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Artificial Neural Based Quality Assessment of Guava Fruit

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Abstract: Merchants and food services are very competitive, and food manufacturers are under considerable pressure not to increase end-product costs when production costs go up. External pressures causing physical texture changes or chemical color, smell, and taste alterations induce fruit tissue injury. To examine this, a novel technique is proposed to identify surface and subsurface flaws utilizing a thermal picture and ordinary digital image concerning the original guava. This study discovered thermal data for thermal image capturing on the guava samples stored in the atmosphere with a FLIR-C2 thermal camera. A systematic Image processing approach was employed to distinguish the injured tissues of the fruits that were unaffected. The total result of the identification of thermal blushes is 95 %, whereas the result of standard image processing is 62.5 %. Theory permitted to differentiate the sound from the defected fruit scorched by birds or insects in creating food processing safety policies, developing the passive thermographic method.

Keywords: Thermal Image; Guava, Image Processing; Thermal Camera

1. Introduction and Background

Agriculture is stated to be the arts and science of cultivating bushes of fruits and vegetables that raise people's thinking as well as feelings and enhance and improve their health¹.

Quality assessment by qualified inspectors is costly, lengthy, arduous, and under its subjective character, necessarily unreliable. Visual inspection is an interactive process involving the product, the eyes, and the brain. Nowadays, food quality control systems utilize thermal imaging cameras, image processing tools, and classification algorithms implemented as computer software. The processing of images and analysis is acknowledged as the cornerstone of computer vision. Due to the sequence of picture treatments, tedious human inspection tasks are minimized².

The treatment of fruit wounds requires careful monitoring since it can potentially impact the entire generation and, as a result, the post-harvest life. Fruit wounds have turned nasty because they may cause significant decreases in the quality and, quantity of horticultural products. It adversely affects agribusiness subservient nations that rely on farming in their economy³.

Image processing plays an essential role in the growth of the food industry and efficient agriculture. Colour and size classifications, which impact supply quality, are made on fruits using existing classification methods. These methods aid in the category of fruits based on their quality requirements. It also assists

growers in selling fruits and vegetables at the highest possible value. With rising concerns about the quality and safety of fruits, the demand for automated and objective quality inspection is increasing⁴.

A system has been developed to identify different dates of fruit maturity status and classify their categories. Results showed that the developed method is helpful and could enhance sorting of the quality dates fruit. The system counts the number of harvested fruits and labels them as well as classified⁵.

A method based on the vision of the machine is used to sort fruits by estimating ripeness and aims at changing the system for sorting the labour. That system consists of picture pre-processing, extraction of characteristics, and fruit categorization using machine-learning techniques. This work describes the vision of the computer and machinery for detecting, counting, and sorting tree fruit⁶.

It is necessary to check the acceptance of the fruit thoroughly. A good technique of segmentation that helps to sort quality fruit in comparison with vision. This study develops a comparison technique for the detection of defective apples using several segmentation methods⁷.

With machine vision and cheap cost software available several days, manual fruit sorting and grading activity were replaced by automatic vision systems. This study examines the fundamental methods of fruit grading. SURF, HOG, and LBP features describe feature extraction methods for color, size, form, and texture. Finally, a short discussion is given of several machine

learning techniques, such as K-NN, SVM, ANN, and CNN. Machine vision will prove to be the future for non-destructive fruit classification and grading⁸⁾.

This research examined the performance of fruit recognition using a new type of picture (MSX image). Developed MSX-based algorithm proved successful in fruit recognition and might be proposed as a viable technique to automate orchard creation⁹⁾.

The monitoring approach was created to identify declining fruit and decay in uncontrolled temperature conditions and natural convection. The monitoring method has been established, which reveals substantial and different temperature variations among decaying tissue and sonic tissue with aggravation of decay¹⁰⁾.

Thermal imaging has been used to identify bruising. The success of thermal imaging was most consistent with therapies that warmed cold apples. The identification of contusions was because of the variations in heat diffusivity between contused and sound tissues¹¹⁾.

The investigation was aimed towards finding guavas damage during chilling and storing at different temperatures utilizing infrared (IR) thermographic data. Three tests with one storage duration were conducted at three different temperatures¹²⁾.

The remainder of this article is organized as follows: Section 2 describes the data collecting procedures that were used to capture thermal images of a variety of healthy and damaged guava fruit. A comparison of two independent samples is performed. Section 3 provides data on quality assessment approaches for imaging processing which can be considered for the research study, and a suitable research analysis methodology. Section 4 provides the outcomes, the results of a systemic investigation, and the interpretations of the observations based on the methodological outlooks. Finally, in Section 5, the conclusion is drawn from observations and assessments in various conceivable circumstances.

2. Data Collection

The phrase quality assessment refers to the application process of technology and techniques for enhanced inspection, processes, and thermal imaging control.

2.1 Hardware Requirement

2.1.1. Thermal imager

Thermal Imager (TI) is commonly used for food safety and quality assessment such as bruise and foreign body detection, temperature validation, and grain quality evaluation in research. The TI used in this experiment is FLIR C2. The FLIR C2 with MSX technique is the world's first full-featured, pocket-sized thermal camera. Here are few samples of Thermal and digital image both captured using FLIR C2 camera of Healthy and defective fruits especially eaten by birds. The thermal picture and digital picture of healthy guava are illustrated in Fig. 1

and Fig. 2.

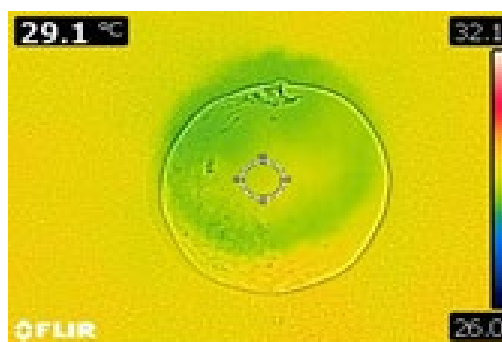


Fig. 1: Thermal image of healthy guava sample



Fig. 2: Digital image of healthy guava sample

The thermal picture and digital photo sample of defective guava fruits eaten by birds are presented in Fig. 3 and Fig. 4.

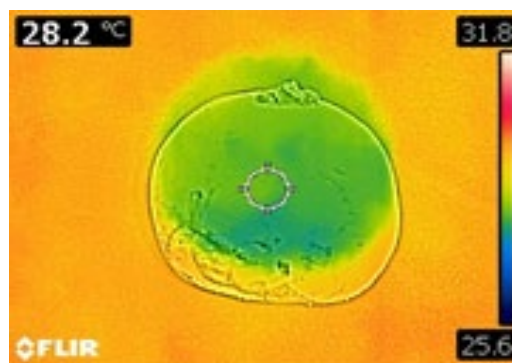


Fig. 3: Thermal image of guava fruit eaten by bird sample



Fig. 4: Digital image of guava fruit eaten by bird sample

3. Methodology

The scientific technique was used to analyze the feature extraction to verify the statistically essential elements in the evaluating group. In the current part, the systemic strategy utilized in this investigation has been described.

Image Processing:

The image processing system's primary function is to assess guava fruit flaws on photographs in their respective regions¹³.

MATLAB software is used to create image processing. MATLAB is a highly interactive language and computer, visual, and programming environment. The language, tools, and integrated mathematical functions allow you to explore various methods and achieve a solution faster. MATLAB may also be used to create the graphic user interface of the program. Firstly, the image is pre-processed such that it is amenable for further damaged extraction of the contour. Therefore, several pre-processing techniques such as image segmentation, histogram equalization are used over the image. The threshold was highly crucial to detect blemishes. Thresholding with a highly adequate threshold generated using the global method provides an image with the contour of the bruise and just the backdrop. After the threshold testing, it is possible to determine the existence of components in the image since the contour is always in the shape of a linked element.

3.1 Pre-processing

Initial processing of RAW image at the base station is performed before it is sent to an end-user before any analysis. This processing is necessary to correct image distortions. The following are some of these pre-treatments:

The primary goal of pre-processing is to improve the contrast of the input picture, minimize the noise in the image, and thus increase processing speed. During pre-processing, an RGB picture is transformed into a grayscale image. Histogram equalization, contrast stretching, and other techniques are used to improve the contrast. Various filters are used to eliminate noise from the input picture. In the suggested method for damaged area extraction, the input picture is improved using a histogram equalization methodology, and noise is eliminated using filtering.

3.1.1. RGB to Gray scale conversion

The image that is taken was RGB. The first step in pre-processing is to convert the RGB picture to grayscale. The primary goal of colour conversion is to minimize the number of colours. The R, G, and B components of each pixel's (I J) 24-bit colour value is separated, and an 8-bit grey value is produced.

3.1.2. Noise removal by median filter

The fundamental purpose of filtering is the removal of noise from the picture. Noise may arise when the camera is captured and because of weather. The median filter is utilized in the suggested approach for removing the noise from salt and paper. It provides the noise reduction technique while more successfully maintaining the edges using a median filter.

3.1.3. Contrast enhancement using histogram equalization

Histogram equalization is a technique for enhancing contrast by adjusting image intensities. Histogram equalization is a contrast adjustment method in image processing that makes use of the image's histogram. Fig. 5 shows pre-processed thermal and digital images of healthy guava fruit and Fig. 6 shows pre-processed thermal and digital images of bird-eaten guava fruit.

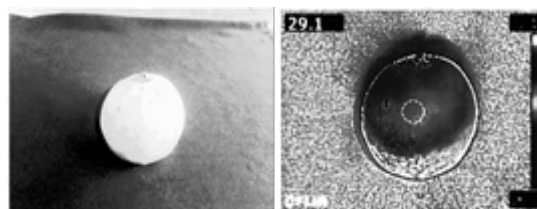


Fig. 5: Pre-processed thermal image and the digital image of healthy guava fruit.

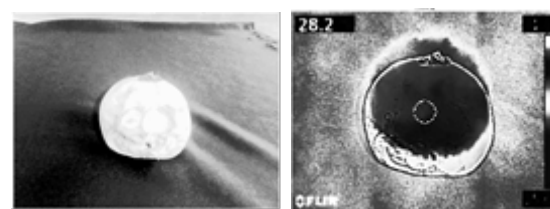


Fig. 6: Pre-processed thermal image and digital image of Guava fruit eaten by bird sample

3.2 Data Reduction

3.2.1. Image Binarization

The grayscale picture is transformed into a binary image during this procedure. First, threshold levels are computed. The MATLAB grey picture is transformed into black and white using the `im2bw` function according to the global threshold operation.

3.2.2. Laplace operations

A Laplacian operator will improve any feature with a strong discontinuity (similar to the noise, regrettably). So, a Laplacian operator's application is to restore fine details to a picture smoothed for noise removal. Fig. 7 and Fig. 8 represent the data reduction operations on the thermal and digital image of healthy guava fruit. Fig. 9 and Fig. 10 illustrate the data reduction operations on the thermal and digital image of bird-eaten guava fruit.

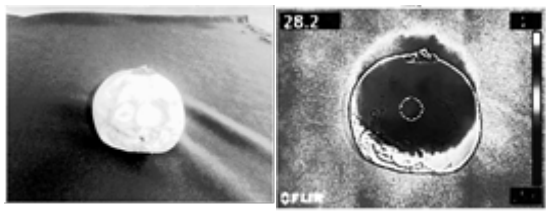


Fig. 7: Data reduction operations on thermal image of healthy guava fruit.

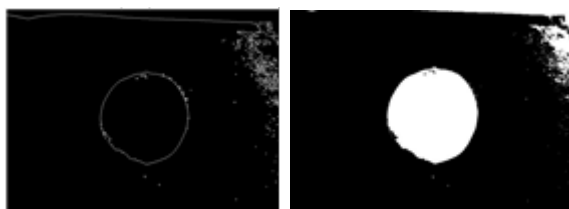


Fig. 8: Data reduction operations on the digital image of healthy guava fruit.

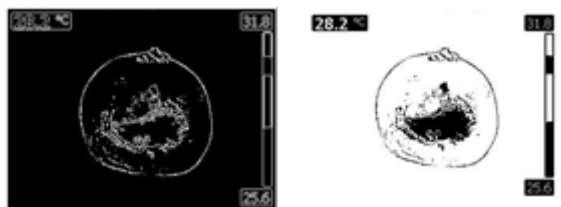


Fig. 9: Data reduction operations on thermal image of guava fruit eaten by bird sample.

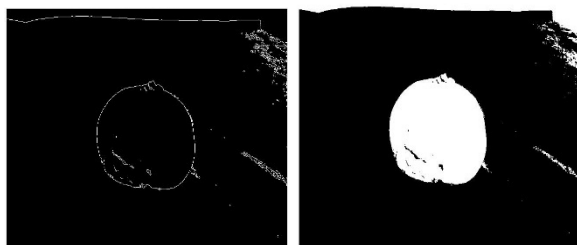


Fig. 10: Data reduction operations on the digital image of guava fruit eaten by bird sample

3.3 Feature extraction

The retrieved picture of guava fruit may have numerous loud or unwanted parts. It improves the damaged fruit area. The results enhance morphological dilation and cleaning of the guava fruit region in the defected fruit zone.

3.3.1. Morphological Dilation Operation

The undesirable items in the picture are eliminated using morphological procedures. The first dilation procedure is done to the image identified on the surface of the guava fruit, and then the imdilate function of MATLAB is filled with that hole.

3.3.2. Extracted guava fruit region enhancement

The picture of the guava fruit might be different noises

or undesirable holes. It improves the damaged area of guava fruit. Fig. 11 and Fig. 12 illustrate the results of the augmentation of guava area by morphological operations of guava area extracted in the thermal and digital image of healthy guava fruit, respectively.



Fig. 11: Feature extraction of thermal images of healthy guava fruit using morphed operations

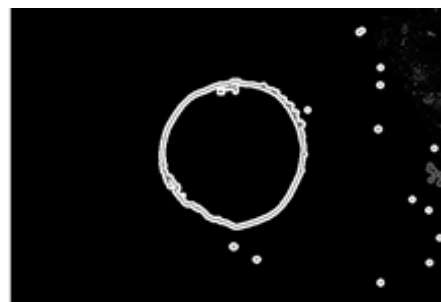


Fig. 12: Feature extraction of digital images of healthy guava fruit using morphed operations

Fig. 13 and Fig. 14 demonstrate the results of the augmentation of guava area by morphological operations of guava area extracted in the thermal and digital image of bird-eaten guava fruit, respectively.



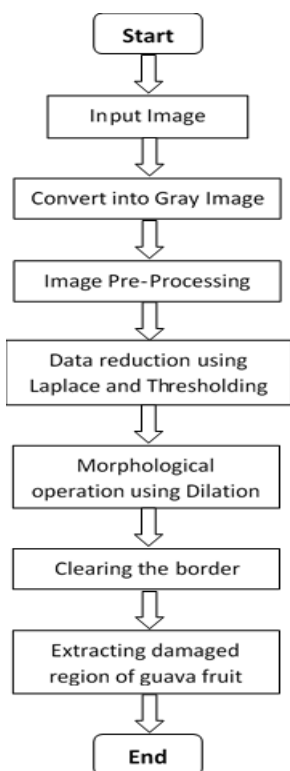
Fig. 13: Feature extraction of thermal images of bird eaten guava fruit using morphed operations



Fig. 14: Feature extraction of digital images of bird eaten guava fruit using morphed operations

3.4 Flow chart for extraction of the damaged part of fruits

Flowchart of extraction of the exact region of defected part of guava fruit.



4. Results and Discussion

The testing took place utilizing this technique to check a total of 40 guavas (20 defected especially bird-eating fruits, 20 sound guava samples). Table 1 and 2 show the final grading rates for different pictures. The total result of the identification of thermal image is 95% (90% for bird eaten guava and 100% for sound guava) and 62.5% for visual pictures (60 percent for bird eaten guava, and 85 percent for sound guava). The detection rates of the active thermal imaging technology are demonstrated in both sound guavas and bird eaten guavas.

Table 1: Results of thermal image processing

Sr. No.	Image Type	No. of samples	Correct detection	Detection Rate (%)
1.	Defective Guava	20	18	90
2.	Sound Guava	20	20	100

Table 2: Result of digital images processing

Sr. No.	Image Type	No. of samples	Correct detection	Detection Rate (%)
1.	Defective Guava	20	8	60
2.	Sound Guava	20	17	85

Heterogeneity in the fruit surface following thermal arousal and changes in its surrounding environment are the key factors impacting test outcomes. During all the tests samples are collected, it is difficult to establish a completely uniform temperature distribution. Thus, the impact of altering the temperature, i.e., changing the colour intensity, influences the outcomes.

Rural communities throughout the world have a number of characteristics, including reliance on natural resources, low population density, and limited connectivity. As a results fruits transportation is considered as important aspects of transportation. Since the roads are not smooth, there may be chances of damage of fruits. Further, the environment, economics, society, and culture are all impacted by agritourism. Tourism events help to improve the community's agricultural and tourism-related commercial prospects¹³. To guarantee that food reaches the homes of its consumers, food supply networks involving farmers, suppliers, and producers require proper management. The key element impacting total recovery costs was truck load capacity, as vehicles with bigger load capacities lowered the frequency of shipping on a route, lessening effect on carbon emissions¹⁴. Electric vehicles are better option for transport of fruits¹⁵. In a number of ways, technology and sustainable development strategies may have a substantial impact on the best performance evaluation^{16,17}.

Neural network had found wide application in around the entire field of engineering for enhancing the efficiency. For a variety of reasons, using a neural network is a great idea^{18,19,20}. In the present work, attention was focused on inspecting the quality of guava fruit by using such advanced technique. Since the guava fruit has different stages from initial hard guava to eatable soft guava, the white and pink guava fruits have a normal climacteric respiration pattern. Fruit tissue hardness reduced gradually in both guava fruit varieties in a comparable manner²¹. Therefore it is important to check the quality of fruit. Some studies elaborate that Antioxidants like phenols and ascorbic acid are abundant in local fruits like guava²². There are various factors that are considered while assessing the quality of fruits such as colour, taste, fruit size, hardness^{23,24}. Nondestructive quality assessment of fruits is essential for the agriculture and food industries. Some approaches, such as image processing and sorting using edge detection, are now frequently employed²⁵. Thereby, the

present work will be helpful for identifying the quality of guava fruit which may be helpful for sorting the destructed guavas.

5. Conclusions

The results of the deep inspection carried out utilizing the guava sample were used to explore an efficient image processing method technique for defected guava fruit extraction. The total result from the identification of injuries is 95% and for ordinary imagery is 62.5%. Thus, the thermal camera's results are superior to the traditional digital camera. The method of identification of damages created by birds on guava fruit in this study may include other varieties of guava or other fruit.

It helps to create particular mechanisms that will be an essential solution in real-world scenarios for an online defective guava fruit detecting system.

References

- 1) T. Dhanabal, and S. Debabrata, "Computerized Spoiled Tomato Detection," *IJRET: International Journal of Research in Engineering and Technology*, **2**(11) 38–41(2013).
- 2) M. Satone, S. Diwakar, and V. Joshi, "Automatic Bruise Detection in Fruits Using Thermal Images," *IJARCSSE*, **7**(5) 727–732(2017).doi: 10.23956/ijarcsse/SV7I5/0116.
- 3) D. Jawale, and M. Deshmukh, "Real time automatic bruise detection in (Apple) fruits using thermal camera," *International Conference on Communication and Signal Processing (ICCSP), Chennai*, 1080–1085(2017). doi: 10.1109 /ICC SP.2017.8286542.
- 4) O. Ayan, D. Z. Demirez, H. K. Kiziloz, G. Inci, S. Isleyen, and Ergin, "The Detection of Spoiled Fruits on a Conveyor Belt Using Image Processing Techniques and OPC Server Software," *International Journal of Computational and Experimental Science and Engineering*, **4**(1), 11–15(2018).doi:10.22399/ijcesen.398335.
- 5) T. Najeeb, and M. Safar, "Dates Maturity Status and Classification Using Image Processing," *International Conference on Computing Sciences and Engineering (ICCSE)*, Kuwait, 1–6(2018). doi:10.1109/ICCSE1.2018.8374209.
- 6) A. Vaidya, and A. Bagade, "Automatic Fruit Detection, Counting And Sorting Using Computer Vision And Machine Learning Algorithms," *International Journal of Computer Engineering and Applications*, **12**(special issue),1-9(2018).
- 7) Yogesh, A. K. Dubey, and R. R. Arora, "A Comparative Approach of Segmentation Methods Using Thermal Images of Apple," *7th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, Noida, India, 412–418(2018).doi: 10.1109/ICRITO.2018.8748437.
- 8) S. Naik, and B. Patel, "Machine Vision based Fruit Classification and Grading - A Review," *IJCA*, **170**(9), 22–34(2017). doi: 10.5120/ijca2017914937.
- 9) J. Feng, L. Zeng, and L. He, "Apple Fruit Recognition Algorithm Based on Multi-Spectral Dynamic Image Analysis," *Sensors*, **19**(4), 1-13(2019). doi: 10.3390/s19040949.
- 10) L. Z. Jiao, W. B. Wu, W. G. Zheng, and D. M. Dong, "The Infrared Thermal Image-Based Monitoring Process of Peach Decay under Uncontrolled Temperature Conditions," *Journal of Animal and Plant Sciences*, **25**, 202-207(2015).
- 11) J. Varith, G. M. Hyde, A. L. Baritelle, J. K. Fellman, and T. Sattabongkot, "Non-contact bruise detection in apples by thermal imaging," *Innovative Food Science & Emerging Technologies*, **4**(2), 211–218(2013). doi:10.1016/S1466-8564(03)00021-3.
- 12) B. J. Gonçalves, T. M. de O. Giarola, D. F. Pereira, E. V. de B. Vilas Boas, J. V. de Resende, Using infrared thermography to evaluate the injuries of cold-stored guava, *Journal of Food Science Technology*, **53**(2), 1063–1070(2016). doi: 10.1007/s13197-015-2141-4.
- 13) A.T. Nugraha, G. Prayitno, A. W. Hasyim, and F. Roziqin, "Social capital, collective action, and the development of agritourism for sustainable agriculture in rural Indonesia," *Evergreen*, **8**(1) 1-12(2021). doi.org/10.5109/4372255
- 14) N. S. Zulkefly, H. Hishamuddin, F. A. A. Rashid, N. Razali, N. Saibani, and M. N. Ab Rahman, "The Effect of Transportation Disruptions on Cold Chain Sustainability," *Evergreen*, **8**(2) 262-270(2021). doi.org/10.5109/4480702
- 15) L. N. Patil, and H. P. Khairnar, "Investigation of human safety based on pedestrian perceptions associated to silent nature of electric vehicle," *Evergreen*, **8**(2) 280-289((2021). doi.org/10.5109/4480704
- 16) S. R. Hamid, C. B. Cheong, and S. Alina, "Sustainable development practices in Services Sector: A case of the Palace Hotel from Malaysia," *Evergreen*, **8**(4) 693-705(2021). doi.org/10.5109/4742113
- 17) H. A. Umar, S. A. Sulaiman, M. Amin BA Majid, M. A. Said, A. Gungor, and R. K. Ahmad, "An Outlook on Tar Abatement, Carbon Capture and its Utilization for a Clean Gasification Process," *Evergreen*, **8**(4) 717-731(2021). doi.org/10.5109/4742115
- 18) T. N. Dief, and S. Yoshida, "System identification for quad-rotor parameters using neural network," *Evergreen*, **3**(1) 6-11(2016). https://doi.org/10.5109/1657380
- 19) G. D. Nugraha, B. Sudiarto, and K. Ramli, "Machine learning-based energy management system for

- prosumer," *Evergreen*, **7**(2) 309-313(2020). doi.org/10.5109/4055238
- 20) N. Weake, M. Pant, A. Sheoran, A. Haleem, and H. Kumar, "Optimising parameters of fused filament fabrication process to achieve optimum tensile strength using artificial neural network," *Evergreen*, **7**(3) 373-381(2020).
- 21) H. A. Bashir, and Abu-Bakr A. Abu-Goukh. "Compositional changes during guava fruit ripening," *Food Chemistry*, **80**(4) 557-563(2003). doi.org/10.1016/S0308-8146(02)00345-X
- 22) Lim, Yau Yan, Theng Teng Lim, and Jing Jhi Tee. "Antioxidant properties of guava fruit: comparison with some local fruits," *Sunway Academic Journal*, **3** 9-20(2006).
- 23) A. Daza, Pedro A. García-Galavís, M. J. Grande, and C. Santamaría "Fruit quality parameters of 'Pioneer' Japanese plums produced on eight different rootstocks," *Scientia Horticulturae* **118**(3) 206-211 (2018). doi.org/10.1016/j.scienta.2008.06.003
- 24) M. Manna, and A. Paul, "Studies on genetic variability and characters association of fruit quality parameters in tomato," *HortFlora Research Spectrum*, **1**(2) 110-116(2012).
- 25) R. S. Jadhav, and S. S. Patil, "A fruit quality management system based on image processing," *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)* **8**(6) 01-05(2013).