Influence of pretreatments on drying rates of chili pepper *(Capsicum annum* L.*)*

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Abstract: The aim of this work was to investigate the influence of pretreatment on drying rates of chili pepper *(Capsicum annum* L.) at various air temperatures and pretreatment methods. Chilies were pretreated mechanically, chemically as well as by a combined form before drying. The changes of moisture content were determined experimentally at temperatures of 35, 50, 60, 70, and 90 ℃ for pretreated and untreated red chilies. The total drying time required for each case was evaluated based on the acceptable value of moisture content (dry basis) for safe storage of vegetables and fruits obtained from literature. In this work, a moisture content of 0.10 (kg water/kg dry chili) was taken as the final moisture content to determine the final drying time. The results of this experiment showed that much shorter drying times were achieved with the application of pretreatments. Increasing the drying air temperature from 35 to 50 ℃ shortened the final drying time by 140 h, which is 72% reduction of the original drying time. The shortest drying time at lower as well as higher temperatures was achieved by making a number of small holes on the skin of chilies (mechanical pretreatment method). In this case, at a temperature of 60 ℃ the final drying time was shortened by 48% compared to the untreated method which was at the same temperature and in the same drying conditions.

Keywords: chili pepper, pretreatment method, moisture content, drying rate, temperature, Ethiopia.

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1 Introduction

Drying is the process of thermally removing moisture to yield a dried solid product. It is a complex process due to a simultaneous heat and mass transfer (Ponting and McBean, 1970). Dehydration of agricultural product is an energy intensive process in which energy expense constitutes a major portion of drying cost (Bruin and Luyben, 1980). Therefore energy management constitutes a very important part in food drying process and energy conservation can contribute to a significant reduction of the total production cost. Optimal operation of dryers is one of the feasible methods for energy saving. Food quality is the other important factor to be

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simultaneously considered with energy conservation (Bruin and Luyben, 1980).

The most important reasons for popularity of dried products are longer shelf-life, product diversification as well as substantial volume reduction to decrease transportation cost. This could be further expanded by improvements in product quality and process applications (Simal, Dey and Rosello, 1997).

The application of dryers in developing countries can reduce losses significantly and improve the quality of dried product when it is compared to the traditional means of drying such as open sun drying. Open sun drying is not always suited to the large-scale production due to the lack of ability to control the drying conditions properly. It also requires longer drying time, which may be the cause of many complications such as uncertainties of ambient conditions, large area requirements, insect infestation or contamination with dust (Togrul and Pehlivan, 2004).

Chili pepper *(Capsicum annum* L.) is world wide known agricultural product The major producers of hot Chilies are India, Mexico, Indonesia, China and Korea. With annual production exceeding 200,000 tons (dry equivalent), Mexico also stands out as the World's largest exporter of Chilies with a 23% global market share worth USD 389 mn. The other major exporters are the USA with 5% global market share followed by China and India, each having less than 1% of global trade has wide medicinal and industrial applications. It is a kind of widely consumed food in many parts of the world. It can be taken as a raw or cooked vegetable and also be used in making paste pickle and sauce. (Singh, Rankine and Seepersad, 2006).

Various types of pretreatment methods can be applied to improve the drying rate. Blanching is a type of pretreatment methods that can soften the skin of the product to be dried for an easy diffusion of water from the inner part of the material to the outer surface. Since drying rate depends on the characteristics of the material to be dried, whether it is porous or non-porous, modification of the shape may increase the rate of the transfer of moisture from the inner structure of the material to the surface and in to the flowing air, i.e., this will enhance the rate of diffusion (Robert, 1981; Robert, Green and James, 1999).

Chemical pretreatments usually are accomplished by dipping waxed fruits in a cold suitable compound for a few minutes (usually fatty acid derivatives are used as wetting agents or emulsifiers) (Ponting and McBean, 1970). The purpose of the solution is to remove the wax layer from the surface of fruits and to allow water to diffuse easily from the internal structure of the material to the surface without damaging the skin.

Many researches are investigating the drying characteristics of chili pepper. Gupta and co-workers focused on various pretreatments applied before drying and their influences as well as the product quality. They recommended that the best drying temperature for blanching method was 55 ℃ (Gupta et al., 2002). Hossain and co-workers studied a single-layer drying characteristics and the color kinetics of red chillis (Hossain, Woods and Bala, 2007). The effects of blanching on the drying rate were studied on the variety from Thailand. It was reported that drying rates increased by increasing the air temperature and the color of chilies was not affected below 65 ℃. Tunde-Akintunde (2010) studied the effect of chemical pretreatment on drying time and the quality of red chili of Nigerian variety. So far no study of drying characteristics on chili pepper of Ethiopian variety has been found in the literature.

The objective of this work was to study the drying rate of chili pepper of Ethiopian variety with a local name Mareko Fana by employing various types of pretreatment methods such as mechanical chemical and combined form of pretreatments at temperatures of 35, 50, 60, 70 and 90 ℃.

2 Materials and methods

Fresh chilies (*Capsicum annum* L.), variety of Mareko Fana, was harvested from the field at Agricultural Engineering Department, Kassel University. Fully ripened chilies of a purely red color were used. Samples were prepared with the following pretreatments:

1). Blanching chili pepper by hot water at 90 ℃ for 3 minutes and cooling it with cold water (BL) (Gupta et al., 2002).

2). Blanching it with hot water, similar to the first case, and soaking it in to sodium tio-sulfite solution with a concentration of 0.3% (w/w). The soaking process was controlled at a temperature of 25±l ℃ for 10 min using a mass ratio between chili and chemical solution of 250 g/L (BCT).

3). Mechanical treatment –making many random small holes on the surface of chilies by using needles with an average diameter of 1mm (HL).

4). Mechanical method – applying external force to press chilies until cracking occurs and the product changes its shape from the conical to the triangular form (Press).

5). Untreated chilies for comparison purpose (WT).

The average initial moisture content of chilies was 4.71 (kg water/kg dry chilies). An average length of 8.5 cm and diameter of 0.65 cm were used. To get the weight loss of chilies, an electronic balance with a precision of ±0.001 g was used throughout this experiment. Duplicate measurements were done for each case.

For each pretreated and untreated sample, drying was carried out at temperatures of 35, 50, 60, 70 and 90 ℃. Weight losses were recorded every one, two or more hours of time intervals depending on the magnitude of drying temperature.

Drying experiments were conducted by using cabinet dryer which was available at Department of Agricultural Engineering of Kassel University. Disadvantage of cabinet dryers were corrected thank to the construction improvement of the dryer. In this work, the velocity of the air passing through the chamber was 0.45 m/s.

A laboratory set up worked by Cuervo-Andrade (2011) (Figure 1) was used without modification. Figure 1 shows the general characteristics of the experimental set up including the cabinet dryer and the air conditioning unit connected for obtaining the conditions of the drying air.

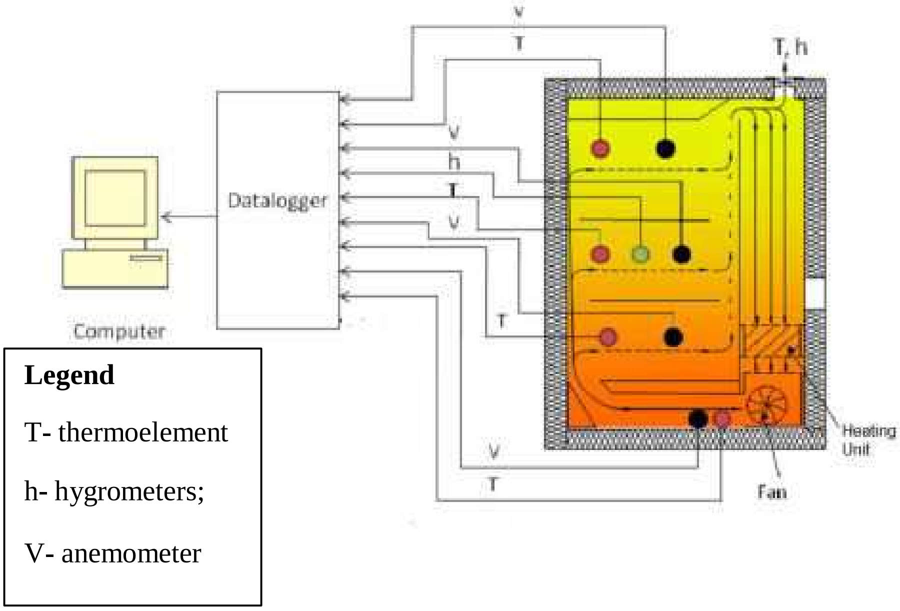

Figure 1 Experimental set up including the cabinet dryer air conditioning unit instrumentation and data acquisition system.

For each type of pretreated and untreated chilies, the decrease of moisture contents with time was recorded until the desired value was achieved. In this case drying process was carried out until the moisture content (dry basis) reached 0.10 (kg water/kg dry chilies). Graphs were drawn with moisture content (a dependent variable) as a function of drying time (independent variable) for each condition. The total drying time required to reach the desired value of moisture content was determined from the graphs.

3 Results and discussion

The curves below show the variation of moisture content (dry basis) with drying time at various temperatures for pretreated as well as untreated chilies as shown in the graphs (from Figure 2 to Figure 6). As the temperature increased, the total drying time required decreased considerably. The moisture content decreased continually when the drying time for pretreated as well as untreated chilies increased, but the rates of decrease for pretreated samples were faster than the ones of the untreated types although the gap between pretreated and untreated got narrowed at higher temperatures. Therefore keeping the temperature constant, shorter drying times was achieved with all types of pretreatment methods compared to the untreated one.

The horizontal red line drawn in all graphs indicates the final moisture content (dry basis) used to determine the total drying time in each condition.

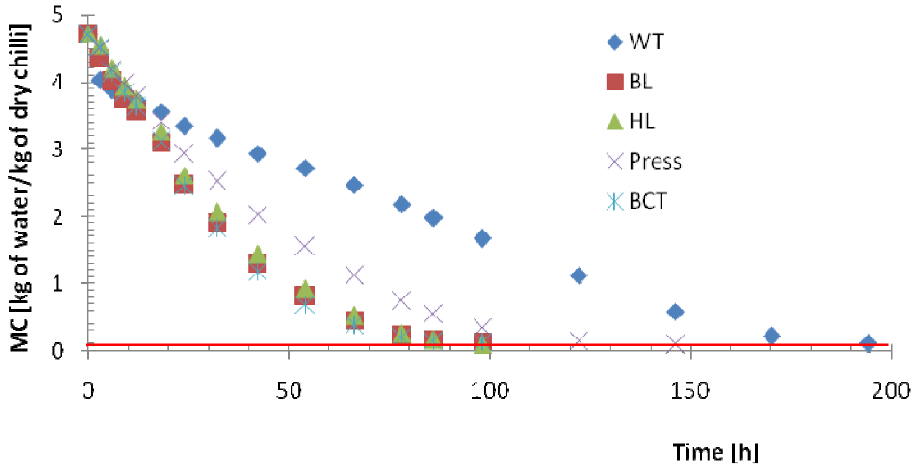

Figure 2 Change of moisture content (dry basis) with time at 35 ℃ for pretreated and untreated samples.

At a temperature of 35 ℃ (Figure 2) faster drying rates were achieved by blanching, chemical pretreatment and hole making methods, but the rate with pressing was slower although it was faster than the rate with untreated method.

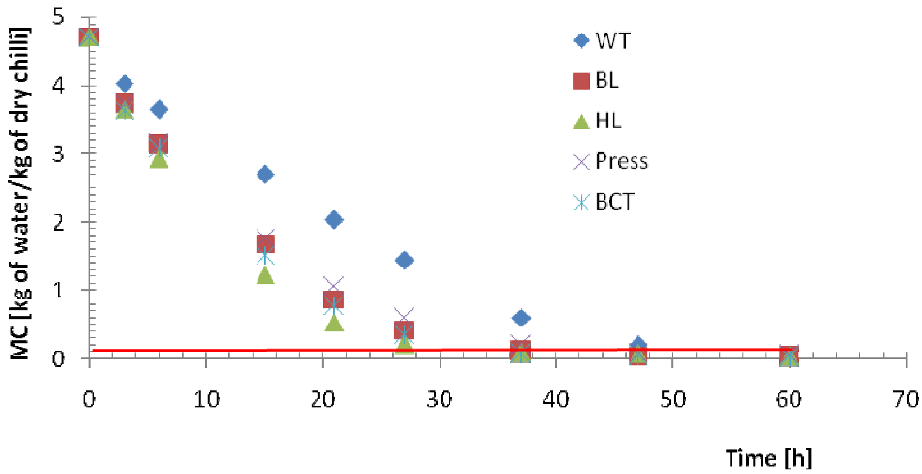

Figure 3 Change of moisture content (dry basis) with time at 50 ℃ for pretreated and untreated samples.

At a tempertaure of 50 ℃ (Figure 3) faster drying rates were achieved by blanching , chemical pretretment and hole making as well as pressing methods with smaller variations among them but the rate of the untreated chillis was still slower than that of the others.

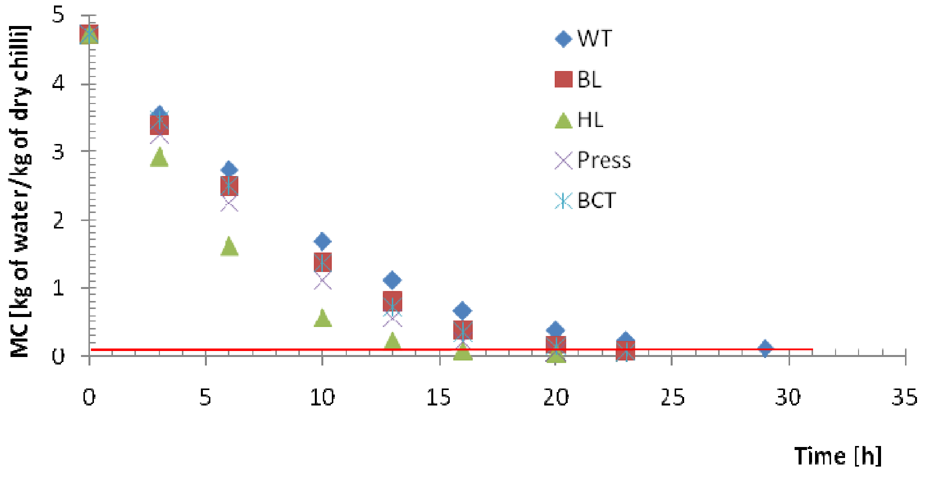

Figure 4 Change of moisture content (dry basis) with time at 60 ℃ for treated and untreated samples.

Figures 4 and 5 show that the fastest drying rates were achieved by hole making method .The remaining pretretment methods also provided shorter drying times than the untreated method but the gaps between them became smaller and smaller compared to lower temperatures.

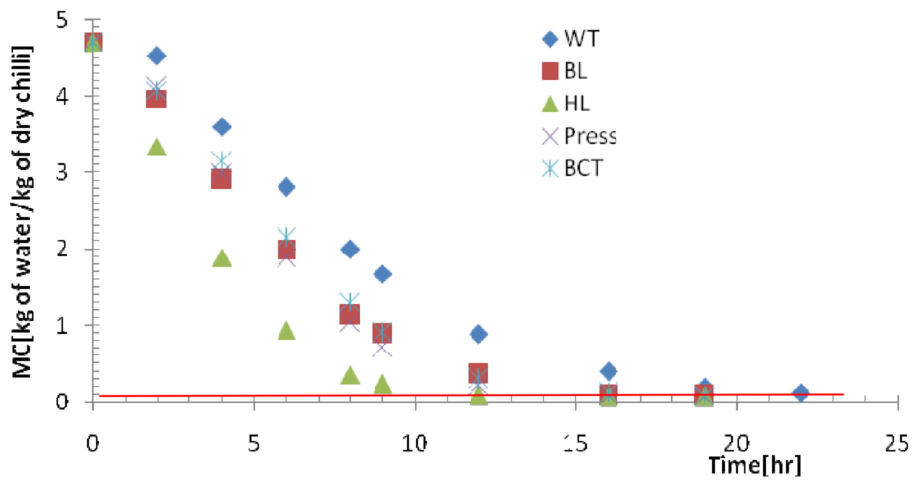

Figure 5 Change of moisture content (dry basis) with time at 70 ℃ for pretreated and untreated samples.

Figure 6 shows that the pretreated as well as untreated methods, except hole making method, provide nearly the same final drying time. This implies that at higher temperatures the pretreatment of chilies does not affect the drying rate.

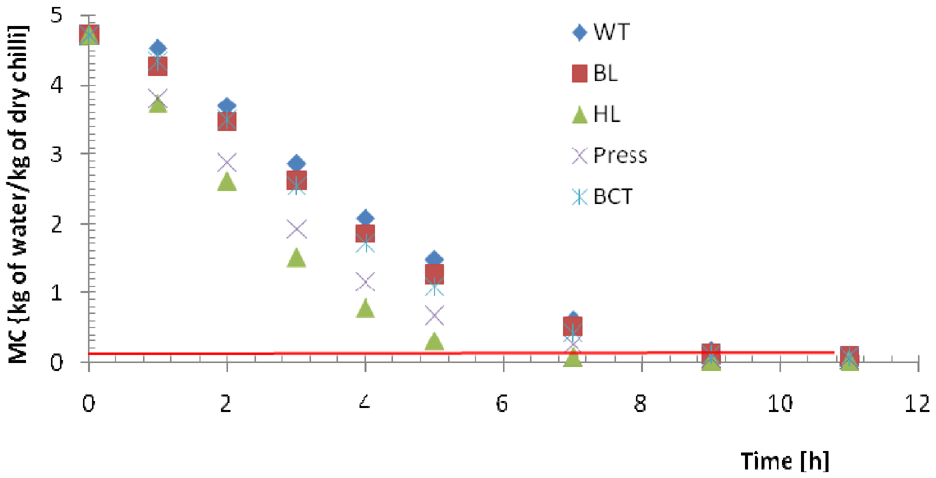

Figure 6 Change of moisture content (dry basis) with time at 90 ℃ for treated and untreated samples.

The short summary of final drying time for these temperatures and pretreatment methods are given in Table 1. The acceptable moisture content to obtain a good quality of dried product and a safe storage is between 0.08-0.11(kg water/kg dry chili) (Satyanarayana and Vengaiah, 2010). Therefore the total drying time, as shown in the Table 1 below, was obtained from the graphs based on a fixed value of the final moisture content of chili pepper, i.e., 0.10 (kg water/kg dry chili).

Table 1 Total drying time required at various temperatures for pretreated and untreated chilies.

Temperature ℃	Type of pretreatment method WT h	BL h	HL h	Press h	BCT h
35	194	95	95	121	96
50	54	38	38	47	36
60	27	22	14	17	21
70	21	16	11	14	16
90	10	9	7	8	9

4 Conclusions

Increasing temperature decreased considerably the drying time of the pre-treated as well as untreated chillies. Increasing the drying temperature from 35 ℃ to 50 ℃ shortened the total drying time by 72% for untreated chillies.

At a constant temperature, the pretreatment of chilies was able to achieve much shorter drying time than the one of the untreated ones. At a temperature of 50 ℃ both blanching and hole making method reduced the drying time by 29.6% compared to the untreated samples. At a temperature of 60 ℃ hole making method shortened the drying time by 48% compared to the untreated method.

Generally pretreatment method by making small holes provides much shorter drying time than the all types of methods used at all temperatures but the visual effect on customers in the market may affect its market value and this requires further investigation. However, HL pretreatment methods are appropriate for more industrial applications such as milling, paint industries, etc. It was observed that at higher temperatures, the rate of drying was not affected by pretreatment methods.

Because of practical reasons such as availability of water everywhere, it's easiness for handling and cheap price, blanching with hot water was recommended as the best type of pre-treatment method although its total drying time required was not the shortest one. However the energy cost of the handling of water to be heated up to 90 ℃ should be considered.

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