LWT - Food Science and Technology 72 (2016) 368–376

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Image processing based classification of grapes after pesticide exposure

Malay Kishore Dutta [a,*], Namita Sengar [a], Navroj Minhas [a], Biplab Sarkar [b], Arnab Goon [c], Kaushik Banerjee [c]

[a] Department of Electronics & Communication Engineering, Amity University, Noida, India
[b] National Institute Abiotic Stress Management, Baramati, Pune 413115, Maharashtra, India
[c] National Referral Laboratory, ICAR-National Research Centre for Grapes, Pune 412307, Maharashtra, India

ARTICLE INFO

Article history:
Received 5 November 2015
Received in revised form
26 April 2016
Accepted 1 May 2016
Available online 4 May 2016

Keywords:
Pesticide exposure
Food quality
Image processing
Non destructive method
Classification

ABSTRACT

Among different toxicants, pesticide is a menace to grapes. For the identification of pesticide in grapes, conventional chemical methods are time consuming, expensive and may need specialized manpower. This paper proposes an efficient image processing based non-destructive method for classification of pesticide treated and untreated (fresh) grapes. Before analysing the grape quality by imaging based technique, the pesticide content of untreated and treated grapes were analysed through LC-MS/MS. A region of interest from the image is segmented from the bunch of grapes and some discriminatory features are extracted in frequency domain using Haar filter. Features are selected up to the third level of decomposition in wavelet domain and analyzed for discriminatory behaviour. The variation in the features of the images is related to the difference between pesticide treated and untreated grapes. These statistical features are then analyzed and used for identification of pesticide content in these samples using a support vector machine (SVM) classifier. The experimental results indicate that the proposed method is efficient for identification of untreated grapes and pesticide treated grapes from the features of the images. The accuracy of identification of pesticide treated grapes is high and the computation time is fast making this method suitable as a real time application for quality control in grapes.

1. Introduction

Grape is an important fruit crop across the world. Throughout the season of cultivation of grapes, it encounters frequent attack from varieties of pests. One of the important fungal attack that reduce the grape production to a great extent is downy mildew caused by *Plasmoparaviticola* and control of this fungal infection is essential for the grape growers. The fungicide mixture of non-systemic Ametoctradin and systemic Dimethomorph is widely used solution for the control of downy mildew infestation. The uncontrolled application of these fungicides can accumulate in grape berries at harvest and may lead to food safety and non-compliance issues, as grapes are consumed directly without any pre-treatments. Thus the presence of the harmful pesticide residues is a cause of concern. Under these circumstances, contaminant monitoring regulations play an important role in controlling grape quality for domestic consumption and export.

Conventionally, the analytical methodology for the determination of pesticide residue requires sophisticated and costly instruments like LC-MS/MS, GC-MS/MS etc. There is also a need for skilled analysts to perform these experiments. These facilities are available in established government and private laboratories, situated in distant places which require extensive time period for the samples to be reached to the laboratory for testing. There is an urgent need to develop methods which can identify pesticide contamination at the field level to circumvent the problem of transportation because improper transportation negatively affects the analytical results.

In the current investigation, grapes are classified as untreated grapes (fresh) and pesticide treated grapes using image processing technique. Imaging methods are non-destructive in nature and also has the advantage of giving results in real time. These attractive properties of image processing methods have been explored for monitoring food quality and control in some applications. Martin et al. uses hyperspectral image processing technique to map grape

* Corresponding author.
E-mail addresses: malaykishoredutta@gmail.com (M.K. Dutta), sengarnamita35@gmail.com (N. Sengar), biplab_puru@yahoo.co.in (B. Sarkar), kbgrape@yahoo.com (K. Banerjee).

http://dx.doi.org/10.1016/j.lwt.2016.05.002
0023-6438/

quality in 'Tempranillo' vineyards affected by iron deficiency chlorosis (Martín et al., 2007). Xing et al. uses combination of chemometric tools and hyperspectral image processing for bruise detection on apples (Xing et al., 2007). Hyperspectral imaging has different application for food quality evaluation and safety inspection: chicken carcasses (Chao, Chen, Hruschka, & Park, 2001; Cheng, Chen, & Wang, 2003), poultry carcasses (Park, Lawrence, Windham, & Buhr, 2002, 2003), vegetables (Cheng et al., 2003). Contaminants and tumor detection in chicken (Galloway, 1975; Selesnick, Baraniuk, & Kingsbury, 2005) and assessment of water and fat contents in fish fillets (Mallat & Zhong, 1992) is done using image processing methods. Dubey et al. uses sum and difference histogram texture based features for detection of defects in fruits (Dubey, Dixit, Singh, & Gupta, 2013). Qiao et al. extracted spectral characteristics and spatial features of pork samples to check the quality of pork using image processing (Qiao, Ngadi, Wang, & GariépyPrasher, 2007). Similar image processing based method is also utilized for acrylamide identification in potato chips in spatial and wavelet domain (Dutta et al., 2015, 2016a). Kamruzzaman et al. uses hyperspectral imaging for prediction of quality attributes of lamb meat by textural analysis (Kamruzzamana et al., 2012). Image processing based method is used in identification of the quality of fish using statistical features in wavelet domain (Dutta et al.,; Dutta et al., 2016b).

1.1. Justification

Detection and identification of pesticide residue in fruits is a challenging task and requires costly sophisticated instruments. Conventional methods are time consuming, expensive and may need specialized manpower. So there is a need to explore non-destructive image processing based methods in this area. Some efforts have been made in this direction, where the image of the food items (Pedreschi, Mery, & Marique, 2007) was analyzed for identification of food quality. Similarly, an image processing based automatic method was proposed for identification of plant disease's visual symptoms (Camargo & Smith, 2009). The non-destructive, rugged and flexible nature of image processing makes it attractive for identification of control parameters that impact product quality (Gowen, O'Donnell, Cullen, Downey, & Frias, 2007). The encouraging results in area of image processing have created immense interest, which needs to be explored further to find out suitable cost effective and efficient methods. An efficient and rapid image processing based non-destructive method is proposed in this paper which could be applied directly to the sample for classification of pesticide treated grapes and untreated grapes.

1.2. Design challenges in image processing based classification for grapes quality

There are design challenges associated in extracting discriminatory features from pesticide treated and untreated grapes bunch and strategically use these features for classification for qualities of grapes. Some of the design challenges are as:

a) Selection of region of interest (ROI) is an important step in image processing based method. An identical and uniform ROI reduces the priority of background without compromising algorithm complexity. ROI selection makes the method computationally fast.
b) Feature extraction from the image is another important step in this process. The choice of domain (spatial domain, wavelet domain etc.) is important which will play a vital role to identify differences and grade quality parameters of fruits, vegetable, fish etc.
c) Selection of features should be based on some important parameters like robustness, discriminatory properties and reliability. Feature selection is an important task as the one selected should be useful for discrimination of classes and gives accurate results. The challenge then is the selection of discriminatory features which has discriminatory properties for classification.

The main contribution of this paper is a novel, efficient image processing technique for automatic classification of untreated grapes and pesticide contaminated grapes using support vector machine (SVM) classifier. This is a non-destructive technique and has the advantage of working in real time scenario making it useful for testing on batches after batches. For accurate and discriminatory feature extraction, region of interest (ROI) of grapes are segmented from the image of the grape bunches and then feature extraction is done from this segmented image in wavelet domain. To improve the performance of classifier only the prominent discriminatory features are selected after feature extraction from wavelet coefficients. The proposed method achieves high accuracy for classification of pesticide contaminated grapes from normal grapes when the SVM is applied with linear kernel.

2. Materials and methods

2.1. Experimental design

Field experiments were conducted on *Vitis vinifera* L. (cv. Thompson Seedless) at the vineyard in Bhandgaon village Pune, located on the western peninsular of India in the state of Maharashtra. Ametoctradin 27% SC and Dimethomorph 20.3% SC was applied at recommended dose (800 mL/ha). The fungicides were sprayed with 1000 L/ha^{-1} water during March, 2015. The treatments, including the untreated control were replicated 3 times. After 2 h of spaying, the grape samples were collected for analysis by image acquisition and processing. Images of grape bunches were taken with a digital camera (NIKON D7000) FORSIX for consecutive days. At the end of the experiments, grape samples were subjected to pesticide residue analysis using LC-MS/MS.

2.2. Sample extraction for residue analysis

Homogenized grape sample 10 g was taken in a 50 mL polypropylene centrifuge tube and 10 mL ethyl acetate was added to it followed by vortex for 1 min. Later, 10 g anhydrous sodium sulfate was added and again homogenized it at 15,000 rpm for 1 min. The sample was centrifuged at 5000 rpm for 5 min. Then 5 mL supernatant was collected into 15 mL polypropylene centrifuge tubes containing 25 mg primary secondary amine (PSA), shaken for 30 s and centrifuged it for 5 min at 10,000 rpm. After centrifugation 2 mL supernatant was mixed with 200 μL of 10% Diethylene glycol (DEG) solution and evaporated to dryness under nitrogen at 35 °C. The volume was reconstituted with 1 mL methanol and 1 mL 0.1% acetic acid in water. Then it was sonicated for 1 min followed by vortex for 30 s. The extract was centrifuged at 10,000 rpm for 5 min and filtered through 0.2 μm Nylon membrane before the analysis in LC-MS/MS.

2.3. LC-MS/MS analysis

An Agilent 1200 series HPLC system (Agilent Technologies, USA) attached to an API 4000 Q-Trap mass spectrometer (Applied Biosystems, MDS sciex, Canada) was used for residue analysis in grape. Chromatographic separation of the test compounds were achieved on Purospher STAR RP18 endcapped column (5 μm, 150 mm length, 4.6 mm ID; from Merck, Darmstadt, Germany). The mobile phase composition was (A) water (100%) with 0.1% formic