0.3329, *ka* = 0.0330 | 0.9995 | $70.84\times10^{-6}$ | 0.0085 |
| Dried basil at 55ºC | Henderson and Pabis | *a* = 1.0721, *k* = 0.0454 | 0.9914 | $685.07\times10^{-6}$ | 0.0532 |
| | Lewis | *k* = 0.0437 | 0.9883 | $778.44\times10^{-6}$ | 0.0599 |
| | Page | *k* = 1.1329 , *y* = 0.0260 | 0.9960 | $120.81\times10^{-6}$ | 0.0361 |
| | Modified page | *k* = 0.0399, *y* = 1.1329 | 0.9960 | $121.09\times10^{-6}$ | 0.0361 |
| | Logarithmic | *a* = 1.0361, *k* = 0.0393, *c* = -0.0181 | 0.9986 | $183.91\times10^{-6}$ | 0.0136 |
| | Modified Henderson and Pabis | *a* = 0.3411, *k* = 0.0412, *b* = 0.3473, *g* = 0.0412, *c* = 0.3364, *ka* = 0.0412 | 0.9979 | $356.72\times10^{-6}$ | 0.0189 |

The criteria for selecting the best fit model was the highest value of coefficient of determination ($R^2_{adj}$), as well as the lowest value of the reduced chi–squares ($\chi^2$) and root mean square error analysis (RMSE). Results from Table 3 showed that the Logarithmic model was the best fit model for tray drying basil leaves at 50ºC and 55ºC and mint leaves at 55ºC. For tray drying of mint leaves at 50ºC, the Modified Henderson and Pabis model was the best fit model. Figure 3 compared the moisture ratio of experimental data and predicted values.

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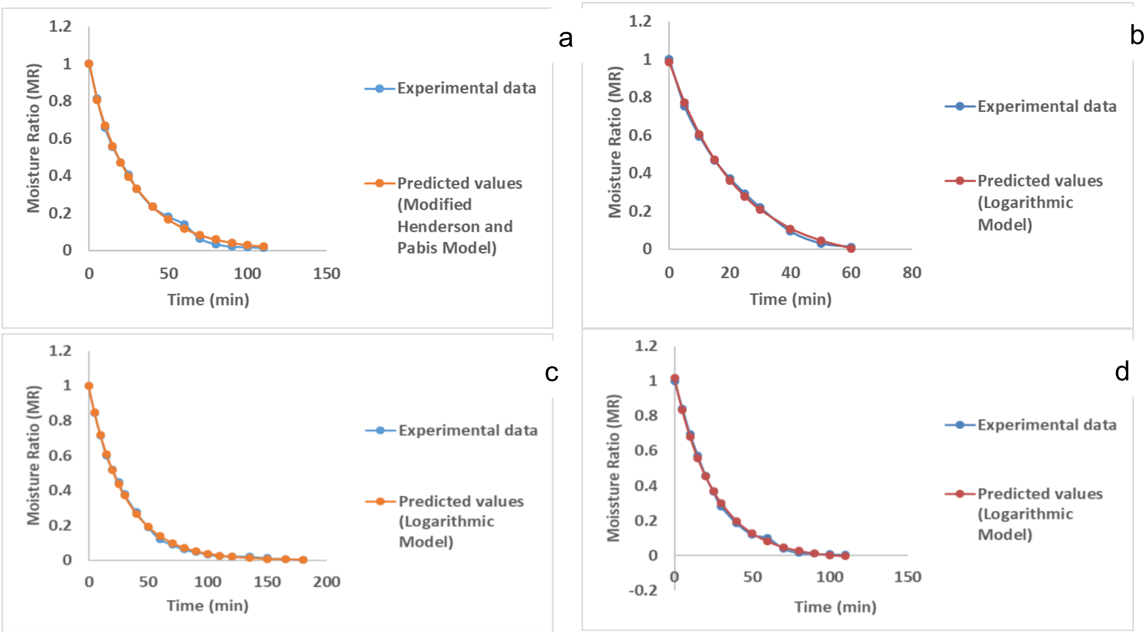


**Figure 3** Moisture ratio of experiment and model prediction with drying time a) mint leaves at 50ºC, b) mint leaves at 55ºC, c) basil leaves at 50ºC, and d) basil leaves at 55ºC

Comparing with previous studies for mint leaves, Therdthai and Zhou (2009) tested with 3 models: Lewis, Page, and Fick. They found that the Page model was best described the drying of mint leaves with RMSEs 0.0298 and 0.0458 for drying at 60ºC and 70ºC, Furthermore, this is similar to Doymaz (2006), that the logarithmic model was the most suitable model to describe the air drying of mint leaves when drying at 35–60ºC (with 0.0186–0.0467 RMSE). However, Park *et al.* (2002) fitted the Page model with drying curves and received satisfactory results ($R^2$ between 0.998–1.000). For basil leaves, several studies concluded different best fit model such as the Midilli and Kucuk's model Lima-Correa *et al.* (2017) and the Page model Gulcimen *et al*., (2016).

### 3.2 The physical properties of dried basil leaves and dried mint leaves

The physical properties of dried mint leaves and basil leaves were shown in Table 4.

**Table 4** Physical properties of dried mint and basil leaves by tray drying at 50ºC and 55ºC

| Properties | Dried mint | | Dried basil | |
|---|---|---|---|---|
| | 50ºC | 55ºC | 50ºC | 55ºC |
| L* | 42.230±0.168$^{a}$ | 41.600±0.035$^{ab}$ | 39.822±0.161$^{b}$ | 43.697±0.592$^{a}$ |
| C* | 10.803±0.073$^{a}$ | 10.363±0.023$^{ab}$ | 7.748±0.084$^{b}$ | 9.162±0.026$^{a}$ |
| h | 111.060±0.106$^{b}$ | 113.311±0.106$^{a}$ | 97.298±0.549$^{b}$ | 102.668±1.505$^{a}$ |
| $a_w$ | 0.547±0.010$^{ns}$ | 0.580±0.007$^{ns}$ | 0.525±0.014$^{ns}$ | 0.593±0.035$^{ns}$ |

**Note:** Mean ± standard deviation within the same row with different superscripts were significant different at $p \leq 0.05$. Mean ± standard deviation in table using paired-samples t-test, *ns* = non-significant

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Data from Table 4 showed the differences in coordinates of L*, C*, hº in color. L* value of dried mint at 55ºC was darker than at 50ºC but they were not significantly different. This is similar Therdthai and Zhou (2009). They concluded that different temperature in drying mint between 60ºC and 70ºC did not make significant different in color. (L*, a*, b* and E). On the contrary, L* value of dried basil at 55ºC was significantly higher than at 50ºC, meaning that the color of dried basil at 50ºC was darker than dried basil at 55ºC. The Chroma, C*, value of dried mint at 50ºC was higher than at 55ºC but not significantly different. However, the C* value of dried basil at 55ºC was significantly higher than at 50ºC. The hue angle, $h^{o}$, value of dried mint and dried basil at 55ºC was significantly higher than at 50ºC. Furthermore, there was no significant difference in water activity between two different drying temperatures. Therefore, drying mint leaves and basil leaves at 55ºC were chosen since drying time at 55ºC was less than 50ºC.

**3.3 Determination of nutrition value**

The antioxidant activity was indicated by the measurements of DPPH and total phenolic compound was shown in Table 5.

**Table 5** $IC_{50}$ and total phenolic compound in different temperatures of mint and basil leaves

| Samples | DPPH ($IC_{50}$ (mg/mL)) | TPC (mgGAE/1g material) |
|---|---|---|
| Fresh basil | 15.562±2.149 | 150.491±9.755 |
| Dried basil at 50ºC | 4.962±0.327 | 370.285±17.848 |
| Dried basil at 55ºC | 1.564±0.135 | 557.680±30.357 |
| Fresh mint | 20.568±1.485 | 215.011±3.483 |
| Dried mint at 50ºC | 2.572±0.233 | 394.824±16.499 |
| Dried mint at 55ºC | 1.838±0.145 | 1102.995±57.626 |

**Note:** $IC_{50}$, TPC of mint and basil leaves are the means ± SD. (n=3), GAE = gallic acid equivalent

The lower concentration of $IC_{50}$ and the higher concentration of GAE indicated the higher antioxidant activity. Data from Table 5 showed that the concentration of $IC_{50}$ from highest to lowest were fresh herbs, dried herbs at 50ºC, and dried herbs at 55ºC, respectively. In addition, the concentration of GAE from highest to lowest were dried herbs at 55ºC, dried herbs 50ºC, and fresh herbs. This indicated the highest antioxidant activity was from dried herbs at 55ºC. Besides the drying time, drying mint leaves and basil leaves at 55ºC were chosen for this reason.

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Therefore, it can be concluded that drying herbs with higher temperature yielded more antioxidant activity than lower temperature. This finding is similar to Samoticha, *et al.* (2016), who studied properties of dried chokeberries at different methods. They found that drying convection drying at 70ºC provided higher antioxidant activity than 60ºC and 50ºC (56.31, 52.23, and 49.56 mgTPC/1 g material). However, this finding is contrast to other research such as Rabeta and Vithyia (2013) that increasing the temperature of drying in hot air oven decreased the total phenolic compound of *Vitex negundo* Linn. tea, and Harbourne *et al.* (2009) that increasing drying temperature of meadowsweet leaves resulted in the loss of some phenolic compounds. Chan *et al.* (2012) studied the antioxidant and antibacterial properties of fresh and oven-dried herbs (oregano, marjoram, rosemary, sage, basil, thyme, peppermint, and spearmint). They found that herbs that were oven dried at 50ºC had the stronger antioxidant properties than 80ºC.

Furthermore, some studies found that oven drying did not affect total phenolic content (Chan *et al.,* 2013) studied effects of different drying methods on antioxidant properties, and found that total phenolic content using oven-drying remain unchanged while microwave and freeze drying methods increased in total phenolic content.

**3.4 Sensory analysis**

According to results above, dried mint at 55ºC and dried basil at 55ºC were chosen to mix with dried licorice roots and dried funnel seeds as ingredients for the herbal blended beverage. Fourteen different proportions dried basil, dried mint, licorice root, and fennel seed (shown in Appendix 1) were sensory tested by 50 respondents for 6 sensory attributes: appearance, color, odor, flavor, after taste, and overall. The results were shown in Appendix 2. Since p-values were all less than 0.05, it could be concluded that there were significant differences among treatments for all attributes. In addition, it was found that that treatment 8 received the highest score for all attributes: appearance, color, odor, flavor, after taste, and overall liking (ranged from 7.5 to 8.0). Therefore, the most appropriate proportion of the herbal blended beverage was 40% of dried mint, 10% of dried basil, 30% of dried licorice root, and 20% of fennel seed.

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**Appendix 1** The proportion of dried mint, dried basil, dried licorice root and dried fennel seed for herbal blended beverage

| Treatment | Mint (%) | Basil (%) | Licorice root (%) | Fennel seed (%) | Total (%) |
|---|---|---|---|---|---|
| 1 | 40.00 | 15.00 | 30.00 | 15.00 | 100.00 |
| 2 | 40.00 | 20.00 | 30.00 | 10.00 | 100.00 |
| 3 | 40.00 | 20.00 | 25.00 | 15.00 | 100.00 |
| 4 | 37.50 | 17.50 | 27.50 | 17.50 | 100.00 |
| 5 | 40.00 | 10.00 | 30.00 | 20.00 | 100.00 |
| 6 | 40.00 | 15.00 | 25.00 | 20.00 | 100.00 |
| 7 | 30.00 | 20.00 | 30.00 | 20.00 | 100.00 |
| 8 | 40.00 | 10.00 | 30.00 | 20.00 | 100.00 |
| 9 | 40.00 | 20.00 | 20.00 | 20.00 | 100.00 |
| 10 | 40.00 | 20.00 | 30.00 | 10.00 | 100.00 |
| 11 | 35.00 | 20.00 | 25.00 | 20.00 | 100.00 |
| 12 | 35.00 | 20.00 | 30.00 | 15.00 | 100.00 |
| 13 | 35.00 | 15.00 | 30.00 | 20.00 | 100.00 |
| 14 | 38.75 | 18.75 | 23.75 | 18.75 | 100.00 |

**Appendix 2** Sensory evaluation of herbal blended beverage

| Treatment | Appearance | Color | Odor | Flavor | After taste | Overall |
|---|---|---|---|---|---|---|
| 1 | 6.8±1.1 | 6.9±1.4 | 6.6±1.4 | 6.8±1.9 | 7.0±2.2 | 6.9±1.3 |
| 2 | 7.3±1.2 | 7.3±1.6 | 6.9±1.4 | 6.5±1.9 | 7.0±2.2 | 7.0±2.3 |
| 3 | 7.1±0.7 | 6.9±0.8 | 7.0±1.2 | 6.4±1.0 | 6.4±1.1 | 6.8±0.9 |
| 4 | 6.9±0.8 | 7.1±0.8 | 6.3±0.8 | 6.6±1.0 | 6.6±1.2 | 6.6±0.9 |
| 5 | 7.6±1.0 | 7.5±1.0 | 6.2±0.9 | 5.9±1.5 | 6.1±1.2 | 6.7±1.2 |
| 6 | 7.6±0.8 | 7.6±0.8 | 6.3±1.2 | 6.0±1.4 | 6.1±1.2 | 6.7±1.0 |
| 7 | 7.5±0.7 | 7.4±0.9 | 6.8±1.3 | 6.7±1.0 | 6.4±1.2 | 6.6±1.0 |
| 8 | 8.0±1.1 | 8.0±0.9 | 7.5±1.4 | 7.5±1.6 | 7.6±1.6 | 7.8±1.3 |
| 9 | 7.4±1.1 | 7.3±0.6 | 6.6±0.9 | 6.7±2.3 | 7.1±1.8 | 7.0±1.6 |
| 10 | 7.8±1.3 | 7.5±1.3 | 6.1±1.3 | 5.7±0.8 | 5.7±0.8 | 6.6±0.8 |
| 11 | 7.9±1.2 | 7.6±1.1 | 6.0±0.8 | 5.5±1.0 | 5.8±0.9 | 6.6±0.9 |
| 12 | 7.6±1.7 | 7.1±1.1 | 6.6±0.5 | 6.0±1.0 | 6.1±1.1 | 6.7±1.4 |
| 13 | 7.8±1.6 | 7.8±1.3 | 7.1±0.5 | 7.5±0.7 | 7.5±0.7 | 7.5±1.0 |
| 14 | 7.4±1.3 | 7.6±1.2 | 7.4±0.9 | 6.7±1.8 | 6.8±1.4 | 7.1±1.2 |
| **p-value** | **0.0498** | **0.0354** | **0.0444** | **0.0135** | **0.0401** | **0.0036** |

**Note:** Data was expressed as mean ± standard deviation

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## 4. Conclusions

This study was the development of herbal blended beverage with unique flavor and health benefits using 4 types of herbs: mint leaves, basil leaves, licorice root, and fennel seeds. Mint leaves and basil leaves were tray dried before mixing with the others. Results indicated that drying temperature affected the physical properties and antioxidant activity. The color of dried mint and basil leaves was best maintained at the 55ºC. The Logarithmic model was the best fit model in drying basil at 50ºC and 55ºC, and mint at 55ºC, while the Modified Henderson and Pabis was the best fit model in drying mint at 50ºC. In addition, the antioxidant activity of drying mint leaves and basil leaves at 55ºC was higher than at 50ºC. Therefore, mint leaves and basil leaves were tray dried at 55ºC. Fourteen different proportions of dried basil, dried mint, licorice root, and fennel seed were tested by 50 respondents for sensory analysis. Results showed that the herbal blended beverage with 40% of dried mint, 10% of dried basil, 30% of dried licorice root, and 20% of fennel seed was most accepted for all attribute: appearance, color, odor, flavor, after taste, and overall with score ranging from 7.5 to 8.0.

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