Image processing algorithms for biospeckle analysis of almond seed

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Abstract

Laser biospeckle technique, as a non-invasive, non-contact and non-destructive method has gained importance in the assessment of biospeckle activity of various biological samples. This study presents the application of the laser biospeckle technique [1] to evaluate the activities of dry and soaked almond seed. We have used conventional image processing algorithms such as inertia moment (IM), absolute value of differences (AVD), and probability mass function of regular difference, temporal speckle contrast and fujii for this analysis. All analyses indicate an increase of biospeckle activity of the soaked almond (402.85 using IM) in comparisons to the dry stage (44.32 using IM) which can be attributed to the initiation of germination. Spectral activity maps obtained using fujii represents the change of surface of the almond seed after soaking water.

Keywords: *Biospeckle, almond seed, algorithm*

1. Introduction

Almond seeds are perennial nutritious food and rich source of proteins and minerals. Almond contains vitamin E, vitamin B, dietary fiber, mono-unsaturated fats and phytosterols. This food reduces risk of different diseases like coronary heart disease, gastroenteritis, kidney pain, diabetes, gastric ulcer, anemia etc [2].

Almond seeds have tough and hard texture but soaking of water makes them soften. This research paper deals with measurement of biospeckle activities of almond seed at dry stage and soaked stage using laser biospeckle technique for the first time to the best of our knowledge and compare them. Laser biospeckle technique is a non-destructive, non-invasive and non-contact technique [1] has been applied in various biological [1, 3] and non-biological fields [4]. Image processing algorithms namely inertia moment (IM) and absolute value of differences (AVD) have been used to measure biospeckle activity values of dry and soaked stages of almond seed whereas spectral activity maps along with biospeckle activity values of two stages of almond seed have been obtained using fujii algorithm. Probability mass function and temporal speckle contrast have been applied to compare between dry and soaked stages of almond.

2. Image processing algorithms

IM and AVD [1] algorithms have been applied to calculate biospeckle activities of almond seed and are given by-

$$IM=\sum_{ij} M_{ij}(i-j)^2$$

$$\mathrm{AVD}=\sum_{ij} M_{ij}\left|i-j\right|$$

Where, M_{ij} is normalised co-occurrence matrix [1].

Probability mass function of regular difference [5] is obtained by calculating the regular difference of the intensities between two consecutive instants of a same pixel in a time history of speckle pattern [1]. This function interprets co-occurrence matrix.

Fujii [6] has been used to determine spectral activity maps along with biospeckle activities of almond seed and is given by-

$$\mathrm{Fujii}=\sum_{k}\frac{\left|I_k(x,y)-I_{k+1}(x,y)\right|}{\left|I_k(x,y)+I_{k+1}(x,y)\right|}$$

Where, I_k is intensity matrix of recorded image and k is the image sequence.

Temporal speckle contrast is ratio of mean value of temporal speckle standard deviation matrix (σ) and mean value of temporal speckle mean matrix (μ) and is given by [5]-

$$\mathrm{Contrast}=\frac{\sigma}{\mu}$$

Temporal speckle mean matrix and temporal speckle standard deviation matrix are respectively given by [5]-

$$\mu=\frac{1}{N}\sum_{k=1}^{N} I_k$$

$$\sigma=\sqrt{\frac{1}{N}\sum_{k=1}^{N}(I_k-\mu)^2}$$

Where, I_k is intensity matrix of recorded image and N is total number of images.

3. Experimental

Dry almond seed was purchased from local market and used as sample at dry stage for biospeckle measurement. This almond was placed in a bowl with normal water such that it was fully covered by water. The bowl was covered for 12 hours. After 12 hours this almond was patted using tissue paper and considered as almond at soaked stage. 128 biospeckle images having 120 x120 pixels height and width was recorded for both dry and soaked conditions of almond seed using our biospeckle set-up. Our set-up consists of a 10 mW He-Ne laser light (wavelength 632.8 nm), microscopic objective, spatial filter and CCD camera (Basler scA 1300-32fc). Whole experiment was performed on a vibration free optical bench kept in a dark room. Schematic of the experimental set-up has been already reported by our research group [3].

4. Results and discussions

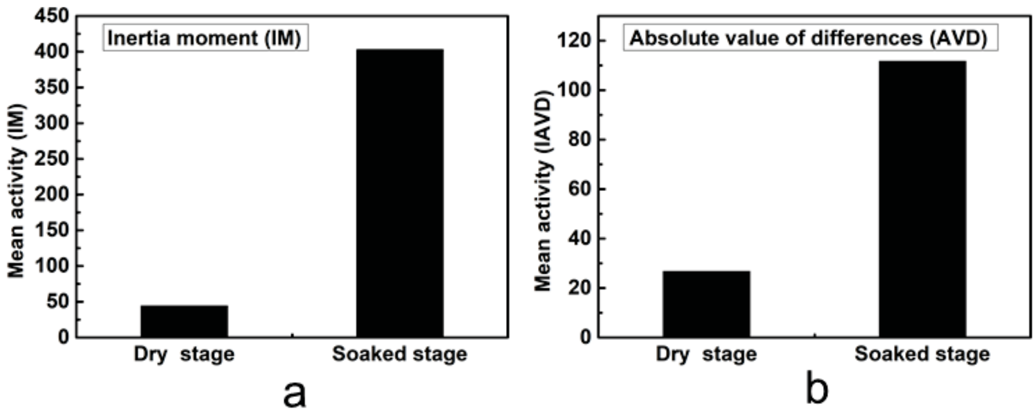

FIG 1. Bar graphs of dry and soaked stages of almond using (a) IM and (b) AVD algorithms.

Bar graphs represented by Fig. 1(a) and Fig. 1(b) show biospeckle activities of almond at dry and soaked stages using IM and AVD algorithms. Graphs show higher biospeckle activity of almond at soaked stage in comparison to dry stage. As biospeckle phenomenon represents the movement of cell particles, higher biospeckle activity represents higher mobility of cell particles of soaked almond than dry almond. Increase of biospeckle activities of almond from dry stage to soaked stage are 358.53 and 84.97 using IM and AVD respectively.

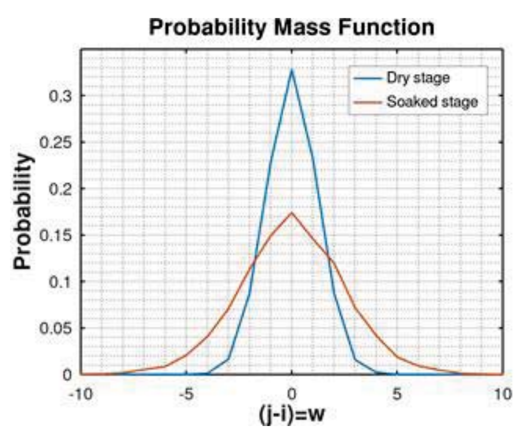

FIG 2. Probability mass functions of regular difference of dry stage and soaked stage of almond.

Probability mass functions of regular difference of dry and soaked almond have been presented by Fig. 2. As this function represents expansion of co-occurrence matrix, more spread of the graph of soaked stage proves higher activity of soaked almond compared to dry almond.

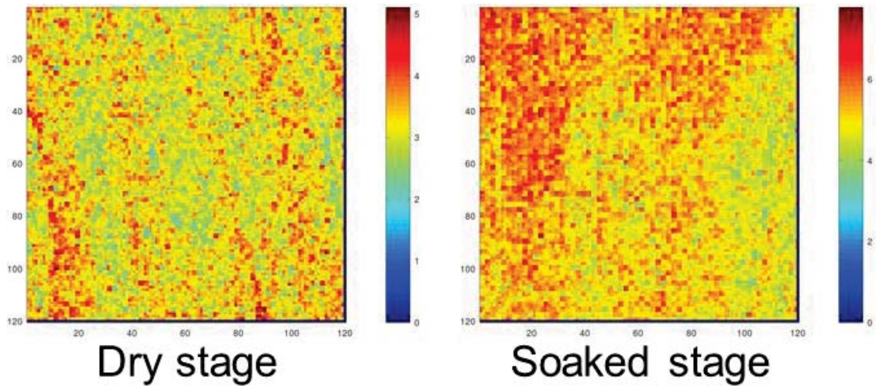

FIG 3. Spectral activity maps of dry stage and soaked stage of almond.

Fig. 3 represents spectral activity maps of two stages of almond seed using fujii algorithm. Red colour of the spectral activity map represents the highest activity and blue colour represents the lowest activity. Results show highest activity points i.e. red colours are more in case of soaked almond than dry almond which represents higher biospeckle activity of soaked almond than dry almond.

Table 1. Biospeckle activity of dry and soaked stages of almond using IM, AVD and fujii algorithms.

	Dry stage	Soaked stage	Increase of biospeckle activity
Biospeckle activity using IM	44.32	402.85	358.53
Biospeckle activity using AVD	26.71	111.68	84.97
Biospeckle activity using fujii	3.16	5.14	1.98

Table 2. Weight of dry and soaked stages of almond.

	Dry stage	Soaked stage	Increase of weight
Weight (gm)	1.01	1.45	0.44

Table 1 represents biospeckle activity values of two stages of almond seed and increase of biospeckle activities from dry stage to soaked stage of almond using IM, AVD and fujii algorithms. Table 2 shows weights of dry almond and soaked almond.

Table 3. Temporal speckle contrast value of dry and soaked stages of almond.

	Dry stage	Soaked stage
Mean value of temporal speckle mean matrix (μ)	30.13	37.12
Mean value of temporal speckle standard deviation matrix (σ)	1.91	3.85
Value of temporal speckle contrast (σ/μ)	0.0634	0.1037

Table 3 shows mean values of temporal speckle mean matrix, temporal speckle standard deviation matrix and values of temporal speckle contrast of dry and soaked almond. Temporal speckle contrast increases from dry stage to soaked stage of almond. Speckle dynamics are affected by inhomogeneous absorption property of region under observation and dark object has low speckle contrast. Lower temporal speckle contrast of dry almond represents darkness of surface of it.

5. Conclusion

Increase of biospeckle activity of the almond at soaked stage in comparisons to dry stage can be indication of initiation of germination. Spectral activity maps successfully show the change of surface of almond seed after soaking water. Biospeckle activity of almond at dry stage shows remnant activity of dry almond.

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