DRIYING OF CHILI PEPPER IN DIFFERENT CONDITIONS

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Abstract-The effects of various pretreatments and drying methods in sun and convection hot air on the kinetics and quality parameters of red chilli pepper were studied. Before the drying process, red chilli peppers were subjected to blanching with boiling water, potassium carbonate and ethyl oleate and then dehydrated by various drying methods. The results illustrated that, pretreated peppers with boiling water and dried at 75°C had the lowest drying time so that they hadn’t significant difference with pretreated peppers with ethyl oleate and dried at 75°C (p<0.01). Evaluation of pepper quality properties indicated that, increasing drying temperature had positive effect on the vitamin C, so that, pretreated peppers with potassium carbonate and dried at 55°C was the highest vitamin C and nutritional content. The best color score was observed in the samples pretreated with potassium carbonate and dried at 65°C. The maximum rehydration ratio was observed in untreated samples (blank) dried at 55°C which didn’t have significant difference (p<0.01) with the water blanched samples dried at 65°C.

Keywords: Pretreatments, Quality parameters; Sun drying; Convective drying.

I. INTRODUCTION

Red chilli pepper is one of the broadly used varieties of pepper and belongs to the family Capsicum frutescens. This product can be used fresh or cooked, and it is typically used in making pastes or sauces (Akintunde, 2010). Red chilli peppers are good sources of vitamins A and C, and are rich in β-carotene and minerals such as potassium (Akintunde, 2010). In order to extend the shelf life of chilli pepper and utilize it in all seasons, it is usually dried after harvest. The traditional sun drying of red pepper is very slow (and takes 7-10 days depending on the weather conditions), the final moisture content cannot be controlled and a relatively low quality dried product is obtained. In this method, chillies become contaminated with dust, dirt, rainfall, animals, birds, rodents, insects and microorganisms (Hossain and Bala, 2007). Under these conditions, losses will reach up to the range of 40-60% of total quantity. This is the reason that different pretreatments and drying techniques have been adopted to reduce drying time and protect the nutritional properties of fresh vegetables during dehydration process. Various pretreatments including blanching (as hot water and steam), osmotic dehydration and usage of chemical agents (potassium meta bisulphate, potassium and sodium hydroxide, potassium carbonate, methyl and ethyl ester, citric acid and ascorbic acid) have been a number of pretreatments practiced in food drying. Blanching inactivates the enzymes (responsible for creating off-flavors in food), increases drying rate and fabricates the final product with desire quality. Overall, the quality of final product can be improved by removal of surface resistance of fruits and vegetables. Akintunde (2010) examined various blanching methods and osmotic treatment at 60 and 70°Brix sucrose concentrations and concluded that the pretreated pepper samples compared to untreated samples were dried faster.

The main object of this research was study the effect of drying process on chilli peppers pretreated with blanching methods (as hot water and steam) and potassium carbonate and ethyl oleate, and subsequently dried in the sun and in a hot-air dryer. Also, its quality factors were determined and they compared in different methods.

II. MATERIALS AND METHODS

Raw material preparation

Red chilli pepper (Capsicum annum) was purchased from a local market. In order to reduce the biological and respiratory activities until experiment time, they placed in a refrigerator at temperature of 4.6-7.2°C. The initial moisture content of fresh chilli was measured 80-90% (w.b) which it is obtained by using an oven at 105°C (AOAC, 1990). After washing the cooled chili pepper (stored in 5°C refrigerator), they were cut into 2.5×2.5 cm pieces (by using a caliper) and the uniform samples with weight of 30g were selected for further processes.

Prerreatments

The following treatments used for chilli pepper before drying:
- Blank (B): Untreated sample.
- Water blanching (WB): Pepper samples soaked in a hot water bath at 90°C for 3 min and then drained on a metal mesh to remove excess water.
- Ethyle oleate blanching (EOB): Pepper samples dipped in a solution containing 2% ethyle oleate at ambient temperature for 1 min followed by draining on a similar mesh.


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- Potassium carbonate blanching (PCB): Pepper samples dipped in a solution containing 5% potassium carbonate at ambient temperature for 1 min followed by draining on a similar mesh.

Drying
The treated and untreated (blank) samples were dried at three temperatures of 55°C, 65°C and 75°C in a conventional air drier (made by Grook company in Iran) until their weights remained constant. This drier was equipped with a fan to circulate air for at least 30 min to reach the desired temperature before each test. The weight control was done by a digital balance (AND, model FX-CT SERIES, FX-300 CT, Japan) in the time intervals of 15 min. After drying process was completed, the samples were cooled and packaged in polyethylene bags. Each experiment was carried out in triplicate.

For sun drying, the treated and untreated pepper samples were placed on a clean cloth and exposed to direct sunlight for several days until its weight did not decreased and became constant. Every hour the samples were weighed and the weight change was calculated. Sample weighting was carried out during the day light from 9 am to 5 pm, due to the fact that significant moisture loss took place at these hours. The sun drying experiments were carried out in Nishapur City (located at northeast of Iran) and Figure 1 shows the average temperature and relative humidity of the ambient air during the day times of October 2013 in this place. According to data obtained from the local weather station the average wind speed during this month, was equal to 7 m/s.

Each experiment was carried out in the three replicates.

\[ \text{Drying time (d)} \]

\[ \text{Temp} + \text{RH} \]

\[ \text{Average temperature (°C)} \]

\[ \text{RH} \]

Figure 1. Average temperature and relative humidity during the day in the sun drying process of red chili.

Physical and chemical tests
In this study, vitamin C content was measured according to AOAC standard method No. 967.21 (AOAC, 1990). Color of chili pepper was calculated according to ASTA (American Spice Trade Association) method. Around 70-100mg of chili pepper was added into about 100 ml acetone in a beaker and kept in the dark storage for 16h at an ambient temperature. The absorbance of an aliquot of the pure acetone (as a blank) and prepared samples were measured at 460nm using a Spectrophotometer (Shimadzo, Model UV-120-02, Japan). The ASTA color value, shrinkage and rehydration ratio of the dried samples were computed by equations 5, 6 and 7 obtained from (Vega-Gálvez et al., 2009), (Devahastin et al., 2004), and (Doymaz and Ismail, 2011) respectively.

\[ \text{ASTA color value} = \frac{\text{Absorbance of acetone extract} \times 16.4 \times I_c}{\text{Sample weight (g)}} \]  

\[ \% \text{Shrinkage} = \frac{V_i - V_f}{V_i} \times 100 \]  

\[ RR = \frac{W_d}{W_i} \]  

In these equations, \( I_c \) is correction coefficient of instrument in the range of 0.4-0.6 and it is considered an average equal to 0.5, \( V_i \) is initial sample volume before drying and \( V_f \) is sample volume after drying, \( RR \) is rehydration ratio, \( W_d \) and \( W_i \) are the sample weight before and after rehydration, respectively.

Statistical analysis
The Statistix program version 8 was used to make ANOVA (analysis of variances) for the recorded data, and comparison of means was determined by using least significant difference (LSD) test at a probability level of 99%.

III. RESULTS AND DISCUSSION

Drying kinetics
In this research, drying of red chilli pepper under different conditions was investigated. The variation of moisture content vs. drying time shows a downward trend, so that, slope of drying curve is faster in the sample pretreated with ethyl oleate (Figure 2). This state is due to the solvent ability of ethyl oleate and solving the waxy skin and cell wall structure of pepper which it will be reduce drying time. Doymaz and Pala (2002) studied drying of another type of pepper with various treatments and obtained similar findings. They reported that, dried pepper with 2% ethyl oleate accelerates drying rate and reduces drying time. Red chilli pepper did not show a constant drying rate period (CRP) under the experimental conditions but exhibited a falling rate period (FRP) like most food products. A similar result was observed by Kaymak-Ertekin (2002). He studied drying and rehydrating kinetics of green and red peppers.
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According to the ANOVA results (Table 1) for the influence of drying air temperature and pretreatment type showed that these variables had pronounced effects on color of dried chilli pepper at 99% probability level. The results illustrated that, chilli pepper pretreated with potassium carbonate and dried at 65°C obtained significantly the highest color value among dried samples pretreated with different methods. Vega-Gálvez et al. (2009) reported similar results when they showed that the increasing of drying air temperature was the cause of red pepper color changes. They stated that, ASTA color more dependent on carotenoid properties of red pepper (such as capxantine, capsorubin and β-carotene) rather than drying air temperature. According to Guiné and Barroca (2012), the discoloration of chilli pepper during drying process is due to the oxidation (enzymatic and non-enzymatic) of its carotenoid compounds. Different pretreatments have been suggested to prevent pigment degradation during dehydration.

On the other hand, pretreatment with ethyl oleate has positive effects on drying conditions of chilli pepper. Doymaz and Pala (2002) showed that, fresh peppers immersed with 2% ethyle oleate had an accelerated drying rate, shorter drying time and produced a product with its attractive color of fresh product. The ANOVA results show the influence of various pretreatments and drying air temperatures on shrinkage of dried chilli pepper. Table 1 displays clearly that the different pretreatments and drying air temperatures had pronounced and significant effects (P<0.01) on both shrinkage and vitamin C content of dried chilli pepper. Furthermore, the chilli pepper pretreated with water blanching and air dried at 75°C had the highest and significant amount of shrinkage. Conversely, the lowest shrinkage value was observed in sun dried chilli pepper. Too much shrinkage at high drying temperatures was probably due to difference between the sample temperature and its glass transition temperature. According to (Champion et al., 2000; Mayor and Sereno, 2004), the structural mobility of the matrix in product during drying was not enough to support the structure of the solid material and more collapse and shrinkage occurred. The vitamin C content of samples treated with potassium carbonate or ethyl oleate and then dried at 55°C were significantly higher the sun dried untreated (blank) sample. Additionally, the lowest amount of vitamin C content was remarked for untreated (blank) samples of sun drying or dried at 65°C and 75°C. Vega-Gálvez et al. (2009) showed that increasing drying air temperature of chilli pepper up to 90°C caused 98.2% reduction of vitamin C in comparison with the fresh product. They stated that, this is due to the irreversible oxidative process of water-soluble vitamin C during drying. Mota et al. (2010) made a similar statement when they studied the vitamin C oxidation during the drying process. The ANOVA results of this study also showed that the kind of pretreatment and drying air temperature had meaningful effect (p<0.01) on the rehydration ratio of dried chilli pepper (Table 1). While the highest rehydration ratio was observed in untreated sample (blank) dried at 55°C, its difference with untreated and water blanched samples dried at 65°C was not significant. The high rehydration ratio of chilli pepper is quite exceptional in comparison with drying of other fruit vegetables and fruits. Doymaz (2007) showed that increasing drying temperature of tomatoes (pretreated with 2% ethyl oleate + 4% potassium carbonate) reduces the rehydration rate. Similar results were observed when Doymaz and Ismail (2011) dried sweet cherry pretreated with 2% ethyl oleate + 4% potassium carbonate.

**Quality properties**

**Figure 2.** Drying curves of chilli pepper in different treatment (a) 55°C, (b) 65°C, (c) 75°C and (d) sun drying.

(a) 55°C, (b) 65°C, (c) 75°C and (d) sun drying.
**Table 1.** Quality parameters of chilli pepper in different drying conditions

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Vitamin C (%)</th>
<th>Crude protein (AST unit) (%)</th>
<th>Shrinkage (%)</th>
<th>Rehydration ratio (g/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-55°C</td>
<td>8.70 ± 1.08</td>
<td>157.9 ± 1.69</td>
<td>4.067 ± 1.64</td>
<td>0.679 ± 0.031</td>
</tr>
<tr>
<td>B-65°C</td>
<td>5.80 ± 1.25</td>
<td>138.6 ± 0.99</td>
<td>3.333 ± 1.44</td>
<td>0.674 ± 0.131</td>
</tr>
<tr>
<td>B-75°C</td>
<td>6.99 ± 0.82</td>
<td>160.9 ± 0.95</td>
<td>3.333 ± 1.44</td>
<td>0.673 ± 0.131</td>
</tr>
<tr>
<td>B-Sun</td>
<td>6.16 ± 0.62</td>
<td>159.1 ± 0.59</td>
<td>1.667 ± 1.44</td>
<td>0.601 ± 0.304</td>
</tr>
<tr>
<td>EOB-55°C</td>
<td>13.05 ± 2.17</td>
<td>160.1 ± 0.82</td>
<td>5.556 ± 0.95</td>
<td>0.640 ± 0.131</td>
</tr>
<tr>
<td>EOB-65°C</td>
<td>9.06 ± 0.62</td>
<td>160.6 ± 0.49</td>
<td>5.000 ± 0.95</td>
<td>0.601 ± 0.304</td>
</tr>
<tr>
<td>EOB-75°C</td>
<td>9.06 ± 1.06</td>
<td>160.8 ± 0.78</td>
<td>6.667 ± 2.20</td>
<td>0.621 ± 0.304</td>
</tr>
<tr>
<td>EOB-Sun</td>
<td>11.96 ± 1.05</td>
<td>160.0 ± 0.27</td>
<td>7.222 ± 2.54</td>
<td>0.587 ± 0.297</td>
</tr>
<tr>
<td>PCB-55°C</td>
<td>14.86 ± 1.25</td>
<td>161.1 ± 0.73</td>
<td>6.111 ± 0.95</td>
<td>0.616 ± 0.309</td>
</tr>
<tr>
<td>PCB-65°C</td>
<td>7.25 ± 1.60</td>
<td>160.6 ± 0.44</td>
<td>6.111 ± 0.95</td>
<td>0.637 ± 0.313</td>
</tr>
<tr>
<td>PCB-75°C</td>
<td>7.07 ± 0.62</td>
<td>160.9 ± 0.56</td>
<td>7.222 ± 2.54</td>
<td>0.597 ± 0.297</td>
</tr>
<tr>
<td>PCB-Sun</td>
<td>11.96 ± 0.90</td>
<td>158.8 ± 1.22</td>
<td>6.333 ± 3.21</td>
<td>0.624 ± 0.313</td>
</tr>
<tr>
<td>WB-55°C</td>
<td>11.96 ± 1.18</td>
<td>158.9 ± 0.44</td>
<td>6.667 ± 2.20</td>
<td>0.635 ± 0.311</td>
</tr>
<tr>
<td>WB-65°C</td>
<td>9.79 ± 1.08</td>
<td>158.9 ± 2.06</td>
<td>8.333 ± 2.28</td>
<td>0.678 ± 0.203</td>
</tr>
<tr>
<td>WB-75°C</td>
<td>9.43 ± 1.66</td>
<td>150.0 ± 0.76</td>
<td>10.000 ± 0.01</td>
<td>0.606 ± 0.304</td>
</tr>
<tr>
<td>WB-Sun</td>
<td>13.05 ± 2.17</td>
<td>155.7 ± 4.34</td>
<td>6.667 ± 2.20</td>
<td>0.639 ± 0.311</td>
</tr>
</tbody>
</table>

*In each column, means with the same letters are not statistically significant difference (p>0.05). *

**CONCLUSIONS**

The following outcomes were obtained from this study for different pretreatments and drying of chilli pepper:

- Hot air drying of chilli pepper reduced the drying time and increased drying efficiency in comparison with the sun drying. Also, the secondary contamination of dried product was decreased considerably due its shorter drying time.

- By increasing drying air temperature the vitamin C content and shrinkage of chilli pepper decreased and increased, respectively.

- The maximum value of vitamin C content was observed in chilli pepper pretreated with potassium carbonate and dried at 55°C. Similarly, the highest shrinkage (10%) was measured in water blanched samples dried at high temperature at 75°C.

- The best color score was observed in the samples pretreated with potassium carbonate and dried at 65°C.

- The maximum rehydration ratio was observed in untreated samples (blank) dried at 55°C which did not have significant difference (p<0.01) with the water blanched samples dried at 65°C.

**REFERENCES**


