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Development of Apple MRI Dataset for Internal Quality Analysis

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ABSTRACT:
Internal quality assessment of agricultural products is a challenging task for exporting premium quality agri products like apple fruits. In this paper, we have analyzed the internal quality of apple fruits by a non-destructive method. We have developed our dataset of MR images of apples by subjecting 21 apples to MRI scanning for the development of robotics detection of internal defects in apples. This MRI scanning led to 196 MR images. A comparative study was carried out based on MRI images with respective external photographic images of apple fruits. Depending on external as well as internal defects the apples were grouped into four categories. Through this study, we can easily identify the percentage and area of the defect without affecting the physical appearance of the apple.

Keywords: MRI images, Non-destructive, dataset, robotics

1. INTRODUCTION:

Agriculture plays a crucial role in improving the economic condition of developing countries, whereas maintaining quality parameters in agricultural products becomes a big requirement in the global market. There is a big challenge to maintain the quality of plant products because there are environmental stress factors as well as pathological invasion. There are several ways to detect the internal structure of agricultural products

Apple fruit is a highly consumable fruit all around the world that holds high commercial value. There is always a challenging aspect in the quality analysis of apple fruits. Apple fruit has a few internal diseases that are not able to the identify by physical observation. (Komal Sindhi et . al.,2016) [1]. Different non-destructive technologies are available to detect internal defects in agricultural products and there are advantages and disadvantages of using different technologies like X-ray, NIR, Sonic/ Ultrasonic method, and MRI on Mangoes fruit diseases (Anita Raghavendra et al., 2016) [2].

Modern challenges of food science require a new understanding of the determinants of food quality and safety. MRI has seen fast growth over the past decades and MRI allows the structure of food to be imaged non-destructively, Since MRI does not have any harmful ionizing radiation, it can be considered a magnificent tool for quality control of food products (Ebrahimnejad Hamed et al., 2018) [3].

2. LITERATURE SURVEY:

Cheng-Jin Du and Da-Wen Sun (2004) [4] reviewed recent advances in image processing techniques for food quality evaluation. Ebrahimnejad Hamed et al (2018) [3] reviewed the use of magnetic resonance imaging (MRI) in food quality control. The author observed that MRI allows the structure of agricultural products to be imaged noninvasively & non-destructively. This review provides an overview of the most prominent applications of MRI in agriculture.

Krishna Kumar Patel et al., (2015) [5] reviewed Recent developments in the application of MRI techniques for food and agriculture products. MRI scanning is a significant technology to get different variety of measurements for the evaluation of maturity and quality parameters in fruits and vegetables and other food materials but also to improve the understanding of fundamental physiological parameters.

Boan Zion et al., (1995) [6] proposed the detection of bruises in magnetic resonance images (MRI) of apples, the author researched by using different pulse sequence techniques investigateates temporal changes in MRI image contrast in bruised & unaffected areas of flesh. The author also reported

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that with time contrast between bruised and non-bruised regions was found in the increasing trend.

Thijs Defraeye T et al. (2013) [7] proposed an application of MRI for Braeburn apple's tissue analysis. In this study, small samples of Braeburn apples were investigated with field MRI for detecting differences in tissue types. The author focused on MRI images for tissue characterization concerning inner and outer cortex tissue and described the internal quality defects such as voids, worms damage, or bruising & their variation over time.

Magnetic Resonance Imaging (MRI) is a more improved imaging method used to produce high-quality images of agricultural products. There are several methodologies used for classifying MR images, which are fuzzy methods, neural networks, knowledge-based techniques, shape methods, variation segmentation, etc. (Murugavalli 2006) [8].

The present study is carried out on documentation of the new apple MRI data set and comparison between MRI images of apple with photographic images of those respective fruits.

3. MATERIALS AND METHODS:

21 Delicia apples were brought from the local market. Based on morphological appearance apples were categorized into two groups as good (G) and defect (D). some apples were in good condition and the remaining apples had some morphological defect. Based on the morphological appearances all apples were labeled and then color photographic images of each apple were taken at different angles like Front, Back, Arial, and Bottom (Fig 1). then these individual Apples were subjected to vertical and horizontal MRI scanning (Fig 2 & 3). MR images were obtained using 1.5 Tesla Sieman's Magnetom Spectro MR machine with T2-weighted MR images with a repetition time (TR) of 8980 and Spin echo time (TE, the period during which sample magnetization dephases and then rephrases) of 100.2 with slice diameter of 116.7mm and interslice gap of 8.0mm. The total number of slices for all channels ranges from 9 to 33, which leads to a total of 196 images. The pixel size of each image was 512 X 512 (Table 1). The images are grayscale. MR image generation time depends on the resolution, the higher the desired resolution the more acquisition are required for image generation and the longer it takes to acquire an image. MRI images were analyzed using RadiAnt DICOM Viewer (64-bit) software. After documenting NMR images all the individual Apples were cut vertically and made into two halves with knife and color photographic images were taken for internal appearances. Visual inspection of the internal structure and locations and severity of the defects was made. Finally, each apple's color photographic images were aligned with respective apple MRI images, and a comparison study was carried out.

Fig 1: Apple photography in different directions. (F: Front, BK: Back, A: Arial, BT: Bottom)

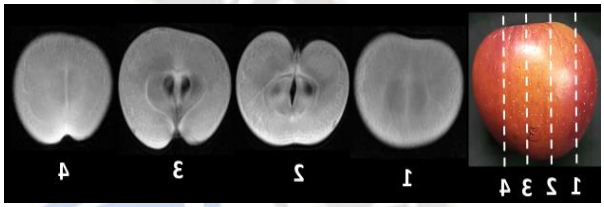

Fig 2: Apple's vertical slices of MRI images.

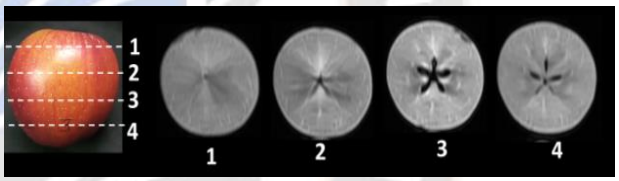

Fig 3: Apple's horizontal slices of MRI images.Table 1: Experimental characteristic of MRI measurements.

Table 1: Experimental characteristic of MRI measurements.

Method	Values
Machine	1.5 Tesla Sieman's Magnetom Spectro
TR	8980
TE	100.2
Slice diameter	100.2
Slice gap	8.0mm
Image size	512 x 512

RESULTS AND DISCUSSION:

only 21 apple fruits were able to scan and a total of 196 MRI slices were acquired by RadiAnt DICOM Viewer (64-bit) software. Most of the individual apple has ten MRI images out of which five vertical slices and five are horizontal. Only a few individual apples have less than five vertical slices.

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After aligning Photographical as well as vertical and Horizontal MRI images, a detailed defect observation chart has been prepared (Table 2).

According to Table 2 fruits were categorized into four groups (Table 3). Group 1 is having fruits that are seen as healthy and no defect observed externally and internally, fruits G1, G4 fall under this group (fig. 4). Group 2, is having apple fruits (G2 & G3) which were externally healthy, whereas the internal vertical cut apple part as well as in MRI images has a very slight defect in the peripheral region of apple fruits (Fig. 5). Group 3 is having fruits (D3, D5) which were having defect at externally whereas MRI images has no defect observed (Fig. 6). Group 4 is made on the following criteria where apple fruits having defect externally as well as internally when compared with photographic as well as MRI images (D1, D4,

Table 2: Defected history (H: Horizontal section, V: Vertical Section, N: No defect, Y: Defect).

Sl. No	Apple No.	Photographic image		Apples MRI images Showing Internal Defect									
		Uncut Apple	Vertically cut apple	Slice 1		Slice 2		Slice 3		Slice 4		Slice 5	
				H	V	H	V	H	V	H	V	H	V
1	G1	N	N	N	N	N	N	N	N	N	N	N	N
2	G2	N	Y	N	N	Y	Y	N	Y	N	Y	N	N
3	G3	N	Y	N	N	N	N	N	N	Y	N	N	N
4	G4	N	N	N	N	N	N	N	N	N	N	N	N
5	D1	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N
6	D2	Y	N	N	N	N	N	N	N	N	N	N	N
7	D3	Y	N	N	N	N	N	N	N	N	N	N	N
8	D4	Y	Y	Y	N	Y	N	Y	N	Y	N	N	N
9	D5	Y	N	N	N	N	N	N	N	N	N	N	N
10	D6	Y	Y	Y	Y	N	Y	N	Y	Y	N	N	N
11	D7	Y	Y	N	N	Y	N	N	N	N	N	Y	N
12	D8	Y	N	N	N	N	N	N	N	N	N	N	N
13	D9	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	
14	D10	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	
15	D11	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y
16	D12	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y
17	D13	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	
18	D14	Y	Y	Y	Y	Y	Y	Y	Y	Y		N	
19	D15	Y	Y	N	N	N	Y	N	Y	Y		Y	
20	D16	Y	N	N	N	N	N	N		N		N	
21	D17	Y	N	N	N	N	N	N		N		N	

Table 3: Grouping of Apples by Comparison study between MRI and Photographic pictures of individual apples.

S. No.	Group No.	Grouping Criteria	Apple No.
1	Group 1	No External & Internal Defect	G1 & G4
2	Group 2	No External defect but Internal defect	G2 & G3

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3	Group 3	Defect at Externally but No defect Internally.	D2, D3, D5, D8, D16 & D17
4	Group 4	Defect at Externally & Internally.	D1, D4, D6, D7,D9, D10, D11, D12, D13, D14, & D15

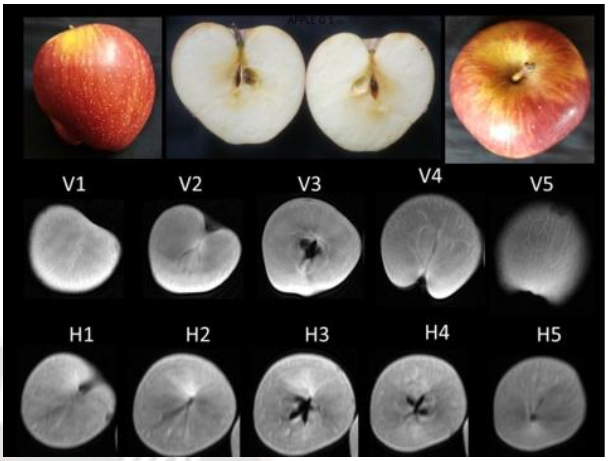

Fig. 4: Group 1 representative (G1), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

RESULTS AND DISCUSSION:

only 21 apple fruits were able to scan and a total of 196 MRI slices were acquired by RadiAnt DICOM Viewer (64-bit) software. Most of the individual apple has ten MRI images out of which five vertical slices and five are horizontal. Only a few individual apples have less than five vertical slices. After aligning Photographical as well as vertical and Horizontal MRI images, a detailed defect observation chart has been prepared (Table 2).

According to Table 2 fruits were categorized into four groups (Table 3). Group 1 is having fruits that are seen as healthy and no defect observed externally and internally, fruits G1, G4 fall under this group (fig. 4). Group 2, is having apple fruits (G2 & G3) which were externally healthy, whereas the internal vertical cut apple part as well as in MRI images has a very slight defect in the peripheral region of apple fruits (Fig. 5). Group 3 is having fruits (D3, D5) which were having defect at externally whereas MRI images has no defect observed (Fig. 6). Group 4 is made on the following criteria where apple fruits having defect externally as well as internally when compared with photographic as well as MRI images (D1, D4, D6, D7, D9, D10, D11, D12, D13, D14, & D15) (Fig. 7). These apple MRI images indicate the location and severity of the defect. For example, in Apple D11 the first two horizontal slices of MRI images are not having any defects, but when we move further three slices were having a clear cut defect area because that fruit was having defect only at the bottom side of that fruit. Whereas in Apple D9, the first two horizontal slices of MRI images were having a prominent defect, but other slices 3,4, and 5 were not showing any defects (Fig. 8). This indicates that fruit is having defects at the top layer but not in the bottom layers of that particular apple fruit. Defect severity is also being calculated based on the coverage area of the defect and color intensity in the MRI images.

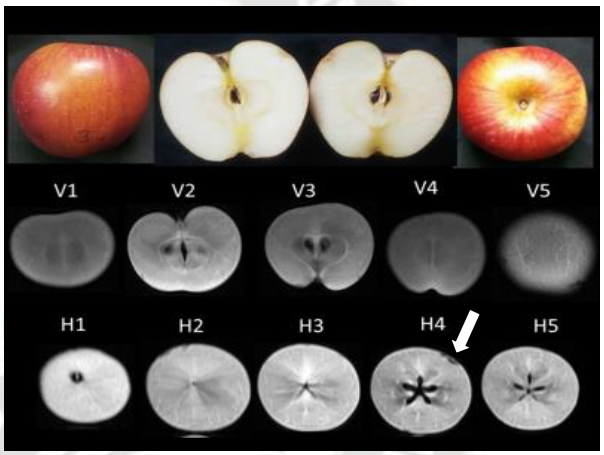

Fig. 5: Group 2 representative (G3), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

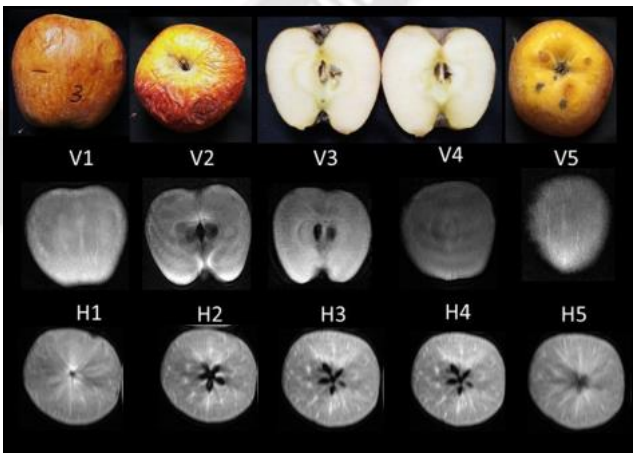

Fig. 6: Group 3 representative (D3), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

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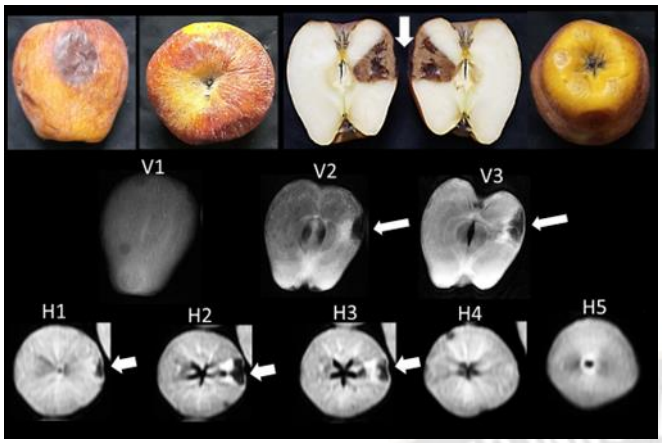

Fig. 7: Group 4 representative (D14), external pictures aligned with 3 Vertical & 5 Horizontal MRI images.

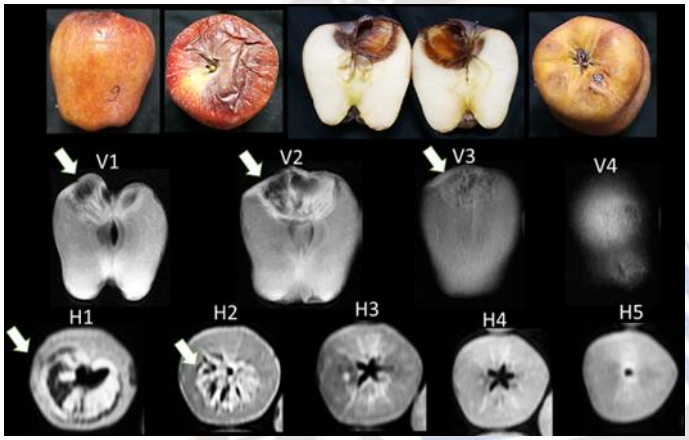

Fig. 8: D9 Apple's external pictures aligned with 4 Vertical & 5 Horizontal MRI images.

CONCLUSION:

This study of the internal quality assessment of Apple indicates that MRI is a non-destructive and non-invasive technique. This entire study was carried out manually for finding out the internal quality of 21 Apples which gave 196 images of different slices. This becomes a very difficult and tedious process for a larger number of Apple's screenings. Further study has to be carried out for simplifying the internal quality of any fruits using Digital Image Processing Technology.

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