

Crumb texture and color analysis with image processing in Iranian breads enriched with soy flour

Mohebbat Mohebbi, Fakhri Shahidi and Ahmad Ehtiati

Department of Food Science and Technology, Ferdowsi University, Mashhad, Iran

Bread is inherently irregular in structure and therefore it is not straightforward to quantify its physical structure and quality. In this research, an image processing technique was applied to bread crumb digital images for color and texture analysis. On the other hand hardness of samples was measured with a texture analyzer. Slices of Iranian bread enriched with soy flour at 4 different levels (0, 4, 8 and 12%) were scanned in color using a flatbed scanner. The images were saved in TIFF format. The centre of each slice was cropped in a square of 500 • 500 pixels and converted to grey-level image (8 bits). A set of 96 images that presented a wide range of porosity, crumb coarseness and crumb heterogeneity was evaluated. Color of the images were determined in L*a*b color space. Mean cell area and void fraction were extracted from the images with ImageJ software. The results showed the effects of formulations and storage of bread crumb on these morphological features.

Keywords: Bread crumb texture, Image texture analysis, Image color analysis

1 INTRODUCTION

Bread is one of the main food products in Iranian civilization. Quality control of Iranian bread has been a challenge for many years. Texture and color are two aspects of bread quality which highly influence the consumer preferences. Image processing has found a widespread application in food industries recently. The potential of image processing for color and texture analysis of foods, has been reviewed in literature [1 - 3], although texture image analysis is less applied. Image texture generally refers to such properties as fineness, coarseness, smoothness, granulation, randomness, and graininess of an image [4 - 6]. Bread crumb has entirely connected solid phase. Description of such complex porous structure can be carried out by image processing techniques in terms of morphological parameters such as mean cell area, void fraction and fractal dimension of the bread images [7 - 10]. In this paper, the possibility of image processing application, as a rapid and objective technique, for quality assessment of Iranian bread fortified with soy flour, is described.

2 MATERIALS AND METHODS

2.1 Materials

Soy flour at 4 levels 0, 4, 8 and 12% (based on flour weight) with water, wheat flour, vegetable oil, fresh yeast, sugar and baking powder was mixed for 20 minutes. In this way, 450 g batter was prepared and after 15 minutes, it was placed in proofer (45 °C, 80% RH) for 20 min, the batter was baked at 260 °C for 10 min in an oven.

2.2 Image acquisition

The images of each slice were separately captured using a flatbed scanner (HP Scanjet 4010) and its supporting software (HP Photosmart premier). The

images were save in TIFF format for processing.

2.3 Image color analysis

Image color analysis was performed using the ImageJ (Version 1.40g). Color space converted from R*G*B to L*a*b was carried out using Color Space Converter plug-in [11], inside the program. Statistical parameters of L, a* and b* values were extracted from converted image.

2.4 Image texture analysis

For detection of crumb morphological features, including mean cell area and void fraction, a thresholding method base on red color was applied in ImageJ (Version 1.40g). Using analyze particle menu lead to measurement of morphological features, mean cell area, and void fraction as follows:

$$V.D. = \frac{\text{Sum of cell area}}{\text{Total area of bread slice}} \quad (1)$$

2.4 Statistical analysis

Results were analyzed using one way analysis of variance (ANOVA) and mean were compared using MstatC (version 1.42) with 3 replication × 4 soy flour levels × 2 preservation times (12 and 36 hours).

3 RESULTS AND DISCUSSION

3.1 Image color analysis

Results of the analysis of variances shows that soy flour has a significant effect on b* value of the bread crumb (p<0.001) but no significant effect on L and a* values (Tabs. 1, 2 and 3). Preservation time has no significant effect on color parameters.

Table 1: ANOVA table of L, a*, b* values means (values with two star were significant at $p < 0.001$).

Source	Df	Mean Squares		
		Mean L	Mean a*	Mean b*
Soy flour levels	3	2.472	0.331	54.073**
Preservation time	1	9.530	2.453	3.479
Soy flour level × Preservation time	3	3.366	0.586	1.501

Table 2: ANOVA table of L, a*, b* values standard divisions (values with two star were significant at $p < 0.001$).

Source	Df	Mean Squares		
		StD L	StD a*	StD b*
Soy flour levels	3	0.604	0.882**	0.428
Preservation time	1	0.390	0.231	3.207
Soy flour level × Preservation time	3	0.548	0.082	1.863

Table 3: Mean comparison of some color parameters.

Soy flour Levels	Mean b*	StD a*
0%	23.58c	2.974c
4%	24.83c	3.200bc
8%	27.40b	3.532ab
12%	30.37a	3.850a

3.2 Image texture analysis

Substantial differences for crumb features were detected from different bread images (mean cell area= 0.011-0.149, void fraction= 0.11-0.34) which can be used as an alternative to visual inspection by expert judges. These parameters have main effects on the perception of bread quality, specially its texture, by consumers.

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