Effects of Two-stage Drying on Physical Properties of Chilli (*Capsaicum annuum* cv. HuarouYon)

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บทคัดย่อ

จากการศึกษาสมบัติทางกายภาพของพริกพันธุ์หัวเรือย่นโดยการอบแห้งแบบอุณหภูมิสองขั้น โดยศึกษาสมบัติทางกายภาพคือ สี อัตราการดูดน้ำกลับ และการหดตัว โดยอบแห้งขั้นที่หนึ่งที่อุณหภูมิ 60, 70 และ 80 องศาเซลเซียส เป็นเวลา 3, 4 และ 5 ชั่วโมง แล้วตามด้วยอุณหภูมิ 50 องศาเซลเซียส เปรียบเทียบกับการอบแห้งแบบอุณหภูมิขั้นเดียวที่อุณหภูมิ 70 องศาเซลเซียส จนกระทั่งความชื้นไม่น้อยกว่า 12 เปอร์เซ็นต์ฐานแห้ง จากการทดลองพบว่าความชื้นสุดท้ายอยู่ในช่วง 9.77-9.85 เปอร์เซ็นต์ฐานแห้ง ($p>0.05$) และปริมาณน้ำอิสระอยู่ในช่วง 0.42-0.44 ($p>0.05$) ตามลำดับ การอบแห้งแบบอุณหภูมิสองขั้นทำให้พริกมีค่าความสว่างสูงกว่าการอบแห้งแบบอุณหภูมิขั้นเดียว($p\leq0.05$) นอกจากนี้พบว่าการอบแห้งพริกที่อุณหภูมิ 70 องศาเซลเซียส เป็นเวลา 4 ชั่วโมง แล้วตามด้วยอุณหภูมิ 50 องศาเซลเซียส มีค่าความสว่างสูงกว่าการอบแห้งที่สภาวะอื่นๆและตัวอย่างควบคุม แต่อย่างไรก็ตามค่าความเข้มสี ค่ามุมของสี ของพริกไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ($p\leq0.05$) นอกจากนี้พบว่าค่าความแตกต่างของสีโดยรวมของพริกที่ผ่านการอบแห้งแบบอุณหภูมิสองขั้นมีค่าต่ำกว่าการอบแห้งแบบอุณหภูมิขั้นเดียว และพบว่าค่าอัตราการดูดน้ำกลับลดลงเมื่ออุณหภูมิและเวลาในการอบแห้งเพิ่มขึ้น โดยการอบแห้งที่อุณหภูมิ 70 องศาเซลเซียส เป็นเวลา 4 ชั่วโมง ช่วยทำให้อัตราการดูดน้ำกลับสูง และการหดตัวของพริกต่ำ

คำสำคัญ: พริก สมบัติทางกายภาพ การอบแห้งแบบสองขั้น

Abstract

This research aimed to study the physical properties of dried chilli (*Capsaicum annuum* cv. HuarouYon) by using two-stage drying. The main quality attributes of dried chilli were color, rehydration rate, and shrinkage. At the first stage, drying air temperatures and times were varied at 60, 70 and 80°C and 3, 4 and 5 hr and followed by 50°C drying until the moisture content was less than 12% (db) compared with one-stage drying temperature (70°C for 6 hr). The final moisture contents and water activities of dried chilli were 9.77-9.85% (db)($p>0.05$) and 0.42-0.44 ($p>0.05$) respectively. The lightness of chilli dried at two-stage temperature was significantly higher than one stage drying ($p\leq0.05$). It was found that using drying air temperature at 70°C for 4 hr and followed by 50°C provided a lighter color of chilli than other conditions and controls. However, the chroma value and hue angle of dried chilli did not significantly differ among different conditions ($p>0.05$). Moreover, the total color difference ($\triangle E$) of chilli dried at two-stage temperature was lower than one stage drying ($p\leq0.05$). The rehydration rate was

decreased with increasing drying temperature and time. The drying at 70°C for 4 hr at the first stage provided the highest rehydration rate and the lowest shrinkage of dried chilli ($p \leq 0.05$).

Keywords: Chilli: Physical properties: Two-stage drying

Introduction

Chilli (*Capsaicumannuum* L.) is a common vegetable regularly consumed in Thailand. This chilli is highly acceptable for its color and flavor, the main quality attributes that determine its overall quality and consequently its final market price [1]. Fresh chilli with high moisture content (300-400% db) after harvest is a highly perishable, the shelf-life of freshly harvested chilli being two or three days [2]. Thus, drying is normally a method used for fruit and vegetable preservation. Its main objective is the removal of water to the level at which microbial spoilage and deterioration reaction are minimized. The basic requirements for vegetable drying are that it must achieve the removal of the required amount of moisture in a reasonable time, obtain a product of acceptable quality, and minimize operative costs [3]. However, it is well known that during hot air drying, vegetables undergo physical, structural, chemical, and nutritional changes that can affect quality attributes such as texture, color, and flavor [4]. A common drying method was the use of one-stage drying with air temperature between 50-80°C [5]. It was found that drying with high temperature affected the physical properties, namely a loss of color and texture, and shrinkage. The use of two-stage drying provided a lighter color of dried chilli than one-stage drying [6]. Using multistage temperatures drying could reduce the loss of color and bioactive compounds of the food product [7], [8]. However, drying temperature and time for chill have not been optimized regarding different physical properties. Therefore, the objective of this work was to study the effects of two-stage drying on physical properties of dried chilli.

Material and methods

Raw Material

Fresh chilli (*Capsaicum annuum* L. cv. Huarou Yon) were grown and harvested in Sisaket province, Thailand and stored at 4-10°C before drying. The sample was selected visually by color, size, and freshness, and with no sign of mechanical damage. The average diameter was about 0.94 centimeters and the length was about 7.20 centimeters. The initial moisture content was 432.20 % (db). Blanching was conducted using hot water at 90° C for 3 min and then cooled in cold water before chemical pre-treatment. The blanched chilli was soaked in chemical solution combining 0.3% (w/w) sodium metabisulfite (NaMS) and 1% (w/w) calcium chloride for 10 min at room temperature [6]

Drying Method

A laboratory tray dryer was used by loading 500 g of chilli for each experimental run. At the first stage, drying air temperature were varied at 60, 70 and 80° C and recorded by the data logger (PRESICA 2002) connected with thermocouple type T. In addition, drying periods at first stage drying were varied at 3, 4 and 5 hr each temperature and followed using 50° C until the moisture content was less than 12% (db). One-stage drying temperature was conducted at 70°C for 6 hr as a control.

Determination of moisture content and water activity

The moisture contents of dried chilli at different drying conditions were analyzed using AOAC method [9]. The water activity of the chilli was measured using a Thermoconstanter (Nonasina, Model PS200 S/N 9809020).

Surface color measurement

The surface color of chilli was measured using a colorimeter (Universal Hunter Lab, Model 45/0 S/N CX-0413). Color was expressed in CIE system, L* (whiteness and black), a* (redness and greenness), and b* (yellowness and blueness). In addition, color intensity (Chroma), Hue angle, and total color difference (△E) were calculated using the following equations (1, 2 and 3 respectively) [10].

$$\text{Chroma} = \sqrt{(a^{*2} + b^{*2})} \quad (1)$$

$$\text{Hue angle} = \arctan b^*/ a^* \quad (2)$$

$$\triangle E^* = \sqrt{(L_f^* - L^*)^2 + (a_f^* - a^*)^2 + (b_f^* - b^*)^2} \quad (3)$$

Where L_f^* is the lightness of fresh chilli, a_f^* is the redness and greenness of fresh chilli and b_f^* is the yellowness and blueness of fresh chilli. L* is the lightness of dried chilli, a* is the redness and greenness of dried chilli and b* is the yellowness and blueness of dried chilli.

Rehydration Rate

The dried chilli was placed in a 125 ml Erlenmeyer flask containing 100 ml of distilled water a controlled temperature of 30°C for 24 hr in a water bath. The mass ratio between solid and liquid was 1:50. The chilli was drained for 1 min and weighed using 2-digit digital balance. The rehydration rate was calculated according to Eq. (4) and express as gram of water absorbed per gram dry matter [5].

$$\text{Rehydration Rate} = (M_f - M_o) \times 100 \quad (4)$$

Where, M_f is the weight of the sample after rehydration process (g), M_o is the weight of the sample after drying process (g).

Shrinkage analysis

The diameter (head and middle part) and length of the chilli were measured by using vernier calipers. The experimental data was obtained from five replications. The volume and shrinkage percentage were calculated according to Eqs. (5 and 6).

$$V = ¶\, r^2 h \quad (5)$$

$$\% \text{ Shrinkage} = (V_o / V_f) \times 100 \quad (6)$$

Where, ¶ is a constant value (3.14), r is a diameter of chilli (cm) and h is a length of chilli (cm), V_o is initial volume of fresh chilli (cm^3) and V_f is final volume of dried chilli (cm^3).

Statistical analysis

Statistical analysis was conducted using ANOVA and Duncan's New Multiple Range Test (SPSS version 16 for window) with a significant level of α=0.05 and confidence interval of 95% ($p<0.05$). All experiments were conducted with three replications.

Results and Discussion

Moisture content and water activity

The moisture contents of the dried chilli under different drying conditions were between 9.77±0.10 - 9.85±0.12 % (db) and the water activities were 0.42±0.02 - 0.44±0.01. The value did not significantly different among different conditions ($p>0.05$).

Color value

As shown in Figure 1, the lightness of dried chilli using two-stage drying was higher than one-stage drying ($p \leq 0.05$). The highest value of lightness was found at 60°C for 5 h., 70°C for 3 hr. and 70°C for 4 hr. followed by 50°C.

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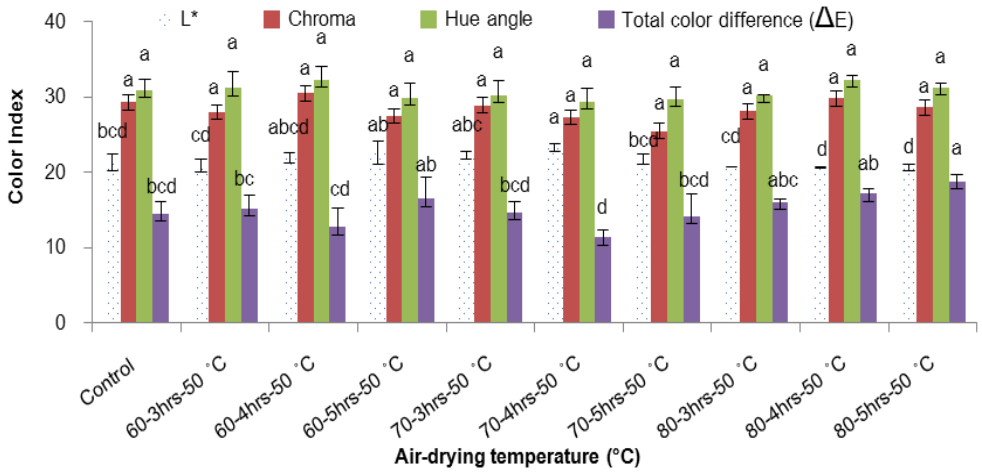

Figure 1 Color Index of dried chilli (cv. HuarouYon) using different two-stage drying air temperatures

This result agreed with the finding of [7] and [8] who suggested that using stepwise temperature drying such as cyclic or multistage temperature can preserve the color of food products. However, two-stage drying did not affect Chroma and Hue angle ($p>0.05$) (Figure 1). However, a decrease of chroma value was observed with increases in drying temperatures at first stage drying. The hue angle was commercially acceptable in the range of 30-35 degree on the basis of chilli powder, which is a redish-orange hue color [11]. This result agreed with finding of [6]. The lowest total color difference was found at 70°C for 4 hr, followed by 50° C. However, a decrease of △E value was observed with an increase in drying temperature at first stage drying. The result was compatible with the lightness result (figure 1) by using drying air temperature at 70° C for 4 hr which provided the highest lightness value.

Rehydration Rate

The rehydration rate of dried chilli using two-stage drying compared with one stage drying is shown in Table 1. The highest rehydration rate was found at 70° C, 4 hours at first stage drying. The rehydration rate decreased with increasing drying temperature and drying period at first stage drying. It was clearly observed that rehydration rate decreased with increasing drying air temperature from 70° C - 80° C. The lower rehydration rate due to a damage of cellular structure by using high temperatures resulted due to the modification of osmotic properties of the cell as well as lower diffusion of water through the surface during rehydration [12].

Table 1 Rehydration rate and shrinkage percentage of dried chilli (cv. HuarouYon) using two-stage drying.

Conditions	% Shrinkage	Rehydration rate
Control	55.32±0.97^{B}	41.98±0.67^{cde}
60-3hrs-50˚C	53.06±1.03^{CD}	44.81±0.75^{bcd}
60-4hrs-50˚C	52.70±1.67^{DE}	45.94±3.49^{abc}
60-5hrs-50˚C	51.29±0.66^{EF}	46.92±1.04^{b}
70-3hrs-50˚C	51.27±0.36^{EF}	50.09±1.36^{bc}
70-4hrs-50˚C	50.55±0.76^{F}	53.82±0.68^{a}
70-5hrs-50˚C	53.42±1.25^{CD}	45.28±0.50^{bc}
80-3hrs-50˚C	54.63±0.53^{BC}	44.27±1.50^{de}
80-4hrs-50˚C	55.34±0.36^{B}	41.15±0.89^{de}
80-4hrs-50˚C	59.98±0.70^{A}	39.94±1.96^{e}

$^{A-F}$ effect of two-stage drying on shrinkage of dried chilli ($p \leq 0.05$).$^{a-e}$ effect of two-stage drying on rehydration rate of dried chilli ($p \leq 0.05$)

The result was compatible with shrinkage. The shrinkage of dried chilli was found to be affected by the drying temperature and drying periods. The lowest of shrinkage was found at 70°C, 3 hr and 70°C, 4 hr. The increasing cell compactness of dried chilli was observed with increasing drying air temperature and time due to cellular structure damage and pectin solubilization [13].

Conclusion

The effects of two-stage drying were on physical properties, color index, rehydration rate, and shrinkage of dried chilli. Two-stage drying could improve the lightness of dried chilli compared with the control. The highest lightness was found at 70°C for 4 hr. Moreover, two-stage drying provided the lowest total color difference and shrinkage with the highest rehydration rate.

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