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*Research Article*

# Preliminary study of chili drying using microwave assisted vacuum drying technology

**Sankrit Tontand and Nantawan Therdthai***

Department of Product Development, Faculty of Agro–Industry, Kasetsart University, Bangkok 10900, Thailand

*Author to whom correspondence should be addressed, email: faginwt@ku.ac.th

**Abstract:** Chili is a heat sensitive material and conventional hot air drying generally produces poor quality of dried chili with unattractive colour. To improve the product quality, microwave assisted vacuum drying was studied. Red chili, *Capsicum annuum*, was pretreated by various treatments including blanching at 100°C (6 min), soaking in 0.5% citric solution (20 min), soaking in 2.0% sodium chloride solution (20 min) with blanching and soaking in 0.5% citric solution (20 min) with blanching. The pretreated samples were dried, using two different microwave powers and times. Results indicated that the chili pretreated with 0.5% citric acid solution and dried at 160 mmHg pressure and 1,120W microwave power for 60 minutes yielded dried chili containing similar colour to fresh chili. Increasing the microwave power to 1,600 W and reducing drying time to 40 minutes tended to reduce redness, yellowness and lightness of dried chili ($p \leq 0.05$). Therefore, pretreatment with citric acid or blanching was required to maintain colour of dried chili when high microwave power was applied. For rehydration test, increasing microwave power and decreasing drying time could improve the weight gain ratio of dried chili.

**Keywords**: food, rehydration, product quality, Thailand

## Introduction

Chili (*Capsicum annuum)* is consumed as both a raw and cooked vegetable, as well as being commonly used in making paste, pickles and sauce. Chili has a high vitamin content (C, B and E), flavanoids, capsaicin and minerals. It is perishable and its physiological and morphological changes occur after harvesting. Due to the changes, chili might be unacceptable for consumption. This research examines using a citric solution to preserve colour during drying. Blanching was also conducted to inactivate enzymes that produce off-flavour and release intracellular gases of the plant tissue.

Drying has been used for decades in chemical and food processing industries for long-term preservation of the final product. The main objective of drying is to remove water from products to avoid microbial spoilage. As chili is very sensitive to temperature, designing the drying condition can be critical to a successful operation. Normally, conventional hot air drying temperature is maintained between 50 and 70°C for a long period of time. Due to the long drying process and over-heated surface during hot air drying, the problem of darkening in colour, loss in flavour and decrease in rehydration ability can occur [1]. To prevent significant quality loss and to achieve fast and effective dehydration, the microwave assisted vacuum drying technology has been introduced to dried food.

Microwave heating is rapid and energy efficient, compared to conventional hot air drying. However, too rapid mass transfer may cause burning spots and non-uniform heating. Microwave-vacuum drying combines the advantages of both microwave heating and vacuum drying. Low temperature conferred by vacuum drying combined with rapid energy transfer by microwave heating generates very rapid and low temperature drying. Thus it has the potential to improve energy efficiency and product quality. Some fruit and grains have been successfully dried by microwave-vacuum drying techniques [2, 3, 4, 5, 6, 7, 8]. The aim of this study was to investigate the effect of pretreatment and microwave-vacuum drying on dried red chili quality.

## Material and Methods

### *Materials*

Fresh red chili (*Capsicum annuum*) obtained from a local market was kept in cold storage at 10-15°C until it was used (within one week). Generally, chili pod size was 6-7 cm length. Moisture content of the samples was determined by infrared moisture analyzer (Sartorius MA50, Scientific LTD). The average initial moisture content of the red chili was 69.5%, wet basis.

### *Methods*

Fresh chili was divided into 4 groups. Each group was pretreated by different methods including 1) steam blanching at 100°C for 6 minutes, 2) soaking in 0.5% critic acid for 20 minutes, 3) soaking in 2% sodium chloride for 20 minutes and 4) blanching and soaking in 0.5% citric acid and blanching. Then all groups of pretreated red chili were pre-dried in a hot air oven at 55°C for 90 minutes. After that, 500g pre-dried chili was dried using microwave assisted vacuum drying. There were two drying conditions including 1600 W microwave power for 40 minutes and 1120 W microwave power for 60 minutes. Both conditions were controlled at 160 mmHg. The experiments were undertaken in two replications.

For quality evaluation, moisture content (with three measurements) and colour (with ten measurements) of samples were measured before and after drying by infrared moisture analyzer (Sartorius MA50, Scientific LTD) and Chroma Meter (Minolta CR 200, Japan), respectively. The colour values were expressed as L*(lightness), a*(redness/greenness) and b*(yellowness/blueness). For the rehydration test for 50 minutes, the ratio of dried samples and water (60°C) was 1:10. During rehydration, sample weights were recorded at

10, 20, 30, 40, and 50 minutes. Weight gain ratio was determined by follows:

$$Weight\_gain\_ratio = \frac{(W_t - W_d)}{W_d} \quad (1)$$

where $W_t$ is weight after rehydration at time t and $W_d$ is weight before rehydration at time t.

## Results and Discussion

### *Effect of pretreatment and drying conditions on moisture content*

Pretreated chili was dried under two conditions and the moisture content is shown in Table 1. Blanching tended to produce dried chili containing lower moisture content, compared with the chemical pretreatment alone. This was because of heat that may damage the cell walls of chili, thereby enhancing water removal. In addition, drying conditions affected moisture content of dried chili ($p \leq 0.05$). With the same pretreatment condition, moisture content after drying at 1600 W for 40 minutes and drying at 1120 W for 60 minutes was not significantly different ($p > 0.05$). Therefore, increased microwave power could shorten drying time. The increased dehydration rate from increased microwave power was also found in drying carrot [9] and mint leaves [10, 11].

**Table 1. Effect of pretreatment and drying conditions on moisture content of red chili.**

| Pretreatment condition | Drying condition (power, vacuum, time) | Moisture content (%) |
|---|---|---|
| Control (without pretreatment) | 1600 W, 160 mmHg, 40 min | 2.05±0.64[a] |
| Blanching at 100°C for 6 min | 1600 W, 160 mmHg, 40 min | 1.98±1.09[ab] |
| 0.5% citric acid for 20 min | 1600 W, 160 mmHg, 40 min | 2.55±0.95[ab] |
| 2% sodium chloride and blanching | 1600 W, 160 mmHg, 40 min | 1.27±0.39[ab] |
| 0.5% citric acid and blanching | 1600 W, 160 mmHg, 40 min | 0.96±0.05[b] |
| Control (without pretreatment) | 1120 W, 160 mmHg, 60 min | 2.36±0.22[ab] |
| Blanching at 100°C for 6 min | 1120 W, 160 mmHg, 60 min | 0.79±0.18[b] |
| 0.5% citric acid for 20 min | 1120 W, 160 mmHg, 60 min | 1.62±0.40[ab] |
| 2% sodium chloride and blanching | 1120 W, 160 mmHg, 60 min | 1.33±0.13[ab] |
| 0.5% citric acid and blanching | 1120 W, 160 mmHg, 60 min | 1.13±0.06[b] |

Note a-b: means within the same column by different letters are significantly different ($p \leq 0.05$).

### Effect of pretreatment and drying conditions on colour of dried chili

Table 2 presents colour (L*, a* and b*) of dried chili that was pretreated and dried under different conditions. Microwave vacuum drying reduced redness (a*-value) of dried chili significantly ($p \leq 0.05$). High microwave power (1600W) tended to yield less redness and yellowness than low microwave power (1120W) ($p \leq 0.05$), unless pretreatment with 0.5% citric acid solution was used. Blanching with or without citric acid also improved yellowness of dried chili, compared with control. To maintain yellowness and lightness (L*-value) of dried chili, low microwave power (1120W) could be applied without pretreatment. When high microwave power was applied, either blanching or soaking in 0.5% citric acid solution was required to maintain lightness of dried chili. Impact of increased microwave power on colour change was possibly due to too rapid heating and

mass transfer. As a result, burning may be found, particularly at the final drying stage [12, 13].

**Table 2. Effect of pretreatment and drying conditions on colour of dried red chili.**

| Pretreatment condition | Drying condition (power, vacuum, time) | L* | a* | b* |
|---|---|---|---|---|
| Control (without pretreatment) | 1600 W, 160 mmHg, 40 min | 23.7±1.3$^{cd}$ | 10.5±2.5$^{de}$ | 7.7±1.4$^{cd}$ |
| Blanching at 100°C for 6 min | 1600 W, 160 mmHg, 40 min | 26.1±1.0$^{abc}$ | 12.1±1.4$^{de}$ | 9.5±1.6$^{bcd}$ |
| 0.5% citric acid for 20 min | 1600 W, 160 mmHg, 40 min | 26.4±0.5$^{abc}$ | 13.7±0.2$^{cde}$ | 12.0±2.5$^{abc}$ |
| 2% sodium chloride and blanching | 1600 W, 160 mmHg, 40 min | 22.3±1.8$^{d}$ | 9.2±0.4$^{e}$ | 6.9±0.5$^{d}$ |
| 0.5% citric acid and blanching | 1600 W, 160 mmHg, 40 min | 24.2±1.2$^{bcd}$ | 14.4±2.1$^{de}$ | 9.2±1.2$^{bcd}$ |
| Control (without pretreatment) | 1120 W, 160 mmHg, 60 min | 27.2±0.6$^{a}$ | 20.5±1.3$^{b}$ | 14.7±2.0$^{a}$ |
| Blanching at 100°C for 6 min | 1120 W, 160 mmHg, 60 min | 26.7±0.2$^{ab}$ | 18.1±1.9$^{bcd}$ | 13.3±0.9$^{ab}$ |
| 0.5% citric acid for 20 min | 1120 W, 160 mmHg, 60 min | 28.8±0.7$^{a}$ | 23.9±1.7$^{b}$ | 15.5±1.6$^{a}$ |
| 2% sodium chloride and blanching | 1120 W, 160 mmHg, 60 min | 24.2±0.3$^{bcd}$ | 17.5±2.5$^{bcd}$ | 11.9±2.5$^{abc}$ |
| 0.5% citric acid and blanching | 1120 W, 160 mmHg, 60 min | 26.7±2.2$^{ab}$ | 19.9±2.4$^{bc}$ | 15.6±2.3$^{a}$ |
| Fresh chili | | 27.0±1.3$^{a}$ | 30.0±1.4$^{a}$ | 12.5±2.1$^{ab}$ |

Note. a-e: means within the same column by different letters are significantly different ($p \leq 0.05$).

***Effect of pretreatment and drying conditions on rehydration***

After drying, chili was rehydrated in warm water ($60^0$C). The rehydration rate is shown in Figures 1 and 2. Pretreatment and drying conditions significantly affected weight gain ratio of dried red chili ($p \leq 0.05$). Pretreatment by soaking in 0.5% citric acid solution, together with blanching, showed the highest weight gain ratio. This was because the cell walls of the product had disintegrated and released air from the tissue. The structure of dried samples then became porous.

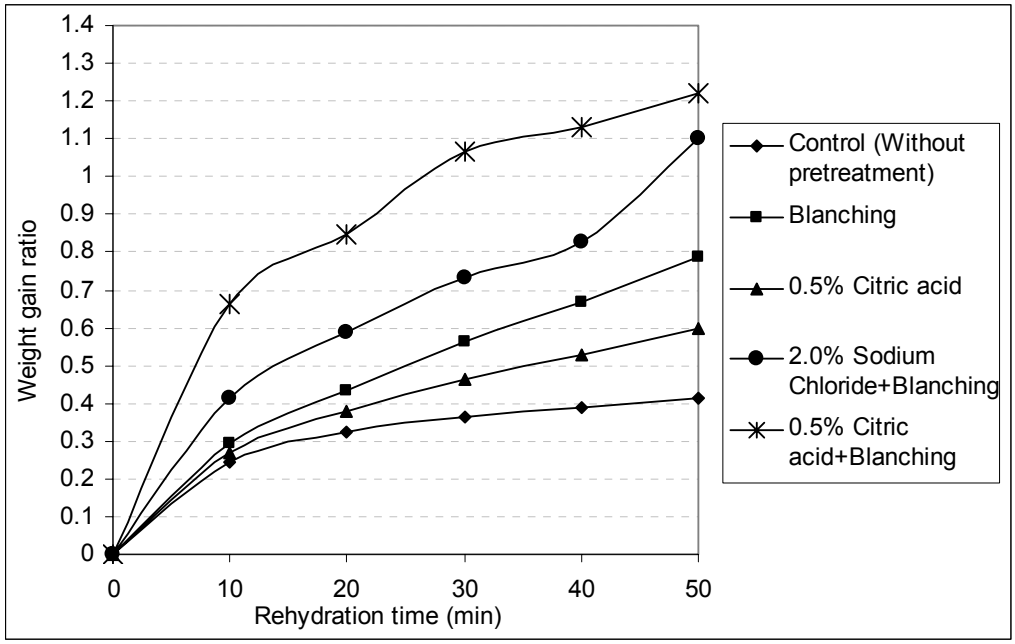


**Figure 1. Effect of pretreatment on rehydration ratio of red chili dried at 1600 W microwave power, 160 mmHg for 40 minutes.**

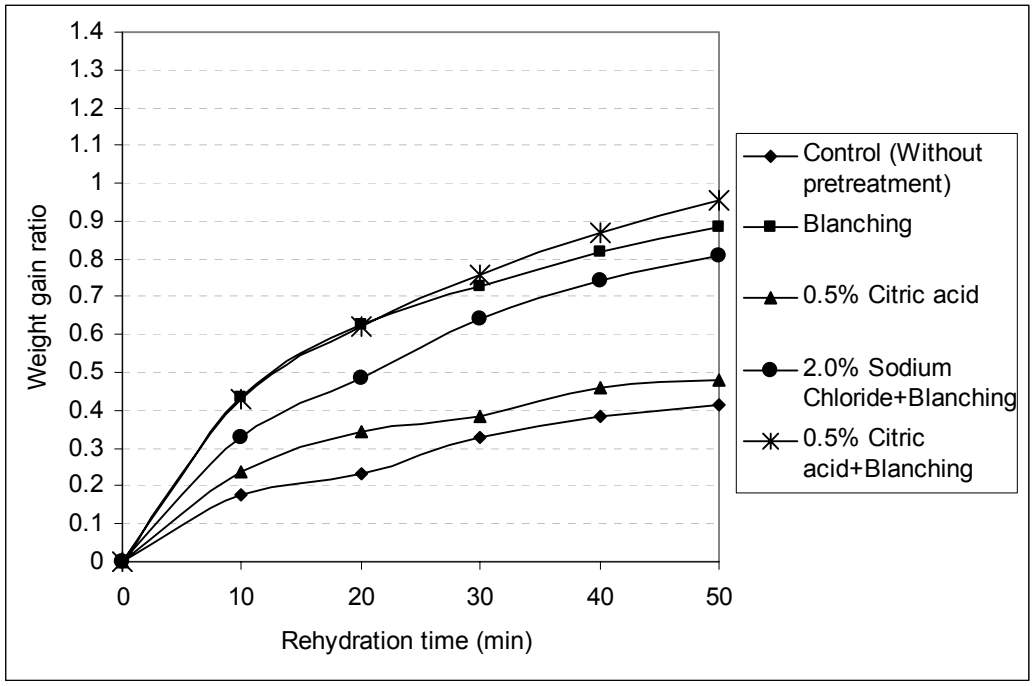


**Figure 2. Effect of pretreatment on rehydration ratio of red chili dried at 1120 W microwave power, 160 mmHg for 60 minutes**.

In addition, it was found that the rehydration ratio could be improved by increasing microwave power under vacuum condition. This was possibly due to reduced shrinkage of dried chili. By using microwave-vacuum heating, the vapour pressure differential between the centre and the surface of product could be very large, resulting in volume expansion and puffing characteristics [5]. The resultant puffing could be beneficial to the rehydation performance. Similar results were reported by Drouzas and Schubert [3], Durance and Wang [4], Pappas, Tsami and Marinos-Kouris [14] and Giri and Prasad [15].

## Conclusions

Microwave-vacuum drying with 1120 W microwave power for 60 minutes could maintain colour of dried chili to be similar to fresh samples. However, during rehydration, the obtained dried chili showed less weight gain ratio than that dried under 1600W microwave power for 40 minutes. Increasing microwave power could reduce shrinkage characteristics, thereby improving rehydration performance. However, using high microwave power affected colour change. To reduce colour change, pretreatment with 0.5% citric acid solution and blanching should be applied before microwave-vacuum drying.

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