برنامه زمانبندی

چهارمین کنفرانس ماشین بینایی و پردازش تصویر ایران

دانشگاه فردوسی مشهد

۲۵ و ۲۶ بهمن ماه ۱۳۸۵

دانشگاه فردوسی مشهد

مجموعه مقالات

چهارمین کنفرانس ماشین بینایی وپردازش تصویر ایران

۲۵و۲۶ بهمن ماه ۱۳۸۵
مشهد مقدس - هتل پردیسان

PROCEEDINGS

4th Iranian Conference on Machine Vision and Image Processing

Pardisan Hotel, Mashad, Iran
Feb. 14-15 2007

An application of image analysis to dehydration of osmosed pumpkin by hot air drying

M. Shafafi Zenoozian
Department of Food Science & Technology, Shahid Beheshti University, Tehran, Iran
mshafafiz@yahoomail.com
H. R. Poor Reza, H.Segare, S. M. A. Razavi, F. Shahidi
Department of Computer Engineering, Ferdowsi University, Mashhad, Iran

Abstract: *Pumpkin are traditionally dried with solar dryers or hot air dryers ,which decrease product quality .To improve the quality of dehydrated pumpkins ,the technique of osmotic dehydration followed by hot air drying has been tested in recent years.The objectives of this study were to investigate the effect of osmotic dehydration as a pretreatment before hot air drying. A computer vision system(CVS) apply to study the color changes during drying.Pumpkin cubes were soaked in 50 %w/w sorbitol and sucrose solutions at 50c for up to 6 hours followed by hot air drying at 60 c and air velocity 1 m/s .A CVS was used for color evaluation during which the color image were converted to L/a/b values .Parameters related to shape (area, perimeter, energy) decreased during drying time. Parameters related to the texture of the image and calculated from the color co-ordinates represented well the complexity and non-homogeneity of the visual appearance of samples. The color changes of dried samples were evaluated with total color change (ΔE^*),which was fitted to $\Delta E^* = a_0 + a_1(t)^{a_2}$ .The "b" and L values were decreased,but the a values were increase in pumpkin samples during hybrid osmotic –air drying respectively.Hot air dried samples pretreated sorbitol had a higher L values compared to the hot air along drying while that pretreated with sucrose exhibited lower L values.The ΔE^* values increased during drying in a sequence of $\Delta E^*_{sucrose\ solution} < \Delta E^*_{sorbitol\ solution} < \Delta E^*_{sucrose+hot\text{-}air} < \Delta E^*_{sorbitol+hot\text{-}air}$*

Keywords: *Pumpkin; Image processing; Image analysis*

چهارمین کنفرانس ماشین بینایی و پردازش تصویر ایران
۲۵-۲۶ بهمن ماه ۱۳۸۵

An application of image analysis to dehydration of osmosed pumpkin by hot air drying

M. Shafafi Zenoozian
Department of Food Science & Technology, Shahid Beheshti University, Tehran, Iran
mshafafiz@yahoomail.com
H. R. Poor Reza,H.Segare, S. M. A. Razavi, F. Shahidi
Department of Computer Engineering, Ferdowsi University, Mashhad, Iran

Abstract: *Pumpkin are traditionally dried with solar dryers or hot air dryers ,which decrease product quality .To improve the quality of dehydrated pumpkins ,the technique of osmotic dehydration followed by hot air drying has been tested in recent years.The objectives of this study were to investigate the effect of osmotic dehydration as a pretreatment before hot air drying. A computer vision system(CVS) apply to study the color changes during drying.Pumpkin cubes were soaked in 50 %w/w sorbitol and sucrose solutions at 50c for up to 6 hours followed by hot air drying at 60 c and air velocity 1 m/s .A CVS was used for color evaluation during which the color image were converted to L/a/b values .Parameters related to shape (area, perimeter, energy) decreased during drying time. Parameters related to the texture of the image and calculated from the color co-ordinates represented well the complexity and non-homogeneity of the visual appearance of samples. The color changes of dried samples were evaluated with total color change (ΔE^*),which was fitted to* $\Delta E^* = a_0 + a_1(t)^{a_2}$ *.The "b" and L values were decreased,but the a values were increase in pumpkin samples during hybrid osmotic –air drying respectively.Hot air dried samples pretreated sorbitol had a higher L values compared to the hot air along drying while that pretreated with sucrose exhibited lower L values.The* ΔE^* *values increased during drying in a sequence of* $\Delta E^*_{sucrose\ solution} < \Delta E^*_{sorbitol\ solution} < \Delta E^*_{sucrose+hot\text{-}air} < \Delta E^*_{sorbitol\ +\ hot\text{-}air}$

Keywords: *Pumpkin; Image processing; Image analysis*

1 Introduction

Pumpkin (*Cucurbita pepo L.)* is one of the important vegetables grown in Iran . Pumpkins are relatively low in total solids, usually ranging between 4% and 10% w/w. A fixed bed air drier can be used to remove the water from the food, by putting it in contact with a hot air stream flowing continuously by the fixed bed containing the product slices .However, up to date, there is limited in research on drying of pumpkin in literature. Krokida Tsami & Maroulis (1998) determined the kinetics on color changes during drying of pumpkin[3]. Krokida et al. (2000) investigated the effect of pretreatment on color of dehydrated pumpkin [4]. Krokida, Maroulis & Saravacos (2001) studied the effect of the drying method on the color of dehydrated pumpkin[5]. The objectives of this work were:(1) To investigate the effect of osmotic pre-treatment on the convective dehydration kinetics of the pumpkin cubes,(2) To estimate the best model for describing the air drying process of the pumpkin cubes,(3) To apply computer vision system (CVS) in order to studying the color changes during drying of pumpkin and determining the drying parameters.

2 Materials and methods

2.1 Preparation of samples

Pumpkin purchased from a local supermarket in Mashhad, Iran and stored at 10 °C until the moment of the experiment. The initial moisture content of the fresh pumpkin varied from 95±1 (%

w.b.). At the start of each experiment, the pumpkin were washed and cut into cubes, with dimensions of 2×2×2 cm using a kitchen slicer.

2.2 Osmotic dehydration and hot air drying

Two different sugar solutions were chosen: 50% w/w sorbitol and 50% w/w sucrose solutions (Merck, Darmstadt, Germany). Five pumpkin cubes randomly were selected as each experimental group and each experiment was done in triplicate. The samples were weighed and placed into 250 ml beakers, containing the osmotic solutions at a temperature of 50 ^oC. for 6 h. The air thin layer dryer used in the experiments was built in steel and insulated with asbestos, having dimensions of 0.25×0.25×1.20 m. It consists of a centrifugal fan, drying chamber with scale-mounted trays, and a connecting duct system .About 100 g of the osmosed pumpkin cubes was uniformly spread a single layer .Fifteen pumpkin cubes were placed over steel perforated tray and dried at 60±1^oC and relative humidity between 30-40%. Also, three pumpkin cubes were removed at each hour just to acquire images and placed back in the drier. Two samples from the remaining cubes were randomly retrieved at each time, photographed. The drying process was stopped when the moisture content decreased about to 0.25 (d.b.%).. All the experiments were replicated three times and the average values were calculated. A monitoring program was written in VISUAL BASIC 6.1 and used to log the data and was downloaded onto a computer.

2.3 Kinetics of color changes during drying

Color is considered as a fundamental physical property of agricultural and food products, since it has been widely demonstrated that it correlates well with other physical, chemical and sensorial indicators of product quality. The color of the product surface is the first quality parameter evaluated by consumers and is critical in the acceptance of it.

The kinetics of color change of pumpkin samples affected by osmotic-air drying was followed by the total color change (ΔE*), which was calculated in the following way [8,9]:

$$\Delta E^* = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]^{1/2}$$

(1)

Where, ΔL*=L -L*, Δa*=a -a*, Δb*=b -b*. The L*, a* and b* values correspond to the values of pumpkin samples at different drying times, whereas the values of L, a and b parameters are related to the raw pumpkin. Experimental data of color changes (ΔE*) was fitted to the following empirical relationship:

$$\Delta E^* = a_0 + a_1 (t)^{a_2}$$

(2)

Where, t is the drying time, a_0, a_1 and a_2 are the regression coefficients. All experiments were done in triplicate.

The following morphological parameters were determined on the segmented image:

Area (A): Number of pixels within the boundary. Perimeter (P): Number of pixels in the boundary of the object.

Contrast: Is a measure of the amount of local variations present in an image. A high contrast value indicates a high degree of local variation where p(i, j) is the relative frequency of occurrence of

two pixel values (one with intensity i and the other with intensity j).

$$Contrast = \sum_i \sum_j (i-j)^2 p(i,j)$$

(3)

Energy: Measures the textural uniformity of an image. It is the sum of the squares of all elements in the co-occurrence matrix. It reaches its highest value when color (or grey) level distribution has either a constant or a periodic form .

$$Energy = \sum_i \sum_j p(i,j)^2 \quad (4)$$

2.4 Color measurement by computer vision system (CVS)

A computer vision system (CVS) provides an alternative to the manual inspection of biological products by integrating an image acquisition device and a computer[2]. Basically, a CVS consists of a digital or video camera for image acquisition, standard illuminants, and computer software for image analysis [1,7].A brief description of each step is as follows:

(i) An image acquisition system consists of four basic components: illumination, camera, hardware and software. Vision systems require the use of a proper light source in order to avoid glitter and obtain sharp contrasts at the border of the sample image. The set-up of the digital camera and its illumination viewing environment is critical for image acquisition and to obtain meaningful and reproducible data.

Samples were illuminated using four fluorescent lamps (length of 60 cm) with a color temperature of 6500 ^oC (PARS SHAHAB Company, Natural

Daylight, 230V/ 20W) and a color reproduction index near to 95% were used for illumination. The four lamps were arranged as a square 35 cm above the sample and at an angle of 45^o with the sample plane to give a uniform light intensity over the food sample. Image of pumpkin cubes were captured directly from the black painted tiles as background using a CCD digital camera (Cybershot Shot, SONY DSC40, JAPAN). Parameters of the digital camera were 1/8 second shutter speed, macro focusing mode, F 8.0 aperture stop, ISO 50 sensitivity, no zoom and no flash. A color digital camera was located vertically at a distance of 12 cm from the sample. The angle between the camera lens axis and the lighting sources was around 45^o to capture the diffuse reflection responsible for the color, which occurs at that angle from the incident light[7]. Sample, illuminators and the CCD were inside a wood box whose internal walls were covered with a black cloth to avoid the light and reflection from the room. Images were captured with the mentioned CCD at its maximum resolution (1728×2304 pixels) and connected to the USB port of a Pentium IV, 2.2 GHz computer. Sony Remote Capture Software (version 2.7.0) was used for acquiring the images directly in the computer in JPEG format.

(ii) Image pre-processing: In order to reduce the computational time of processing, the images were sub-sampled to 156×208 pixels.

(iii) Segmentation: Through image segmentation, the object of interest is separated from the background and other secondary entities [2]. The segmentation process involved the following steps (Fig.1).

(1) Application of a threshold at Ycbcr color space and background subtraction to obtain the binary image,

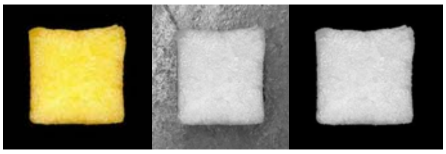
(2) Closing the small noisy holes within the object of interest,

(3) Removing all objects surrounding the pumpkin contour,

(4) Overlapping the contour of the binary image to the original color image.

(iv) Image feature extraction: The extraction of quantitative feature information from images is the objective of image analysis. The features extracted from the properties of pixels inside the object boundary are called internal image features. The most important internal features are color and image texture.

(v) Conversion of RGB images into L*a*b* units: This methodology was developed previously and is carefully detailed [6,8]. The CVS perceived color as RGB signals that are device-dependent, therefore, to ensure correct color reproduction, they were converted into XYZ tri-stimulus values and later to CIE Lab color co-ordinates using a macro written in Matlab 7.1.All the algorithms for preprocessing of full images, segmentation from the background, and color analysis were written in MATLAB 7.1 (The Math-Works, Inc., USA).



(a) (b) (c)

Fig. 1. (a) Color image of the pumpkin dried sample; (b) grayscale image of the pumpkin sample; (c) segmented image of the pumpkin sample

3 Results and discussion

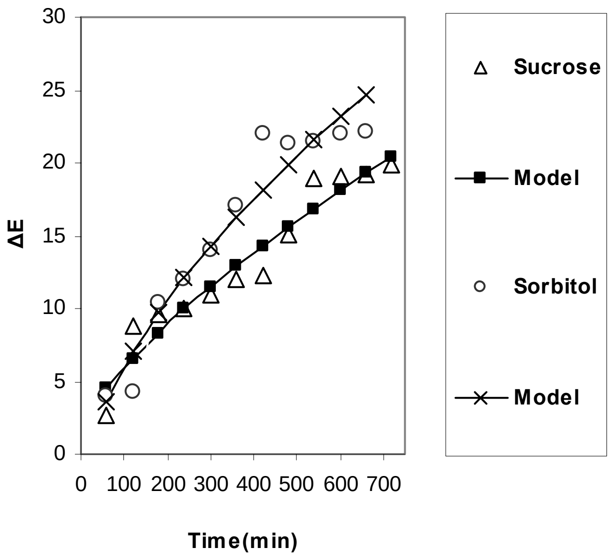
3.1 Kinetics of color change during air-drying

In this study, two osmotic solutions (sorbitol 50% w/w and sucrose 50% w/w) were selected in order to evaluate the effect of pre-osmosed over color changes in pumpkin samples during air drying. The results showed that after hot air drying, ‘‘L’’ values were higher in osmosed samples with the 50% sorbitol solution than in untreated samples (Table 1). On the other hand, ‘‘L’’ values were lower in osmosed samples with the 50% sucrose solution than in untreated samples (significant differences at $p<0.01$). It means that the 50% sorbitol osmosed samples had a higher ‘‘L’’ value representing less darkening compared to 50% sucrose osmosed samples. The color parameter ‘‘a’’ increased in osmosed samples during air-drying (significant differences in most cases at $p<0.01$), but the color parameter ‘‘a’’ had not significant difference at $p<0.01$ between untreated samples and 50% sorbitol osmosed samples (Table 1). Furthermore, the ‘‘b’’ values were significantly higher for the osmosed samples in comparison with the osmosed samples after air drying ($p<0.01$). However, the color parameter ‘‘b’’ was not significant at $p< 0.01$ between untreated samples and 50% sucrose osmosed samples (Table 1). Generally, the ‘‘b’’ and ”L” values were decreased, but the “a” values were increased in pumpkin cubes during hybrid osmotic–air drying, except for the samples treated with sorbitol 50% solution. In this research, osmosed samples in 50% sucrose solution were found to be slightly better than those that were pre-osmosed in 50% sorbitol solution in color retention during drying. ΔE* values were calculated from equation (1) and were fitted to empirical relationship (2) corresponding to drying time. The results of this research showed that the ΔE* values increased during osmotic dehydration and air drying (Table 1). The order of ΔE* values were found as follow:

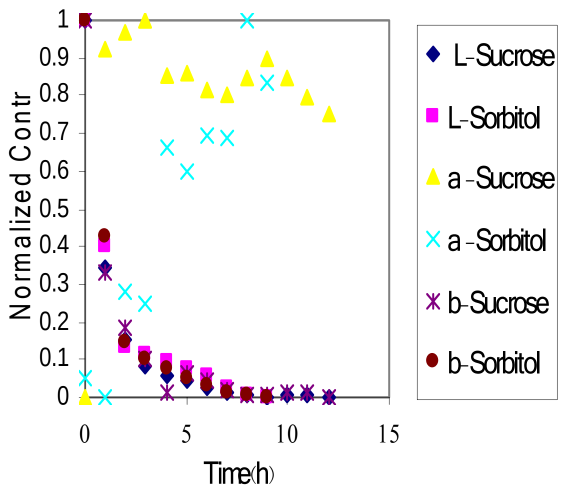
$\Delta E^*_{\text{sucrose solution}} < \Delta E^*_{\text{sorbitol solution}} < \Delta E^*_{\text{sucrose+air drying}} < \Delta E^*_{\text{sorbitol + air drying}}$

The parameters R^2, a_0, a_1 and a_2 were obtained 0.932, -2.941, 0.569, 0.598 and 0.931, 1.405, 0.156, 0.729 for pre-osmosed samples in sorbitol and sucrose solutions, respectively. The ΔE* experimental and predicted values versus time were shown in Fig. 2. It can be seen that Equation (2) gave a good fitting to the experimental data.

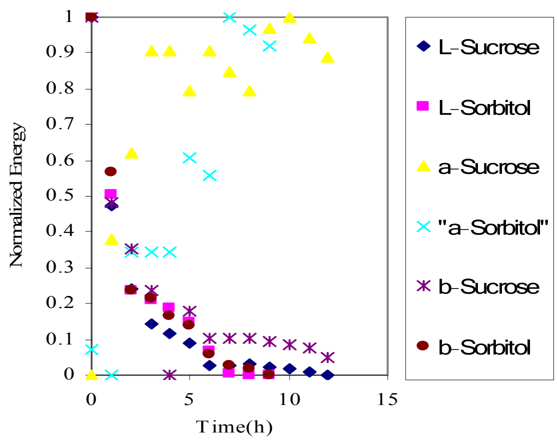
In order to represent the textural feature calculated from the co-occurrence matrix for L*, a* and b*, values for each drying time were normalized. For image texture analysis, each textural feature (e.g.,energy, contrast.) was computed separately for L,a and b Interestingly, Bolin and Huxsoll (1987) reported that the roundness of cells in pumkin cube decreased with drying time.As observed in Fig(3) and Fig(4), the energy and the contrast decreased with the drying time .As shown in Fig(5), all morphological features(Area,Perimeter) decreased smoothly with drying time.



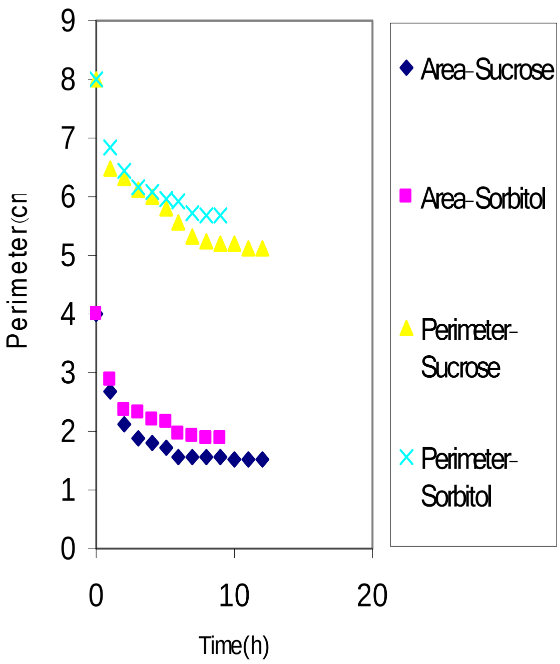
Fig(2).ΔE changes of osmotically treated pumpkin samples in sucrose and sorbitol solutions during air-drying.



Fig(3).Contrast normalized changes of osmotically treated pumpkin samples in sucrose and sorbitol solutions during air-drying.



Fig(4).Energy Normalized changes of osmotically treated pumpkin samples in sucrose and sorbitol solutions during air-drying.



Fig(5).Morphological changes of osmotically treated pumpkin samples in sucrose and sorbitol solutions during air-drying.

Table 1 Color parameters of fresh pumpkin and samples after osmosis dehydration and osmosis-air drying

Treatment	*L*	*a*	*b*	*ΔE*
Untreated (raw) samples	89.281[b]	0.2708[d]	75.045[b]	0
Osmosed samples				
Sucrose 50%	87.092[c]	1.5363[c]	74.361[b]	2.6194
Sorbitol 50%	90.223[a]	0.0540[d]	78.866[a]	3.9414
Osmosed and air-dried samples				
Sucrose	71.482[e]	4.6452[b]	67.366[c]	19.8723
Sorbitol	73.567[d]	7.4955[a]	61.407[d]	22.0255

Samples in same column with different letter differ significantly at $p < 0.01$

4 Conclusions

Under the experimental conditions of this work drying produces drastic changes in the shape, color and image texture of the pumkin cubes that were quantified by means of CVS and image analysis.In this way, the proposed models allow the simulation of mass transfer processes during air drying, and consequently it can be used as a useful tool in the design and control of the corresponding industrial operation.This paper also presented a method that uses a combination of digital camera, computer, and software to measure the surface color of foods during drying. The implemented CVS allows determining the color of pumpkin cubes from RGB images into Lab units in an easy, precise, representative, objective and inexpensive way.

References

[1]Brosnan, T., & Sun, D. (2004). Improving quality inspection of food products by computer vision – a review. *Journal of Food Engineering,* 61, 3–16.

[2]Ferna´ndez L., Castillero C. & Aguilera J.M. (2005). An application of image analysis to dehydration of apple discs, *Journal of Food Engineering*, 67, 185–193.

[3]Krokida, M. K., Tsami, E., &Maroulis, Z. B. (1998). kinetics on color changes during drying of some fruits and vegetables. Drying Technology, 16(3–5), 667–685.

[4]Krokida, M. K., Kiranoudis, C. T., Maroulis, Z. B., & Marinos- Kouris, D. (2000). Effect of pretreatment on color of dehydrated products. Drying Technology, 18(6), 1239–1250.

[5]Krokida, M. K., Maroulis, Z. B., & Saravacos, G. D. (2001). The effect of the method of drying on the color of dehydrated products. *International Journal of Food Science and Technology*, 36(1), 53–59.

[6]Leon, K., Mery, D., Pedreschi, F., & Leon, J. (2006). Color measurements in L*a*b* units from RGB digital images. *Food Research International*, Article in press.

[7]Mendoza F., Dejmek P. & Aguilera J.M. (2006). Calibrated color measurements of agricultural foods using image analysis, *Postharvest Biology and Technology*, Article in press.

[8]Pedreschi, F , Leo´n,J., Mery D., Moyano P. (2006). Development of a computer vision system to measure the color of potato chips, *Food Research International* in press.

[9]Rodriguez V. T., Rojas A.M. , Campos C.A. & Gerschenson L.N. (2003). Effect of osmotic dehydration on the quality of air-dried Porphyra, *Lebensm.-Wiss. U.-Technol.* 36, 415–422.