Application of image texture analysis for evaluation of osmotically dehydrated kiwifruit qualities

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The objective of current work was to study the effect of different drying conditions on textural futures of microscopic images of osmotically dehydrated and air dried kiwifruit slices. Kiwifruits were dehydrated with sucrose solution and were subjected to air drying at the temperatures of 60, 70 and 80ºC for 5, 6 and 7 hours. Microscopic images at different drying conditions were collected and some image texture indexes namely, entropy, homogeneity, correlation and contrast were extracted. Textural futures were used to describe microstructural changes during drying of kiwifruit. Results showed that different drying conditions had significant effect on these parameters. The correlation of the textural features with physicochemical characteristics of dried kiwifruit was also investigated. Regression experiments revealed that determination of textural features as an objective and non-destructive method have potential to indicate osmotically dehydrated kiwifruit qualities.

Keywords: Image texture analysis, kiwifruit, microstructure

1 INTRODUCTION

Kiwifruit (*Actinidia deliciosa*) is a valuable fruit with characteristic taste and flavor and high vitamin C content. Because of high moisture content (above 80% by weight) and availability only seasonally, use of preservation method is necessary to increase its shelf life. Drying is one of oldest technique of food preservation, which causes reduction in microbial growth and enzymatic and chemical deterioration [1]. Hot air drying is a common drying method, based on simultaneous heat and mass transfer. However this method is high cost process due to its energy requirement. Use of osmotic dehydration as a pre-treatment before hot air drying could reduce the initial water content and as a consequence total processing time will be less [2].

Final dried product's quality usually is characterized by its physicochemical properties such as rehydration capacity, shrinkage and moisture content. There are several problems in determination of these parameters such as time consuming and sample destruction. Changes in physicochemical properties are primarily caused by microstructural changes. Therefore application of Image texture analysis can be used to characterize image features of microstructure, which are highly correlated with these parameters of dried products.

The objects of this study were to use osmotic dehydration and air drying to increase the shelf-life of kiwifruit and employ image texture analysis as a rapid and non-destructive method to characterize physicochemical properties of dried kiwifruit.

2 MATERIALS AND METHODS

2.1 Osmotic dehydration and air drying

Kiwifruits (cultivar Hayward) were cut into 40 mm diameter and 10 mm thickness and placed into a baker, which contained osmotic solution of 30% prepared with food grade sucrose. Osmotic dehydrations were performed at 20°C for 2 hours. Dehydrated samples were subjected to air drying at 60, 70 and 80°C. Air drying was performed for 5, 6 and 7 hours. Selected temperatures are usually used for drying of fruits or vegetables [3 - 4]. Shrinkage, rehydration capacity and moisture content of final dried products were determined.

2.2 Image texture analysis

Digital images of the microstructure of kiwifruit were attained from the microscope camera (Dinolite, China) at a 640×480 pixel resolution and at 160× magnification. The texture of an image region is determined by the way the gray levels are distributed over the pixels by the region. Entropy (*E*) shows the values of the smoothness of images, Homogeneity (*H*) quantified the uniformity, correlation (*COR*) is a measure of image linearity and contrast (*CON*) shows the variations of local gray levels. Contrast takes high values for images of high contrast. These image texture features were computed using a program developed in MATLAB 7.0, based on following equations (Eqs. 1 - 4) [5 - 6]:

$$E = \sum_{i-0}^{N-1} \sum_{j-0}^{N-1} P(i,j) \log P(i,j) \quad (1)$$

$$H = \sum_{i-0}^{N-1} \sum_{J-0}^{N-1} \frac{p(i,J)}{|i\ j|} \quad (2)$$

$$COR = \frac{(\sum_{i-0}^{N-1} \sum_{j-0}^{N-1} (ij) P(i,j)) \mu_x \mu_y}{\sigma_x \sigma_y} \quad (3)$$

$$CON = \sum_{i-0}^{N-1} \sum_{j-0}^{N-1} (i\ j)^2 P(i,j) \quad (4)$$

where μ_x, μ_y and σ_x, σ_y are the mean and standard deviation, respectively of the sums of rows and columns in the matrix, which was generated from an image by estimating the pair wise statistics of pixel gray level. P is probability of occurrence of gray levels whit respect to relative spatial pixel position.

3 RESULTS AND DISCTION

As the drying temperatures and times were increased the moisture content and rehydration capacity were decreased. On the other hand longer drying times and higher temperatures resulted in more extensive shrinkage and ruggedness of the kiwifruit microstructure. The average values of these psychochemical properties as well as image texture features of dried kiwifruit are shown in Tab. 1. Changes in image texture features showed similar trend to physicochemical properties changes.

The correlation coefficient between moisture content, rehydration capacity and shrinkage, and image texture features are presented in Tab. 2. This table shows there are good agreements between physicochemical properties and contrast and homogeneity of image texture. While correlation coefficients between energy and correlation of images and these physicochemical properties are slightly lower.

Table. 1: Average values of physicochemical properties and image texture features of dried kiwifruit.

Temperature	Time	Sh	RC	MC	CON	COR	E	H
60	5	0.66	0.29	0.54	0.1537	0.7610	0.5227	0.9423
60	6	0.75	0.25	0.38	0.1540	0.8412	0.4130	0.9430
60	7	0.78	0.24	0.31	0.1495	0.8053	0.4407	0.9431
70	5	0.70	0.23	0.44	0.1289	0.8470	0.4938	0.9525
70	6	0.75	0.21	0.32	0.1415	0.7691	0.5473	0.9474
70	7	0.81	0.22	0.26	0.1049	0.7814	0.5721	0.9641
80	5	0.79	0.22	0.31	0.1238	0.7512	0.6056	0.9564
80	6	0.80	0.22	0.23	0.1218	0.7127	0.6525	0.9571
80	7	0.80	0.20	0.18	0.1206	0.7196	0.5741	0.9564

* Shrinkage; ** Rehydration capacity; ** Moisture content

Table 2: Correlation coefficient between physicochemical properties and image features.

Physicochemical properties	Correlation coefficient			
	CON	COR	E	H
Sh*	0.64	0.45	0.45	0.64
RC**	0.69	0.45	0.48	0.67
MC***	0.63	0.53	0.48	0.62

* Shrinkage; ** Rehydration capacity; ** Moisture content

4 CONCLUSION

In this investigation, image texture analysis was employed to describe microstructural changes of osmotically dehydrated and air dried kiwifruits, which are correlated with their physicochemical properties. The results showed that contrast and homogeneity were better fitted with these parameters. However, physicochemical properties of dried kiwifruit may also depend to some other image features.

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