EFFECT OF DRYING TEMPERATURE ON VITAMIN C OF LEMON FRUIT

Fawzia I. Moursy[1], Amira Sh. Soliman[2], Manal A. Sorour[3], Sana R. Rohiem[4]

[1,2] Natural Resources Dept., Institute of African Research and Studies, Cairo University, Giza, Egypt.

[3,4] Food Eng. and Packaging Dept., Food Tech. Research Institute, Agric. Research Center, Giza, Egypt

ABSTRACT

Fresh samples of lemon fruit were dried in laboratory dryer at different temperatures 80, 90, 100 and 110°C. The samples were taken as a whole fruit and cut into halves, quarters and slices. The results indicated that drying took place in the falling rate period at all temperatures studied for all samples. Moisture transfer from lemon fruit was described by applying the Fick's diffusion model, and the effective diffusivity was calculated. Effective diffusivity increased with increasing temperature. An Arrhenius relation with an activation energy value of 484.135, 604.9314, 1316.574 and 1740.318 kJ/mol. for whole fruit, half, quarter and slices respectively expressed the effect of temperature on the diffusivity. The effect of temperature on the degradation of vitamin C was investigated and the optimum temperature was determined for all samples studied.

Keywords: Drying Of Fruit, Diffusivity, Vitamin C, Optimum Temperature, Activation Energy

1. INTRODUCTION

Drying is one of the oldest methods of food preservation and it represents a very important aspect of food processing. The main aim of drying products is to allow longer periods of storage, minimize packaging requirements and reduce shipping weights. Sun drying is the most common method used to preserve agricultural products in many parts of the world. However, it has some problems related to the contamination with dust, soil, sand particles and insects and being weather dependent. Also, the required drying time can be quite long. Therefore, the drying process should be undertaken in closed equipment to improve the quality of the final product. [1]

Fruit drying is a process of removing moisture to preserve fruits by preventing microbial spoilage. Itincrease shelf life, reduce weight and volume thus minimizing packing, storage, and transportationcost and enable storage of food under ambient environment. But, it is a complex process whichinvolves combination of heat and mass transfer and physical property change and shrinkage of thematerial. [2]

Drying fruits allows their preservation by reducing the water content, and thus inhibitingenzymatic modifications and microbial growth. Besides conservation, among the importantadvantages of drying are the reduction in size and weight, facilitating transport and reducingstorage space as well as avoiding the expensive cooling systems. Finally, it increases fooddiversity, allowing alternative ways of consuming foods [3]

Drying has a great potential in process foodindustries as it is perhaps the oldest, most common and most diverse of chemical engineering andoperation for food preservation. However, drying is an energy intensive process as it usuallyrequires hot air as heating medium to allow simultaneous heat and mass transfer between the dryingair and material being dried. Moreover quality of food degrades during drying. A good dryingmodel is essential for optimization of this process for reducing energy consumption and improvingproduct quality. Several drying model have been proposed to describe drying kinetics. Most of themare empirical which do not help toward optimization because they cannot able to capture the realphysics behind drying and are only applicable for specific operating conditions. The diffusion basedmodel can capture well the physics during drying [4,5]

According to the authors [6-10] there are many factors affecting the drying rate of the agricultural products. The most affecting factors related to the drying air are the drying air temperature, the drying air relative humidity and the drying air velocity as well as the product initial moisture content.

Azizi and Peyghambarzadeh [11]investigated the convective hot air drying of potato slabs and the effects of drying air temperature and slab thickness using a batch tray dryer. The temperature of drying chamber varied in four levels (50, 60, 70, 80°C) and slab thickness changed in three levels (0.5, 1 and 1.5 cm). For the prediction of effective moisture diffusivity (D_{eff}), the conventional Fick's diffusion model was modified considering the temperature variation of the sample during the drying period. Comparing the prediction of conventional Fick's model with those of modified model indicates that the model proposed in this study shows better agreement with the experimental data.

The problem of chemical conversions during drying is extremely complicated. During the drying process, concentrations change also and it is not clear to what extent thereby the chemical changes are influenced. The role of water in quality decay kinetics in foods has been an important subject of discussion and several hypotheses on how water content and molecular mobility affect the chemical reactions involved have been proposed. These hypotheses include: (1) increasing mobility of reaction partners and catalysts with increasing water activity, (2) increasing energy of activation with decreasing water activity, and (3) changing concentration of water soluble reaction partners.

The objective of this work is to determine the optimum drying temperature for different shapes of lemon fruit and the effect of drying air temperature on the degradation of vitamin C.

II MATERIAL AND METHODS

Lemon fruit (citrus aurantifolia) were selected from a local market. The drying experiments were carried out using a laboratory scale hot-air dryer installed in Department of Food Engineering and Packaging, Agricultural Research Center.Moisture content was measured according to the method of [12]. Lemon were washed and cut into quarters, halves and slices (1 mm), the product was spread as a thin layer in the dryer after stabilizing heated air at the desired temperature and constant velocity, Weight loss of samples was recorded at one hour intervals during drying until it reaches the equilibrium conditions.

2.1. Mathematical Modeling of the Drying Curves

Drying curves were fitted into the simple exponential model Eq. (1); simplifying the general series solution of Fick's second law generally leads to the model. The simple exponential model is the first term of a general series solution of Fick's second law [13]. It is generally assumed that the mechanism of moisture migration during thin layer drying of food materials is characterized by diffusion as described by Fick's second law of diffusion [14-17]

$$MR = \frac{M(t) - M_e}{M_0 - M_e} = Ae^{-kt} \tag{1}$$

Where, MR (moisture ratio) is the unaccomplished moisture change defined as the ratio of the free water still to be removed at time (t) to the total free water initially available moisture ratio.

M(t) is the moisture content at time t (kg water/kg dry matter).

M_e is the equilibrium moisture content (kg water/kg dry matter).

M_0 is initial moisture content (kg water/ kg dry matter).

A, k are constants of the model.

The diffusion based model is based on the assumptions that the system is isotropic (the diffusion properties are constant in all directions).

The main advantage of Eq. (1) is in the fact that both coefficients A and k can be deduced by taking logarithms of both sides of the relation, thus linearizing it:

$$\ln(MR) = \ln A - k.t \tag{2}$$

Where, MR is the moisture ratio

A, k is a constant of the model

t is the time, min.

The values of the k coefficient obtained can be related therefore to the drying conditions if approximated with a simple Arrhenius-type equation,[18-20]

$$D = D_0 \exp \frac{-E_a}{R.T} \tag{3}$$

The coefficients of which can be easily obtained if linearized as:

$$\ln D_{eff} = \ln D_0 - \frac{E_a}{R} \cdot \frac{1}{T} \quad (4)$$

Where, D_{eff} is the effective diffusivity, m2/min.

D_0 is the pre-exponential factor of Arrhenius equation, m2/min.

Ea is the activation energy, kJ/mol

R is the gas constant, kJ/mol. K

T is the temperature, K

The A and D_0 coefficients can be related to the drying air conditions by applying regression analysis techniques. The above Eqs. (2) and (4) were applied to fit the drying data identifying the influence of the air temperature and velocity on the effective moisture diffusivity and the drying constants.

2.2. Determination of Vitamin C

In case of vitamin C, estimation, samples were prepared according to the method described by [21]. The chromatographic procedure used was based on the isocratic method reported by H.S. [22]

2.2.1. Separation and Identification of Vitamin C Constituents

A high performance liquid chromatographysystem equipped with a variable wave length detector (Agilant,Germany) 1100. Also the HPLC was equipped with auto sampler,Quaternary pump degasser and column compartment. Analyses were performed on a C18 reverse phase (BDS 5 µm, Labio, Czech Republic) packed stainless-steel column (4 ×250 mm, i.d.).

III RESULTS AND DISCUSSION

3.1. Drying of Lemon Fruit

3.1.1. Influence of Air Temperature

The effect of three temperatures, (80, 90, 100 and 110ºC) on the drying curve of fresh lemon fruit with different shapes is shown in Figs.1-4. The figures show that drying took place in the falling rate period at all temperatures studied and liquid diffusion controls the processes. Similar results were obtained by Doymaz, [13] for Okra, and Gupta, [23] for Red chili.

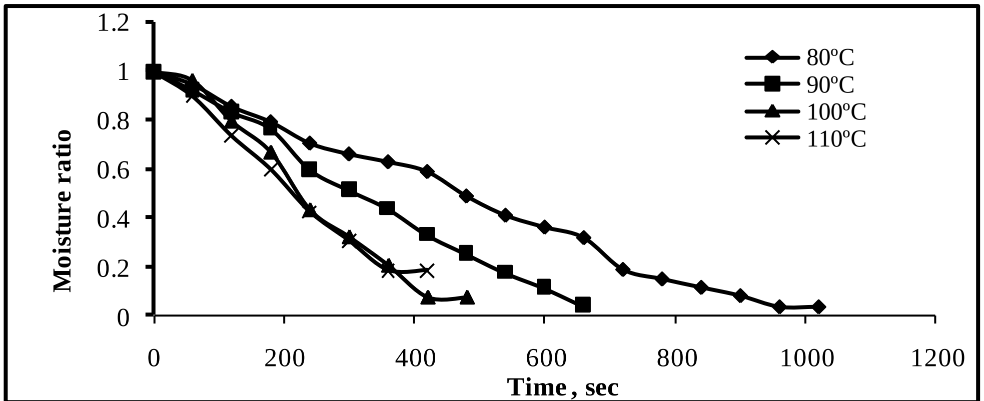

Fig. 1 Effect of time of drying on moisture ratio at different temperatures for whole lemon fruit

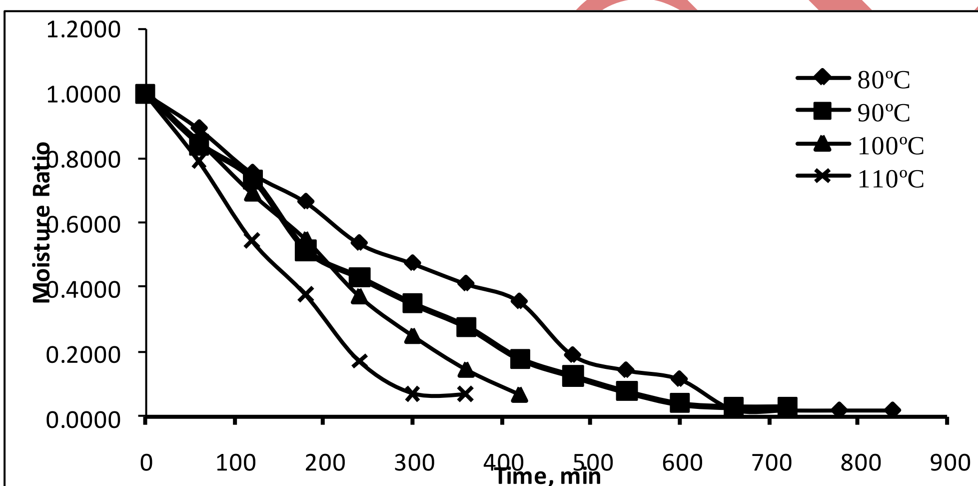

Fig. 2 Effect of time of drying on moisture ratio at different temperatures for lemon fruit cut into halves

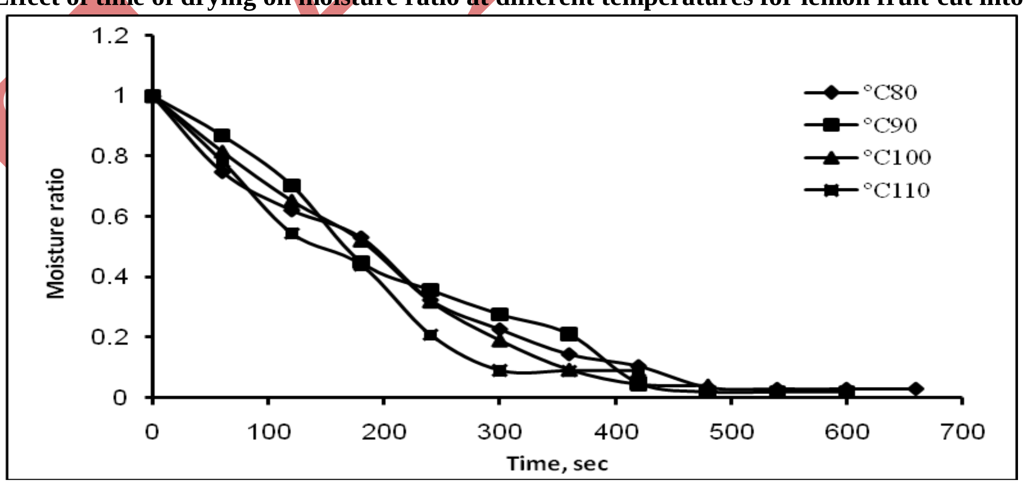

Fig. 3 Effect of time of drying on moisture ratio at different temperatures for lemon fruit cut into quarters

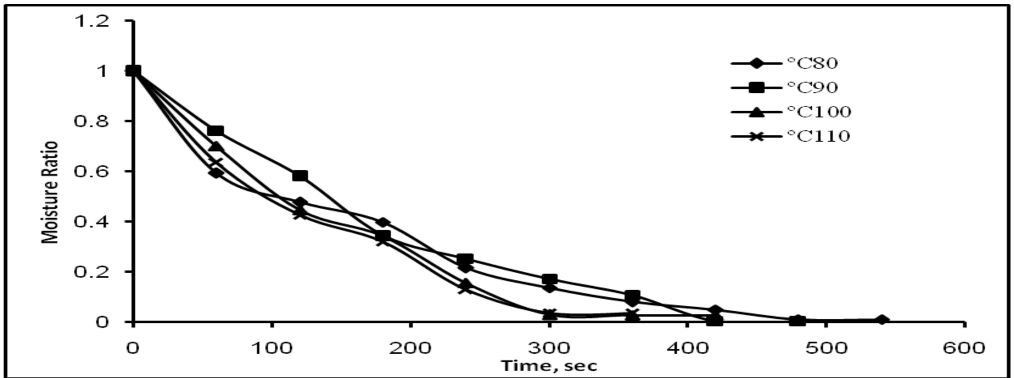

Fig. 4 Effect of time of drying on moisture ratio at different temperatures for lemon fruit cut into slices

It is obvious from Figs.1-4 that increasing the drying temperature caused an important increase in the drying rate and the drying time is decreased. The time required for the moisture ratio to reach any given level was dependent on the drying conditions, being highest at 80ºC and lowest at 110ºC.

Effective diffusivities are determined by plotting experimental drying data in terms of ln(MR) versus time resulting in a straight line according to linear expression ofEq. (2), a plot of ln(MR) versus time gives a straight line with a slope (k) as shown in Figures (5-8).

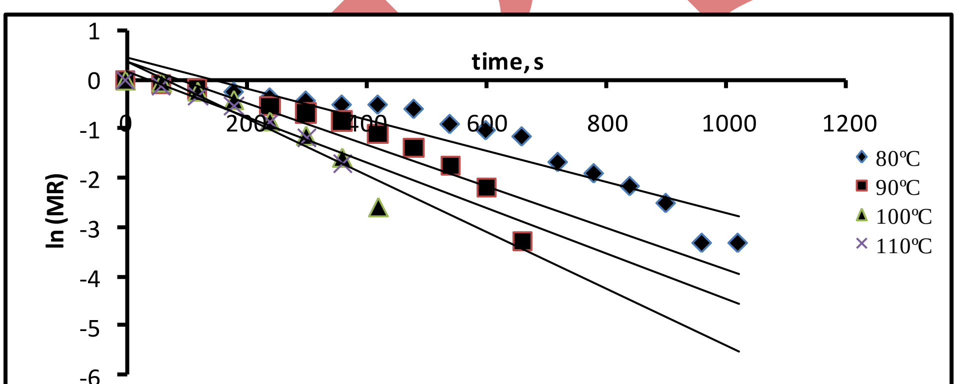

Fig. 5 Variation in ln(MR) and drying time for whole lemon fruit dried at different temperatures

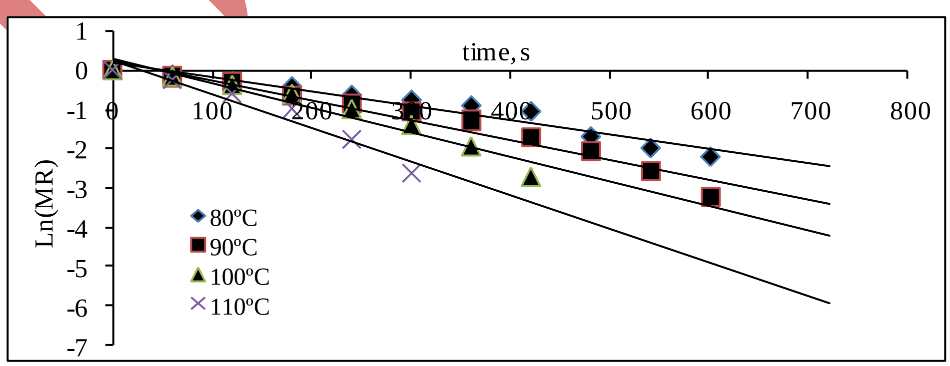

Fig. 6 Variation in ln(MR) and drying time for lemon fruit cut into halves dried at different temperatures

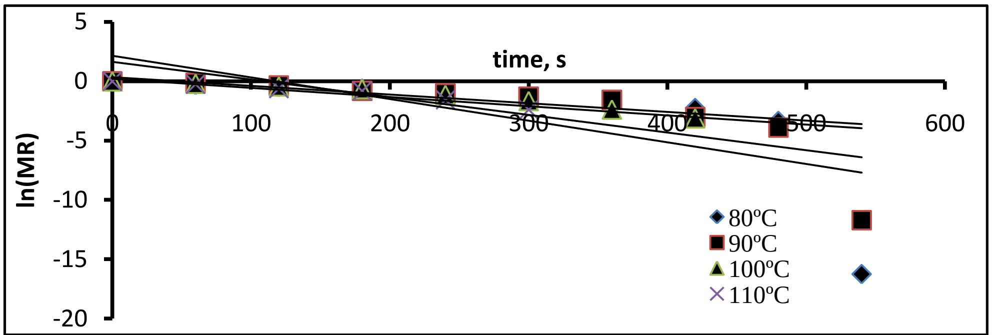

Fig. 7 Variation in ln(MR) and drying time for lemon fruit cut into quarters dried at different temperatures

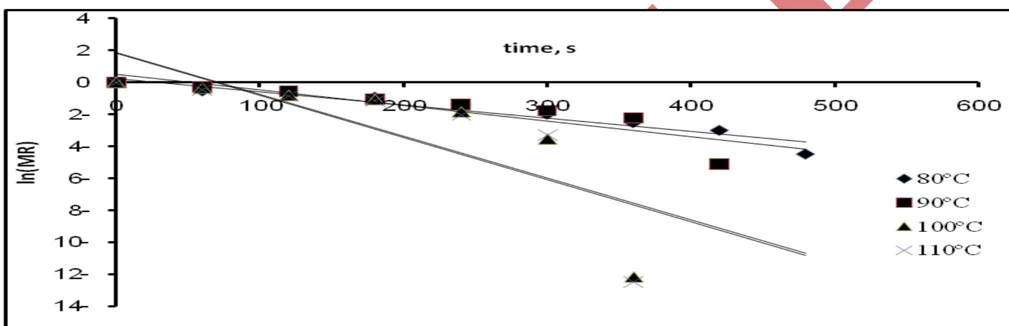

Fig. 8 Variation in ln(MR) and drying time for lemon fruit cut into slices (2mm) dried at different temperatures

3.1.2. Activation Energy

The activation energy was calculated by plotting the natural logarithm of D_{eff} versus 1/T as presented in figure (9). The plot was found to be a straight line in the range of Temperatures studied, indicating Arrhenius dependence. The activation energy for lemon samples was found to be 484.135, 604.9314, 1316.574 and 1740.318 kJ/mol. for whole fruit, half, quarter and slicesrespectively. The lower activation energy translates to highermoisture diffusivity in the drying process.

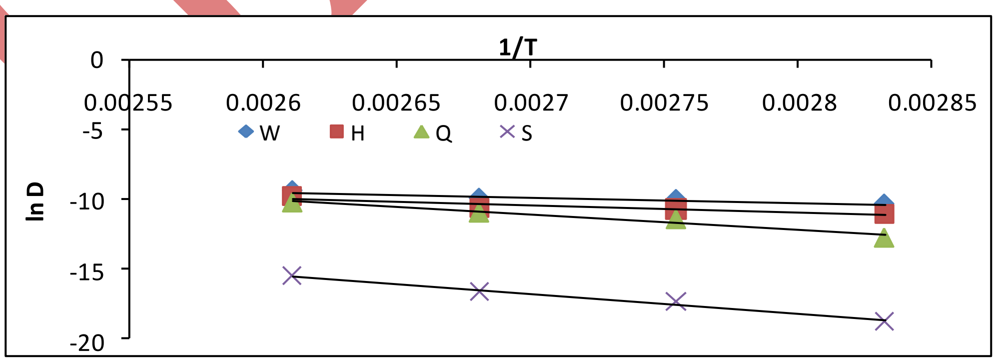

Fig. 9 Arrhenius-type relationship between effective diffusivity and temperature for different shapes of lemon fruit. W: Whole fruit H: Fruit cut into halves Q: Fruit cut into quarters S: Fruit cut into slices (2mm)

3.1.3 Effect of Temperature on Degradation of Vitamin C

The effect of drying temperature on the degradation of vitamin C was determined and compared with the fresh samples. Figure shows that vitamin C content increases with increasing temperature and after certain temperature it begins to decrease for all samples studied except for whole fruit it increases continuously until 110°C. The optimum temperatures were 90°C for samples cut into halves and 100°C for samples cut into quarters and slices.

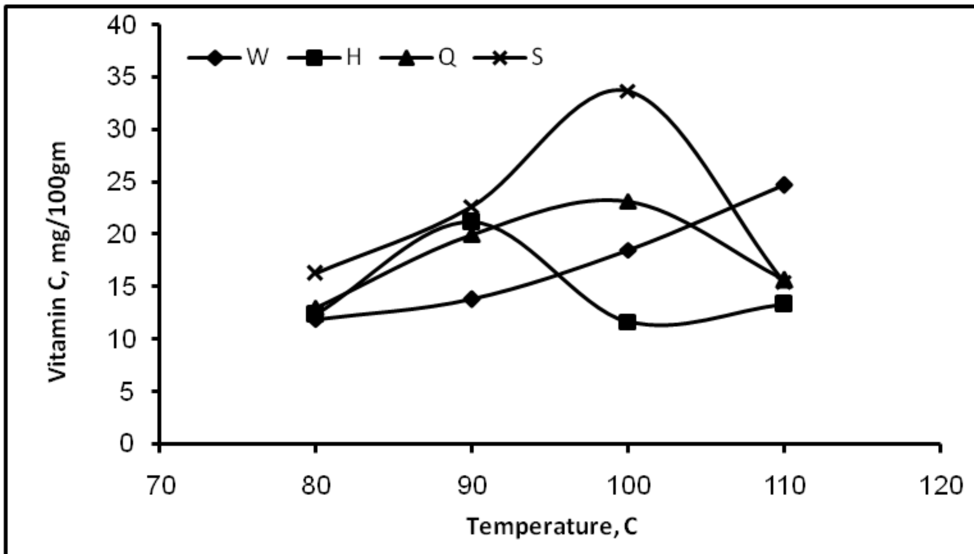

Fig.9. Degradation of vitamin C with temperature for different shapes of lemon fruit
W: Whole fruit H: Fruit cut into halves Q: Fruit cut into quarters S: Fruit cut into slices (2mm)

IV CONCLUSION

The effect of hot-air drying temperature on vitamin C content of whole lemon fruit and fruit cut into halves, quarters and slices were determined. It was found that vitamin C was affected by drying temperature.Vitamin C content increases with increasing temperature and after certain temperature it begins to decrease for all samples studied except for whole fruit it increases continuously until 110°C. The optimum temperatures were 90°C for samples cut into halves and 100°C for samples cut into quarters and slices.

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