

DETECTION OF STRAINED YOGHURT (LABNEH) MOLDS USING COMPUTER VISION

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Abstract

In terms of appearance, color and smoothness take important place in dairy products quality. It has to be clean from rust, mold and brine dirt. This paper presents a robust mold detection system for strained yoghurt. Using computer vision and image analysis, labneh controlled with some appearance parameters like texture and color difference. The proposed system is also improvable to use for another products in food industry.

Key words: mold detection; strained yoghurt; computer vision

INTRODUCTION

Concentrated yoghurt, which is popularly known as ‘labneh’ in the Middle East and as ‘strained yoghurt’ in Greece and the rest of Europe, is consumed as a main dish at breakfast in many middle eastern countries, such as Iraq, Iran and the Lebanon, but it can also be served as a dip with garlic, dried herbs (usually mint and parsley) and red peppers, or with cucumber and olive oil (Özer & Robinson 1999).

Kaaki (2009) described several techniques to make a labneh: straining plain yogurt in a cloth bag or animal skin (Tanime & Robinson 1978), separating whole milk fat using centrifuge known as mechanical separation (Lehmann, Dolle & Büker 1991), reconstitution of skim milk powder in water (El-Shibiny, El-Dien & Hofi 1979) and fermentation of ultrafiltration retentate (Tamime 1993).

Otaibi and Demerdash (2008) agree that the shelf life of traditional labneh is short, even if stored at low temperatures. The presence of live starter bacteria and yeast and mold contaminants coupled with packaging/storage conditions lead to the formation of off-flavors and other undesirable physicochemical changes that eventually lead to product failure (Muir & Banks 2000). Also packaged labneh, as a concentrated product with a high concentration of lactic acid and limited access to air during refrigerated storage, is thought to be most suitable for the growth of yeasts (Nsabimana, Jiang & Kossah 2005).

Count of molding due to changes in ambient temperature during storage as shown in Figure 1. With reference to Figure 1, it is quite possible to labneh become moldy on the shelf or warehouse of shopping store at the room temperature within six days.

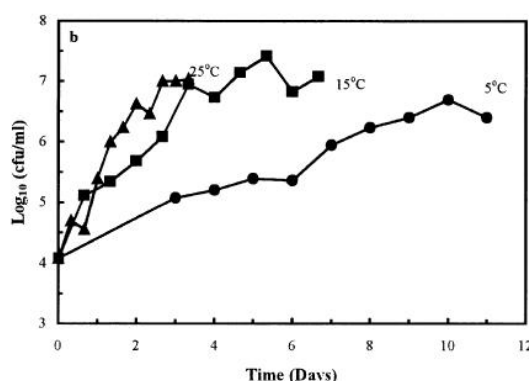


Figure 1. Al-Kadamany et al. (2002) changes in yeast and molds during storage of cloth-bag labneh findings

The increased awareness and sophistication of consumers have created the expectation for improved quality in consumer food products. This in turn has increased the need for enhanced quality monitoring. The basis of quality assessment is often subjective with attributes such as appearance, smell, texture, and flavour, frequently examined by human inspectors (Brosnan & Sun 2004). Therefore the aspect and color of the food surface is the first quality parameter evaluated by consumers and is critical in the acceptance of the product, even before it enters the mouth. Consumers tend to associate color with flavor, safety, storage time, nutrition and level of satisfaction due to the fact that it correlates well with physical, chemical and sensorial evaluations of food quality (Pedreschi et al. 2006).

Computer Vision (CV) is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control and robot guidance in industrial applications (Mahendran, Jayashree & Alagusundaram 2011).

As a result automated visual inspection is undergoing substantial growth in the food industry because of its cost effectiveness, consistency, superior speed and accuracy (Brosnan & Sun 2004). Based on these mentioned studies, the aim of this study is to detect molds on strained yogurt by studying images taken during the mold growth process using computer vision.

MATERIALS AND METHODS

Materials

As the research materials, three different brands samples were used. Samples made from cow's milk and were collected from markets. Nutritional values of the Sample 1 in 100 grams; 5,6 g protein, 18 g fat, 6,5 g carbohydrate, 354 mg calcium, 210 kcal calories (880 kj). For Sample 2 in 100 grams; 4,9 g protein, 17,1 g fat, 6,3 g carbohydrate, 120 mg calcium, 199 kcal calories (831 kj). And for Sample 3 in 100 grams; 4,3 g protein, 18 g fat, 6,5 g carbohydrate, 280 mg calcium, 205 kcal calories (850 kj).

To take images from samples, Sony R800i Camera 5MP (2592 x 1944 pixels) was used and Samsung NP550-P5C Laptop (i7-3610QM 2.30Ghz CPU, 8GB Ram) used to editing and filtering images and also coding program. The application was developed in Visual Studio 2010 with C# language.

Sample collection and preparation

Images were captured for a total of eight days during molding process. Although the strained yogurt couldn't be molded during production at factory, it is likely to start molding at the markets warehouse. Because of that, considering the fact that the applicable to real life, study was carried out in a space

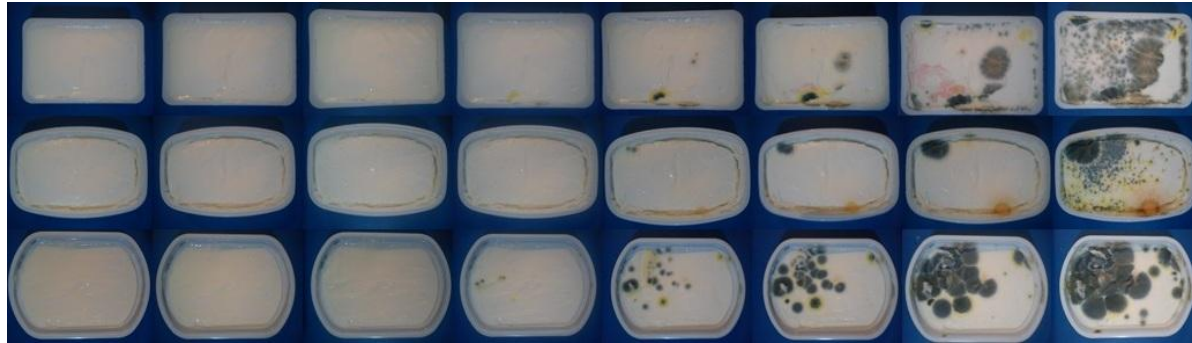


Figure 3. Images obtained during the formation of molds

which as clean as warehouse at room temperature and room lighting. Hereby, experiment can be applied in depots and market storages as shown in Figure 2.

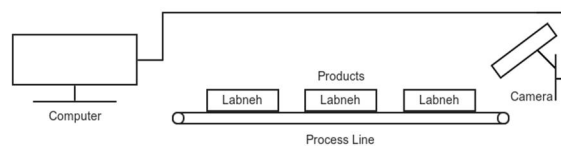


Figure 2. Implementation of the application in market storages

Dataset

The images using for mold detection are shown in Figure 3.

Total 24 images were used: 14 of them were molded. All of the images were stored in RGB color-space at 8 bits per channel. The images were gathered at the approximately same time (08:00-09:00 AM) of everyday during molding process. Flashlight was not used.

Methods and Detection

When using image analysis techniques it's important to be able to distinguish the parts of the image containing interesting information from those that don't. For that reason it's important to be able to segment the image into two or more parts. One, or a couple, containing information and others that don't (Wrangborg 2007). Therefore first step of the detection is separate irrelevant parts. In this study four different techniques used for feature extraction: Converting to grayscale, converting to binary using threshold value, subtracting images and adaptive threshold.

In first place, it is important to get grayscale of image. Grayscale image help us to characterizing features using intensity information. Using basic idea of conversion to black-and-white, every pixel value sets to average value of its own:

$$P_{\text{gray}} = (P_r + P_g + P_b) / 3 \quad (1)$$

Where in RGB color model which means initials of the three additive primary colors; red, green and blue, P_r , P_g and P_b are pixel's RGB values and P_{gray} is pixel's grayscale value. It is also possible to get other results through using weights on pixels RGB values but in this work it will be sufficient. The processed image using this method is shown in Figure 4b.

Second step is specifying a threshold value and using this value, convert grayscale image to binary image. It is also bring out a main extraction mask for irrelevant areas. To determine threshold value, histogram values must be considered. In image processing, histogram is defined as the statistic probabilistic distribution of each gray level in a digital image (Castleman 1996). After determining, using thresholding operation expressed as,

$$dst(x, y) = \begin{cases} 255 & src(x, y) > threshold \\ 0 & otherwise \end{cases} \quad (2)$$

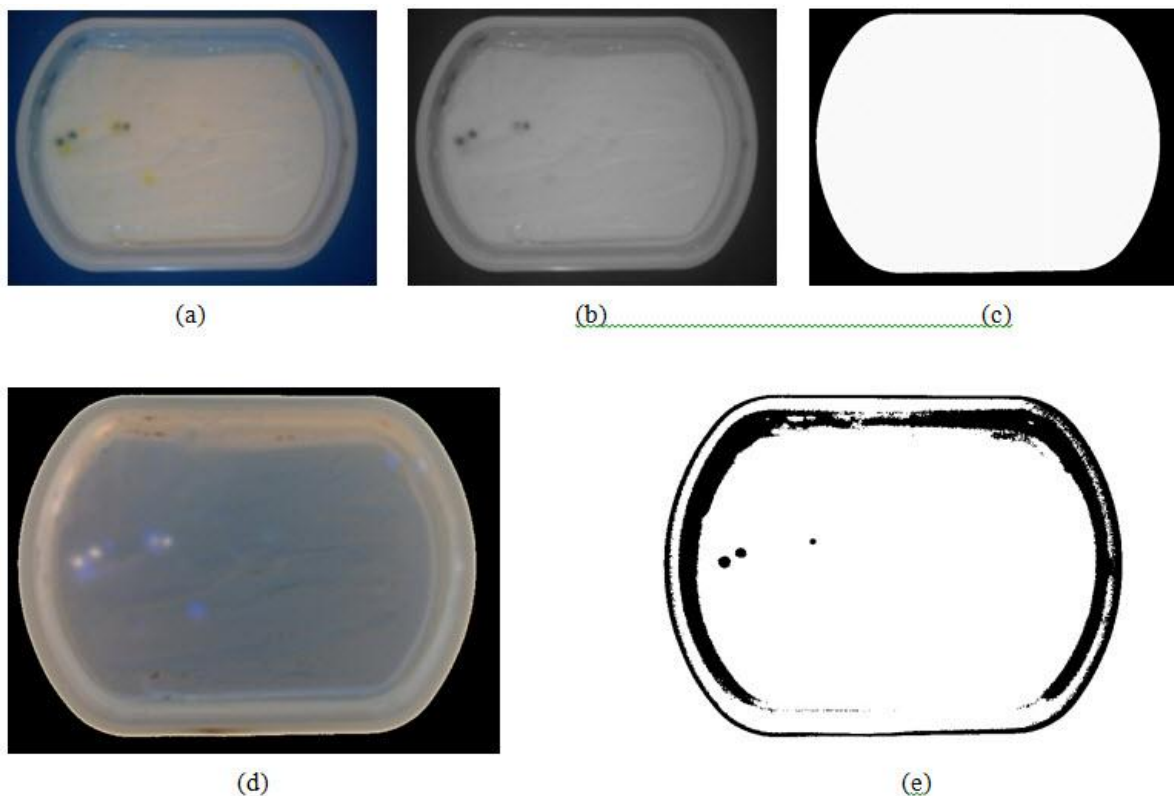


Figure 4. Detection process images: (a) Original Image, (b) Grayscale Image, (c) Mask, (d) Mask subtracted from grayscale image, (e) binary image that converted from subtracted image

Where $dst()$ is output pixel, $src()$ is intensity of pixel, and x, y are coordinates of pixel location. For each pixel in the image, a threshold has to be calculated. Basically if the intensity of the pixel is higher than threshold, then the new pixel intensity is set to 255. Otherwise, the pixels are set to 0. The mask is shown in Figure 4c.

Other process after mask obtained, comparing two images and subtracting each other. It also refers to finding region of interest from image. When we think about two images as two arrays of pixel values, difference between two arrays gives us subtracted area. The subtracted image is shown in Figure 4d.

Last phase of detection is using another binary conversion to subtracted area. This time using adaptive threshold consisting Mean Filtering shows clear-cut mold particles. There are several methods except Mean Filter like Median Filter or Sum Max and Min values in the block size and divide in two.

Block size is pixel's neighborhood, matrix of numbers named kernel (Often 3x3 used). Larger the neighborhood is, the poorer the result, since it is more influenced by the illumination gradient. In addition, the larger the environment is, the more it is expensive to perform the needed computation. On the other hand, if the environment is too small, then there is risk of being exposed to insufficient data (Milstein 1998).

Mean filter is a filter that replaces the center value with the average of all the pixel values in the block size. With simple calculation, sum all pixel values in the block size and divide into pixel count. It uses to smooth images and eliminate noise but at this work it helps to determine the threshold value thus molds are getting clearer in a binary image. The clear image is shown in Figure 4e.

S. No.	M. Area	uM. Area	D. Area	uD. Area	S.Rate
S.1 - Day1	0	100	0	100	100
S.1 - Day2	0	100	0	100	100
S.1 - Day3	0	100	0	100	100
S.1 - Day4	1	99	1	99	100
S.1 - Day5	5	95	5	95	100
S.1 - Day6	10	90	9	91	90
S.1 - Day7	25	75	22,5	77,5	90
S.1 - Day8	60	40	48	52	80
S.2 - Day1	0	100	0	100	100
S.2 - Day2	0	100	0	100	100
S.2 - Day3	0	100	0	100	100
S.2 - Day4	0	100	0	100	100
S.2 - Day5	2	98	2	98	100
S.2 - Day6	5	95	5	95	100
S.2 - Day7	15	85	15	85	100
S.2 - Day8	50	50	40	60	80
S.3 - Day1	0	100	0	100	100
S.3 - Day2	0	100	0	100	100
S.3 - Day3	0	100	0	100	100
S.3 - Day4	2	98	2	98	100
S.3 - Day5	12	88	9,5	90,5	80
S.3 - Day6	25	75	20	80	80
S.3 - Day7	50	50	45	55	90
S.3 - Day8	80	20	56	44	70

Table 1.Detailed numbers about samples where S. No. M. Area uM. Area D. Area uD. Area and S. Rate are Sample No, Molded Area, Unmolded Area, Detected Area, Undetected Area and Success Rate

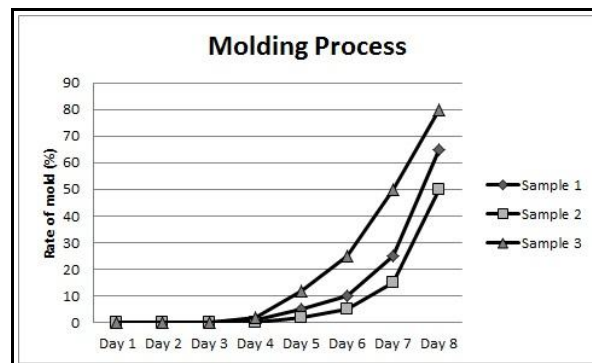


Figure 5.Molding Process day by day

RESULTS

As shown in Figure 6, detection application to three different brands products gives us for sample 1, %95; for sample 2, %97.5; for sample 3, %90 success rate. About those rates, therefore main preference detection process on molded labneh, also important detection of clean labneh on days that mold hasn't started yet.

In this point all samples give us no molded %100 rates on early days which are average first 3 or 4 days depends on sample.

Another important consideration is rates show difference of area between how large area molded and how much has been detected. Day by day, how much mold formed compared to entire sample can be accessed in Figure 5. Exponential increase in the amount of mold is other noteworthy occurrence.

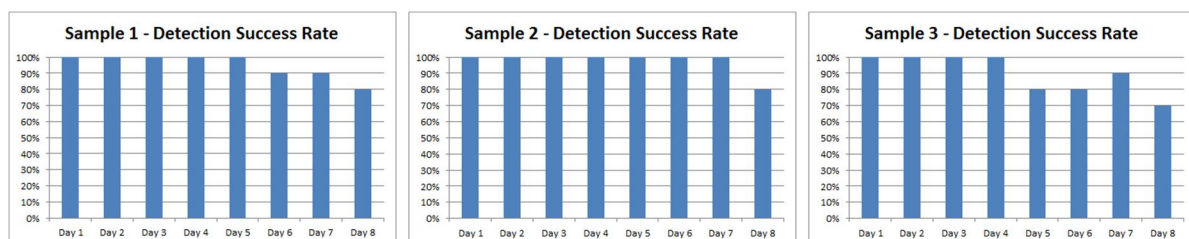


Figure 6.Samples detection success rate

Low rates on last days of the test, losing the importance because what really matters is not how much detected, is identifying detection on day that molding started. The concept of the correct day makes the distinction about achievement of software. Because the first reason about the software can be implemented to real-life is able to detect. From this point application also gives %100 detection success rate on first molded day. Detailed numbers about detected, molded areas and success rates can be found separately from the Table 1.

To summarize success of application, according to the data in the Table 1, we get %91 total success rate.

CONCLUSIONS & FUTURE WORK

Study on products images using computer vision has great potential and profitable investment for automated agricultural tasks. It is easily installed, made error rate to zero and also expended small funds comparing to the human resources.

The proposed study analyzes and works not only strained yoghurt but also works for white products which can be molded. It is possible to develop selectively for other products like tomato paste, bread etc. Besides that, used techniques for detection can be improvable for better success rate. For more long-range further work, chance to be implementing to a selector lever, obtained detection and separation autonomously between molded and not molded products.

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