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Influence of Cold Plasma on Sesame Paste and the Nano Sesame Paste Based on Co-occurrence Matrix

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Abstract:

The aim of the research is to investigate the effect of cold plasma on the bacteria grown on texture of sesame paste in its normal particle and nano particle size. Starting by using the image segmentation process depending on the threshold method, it is used to get rid of the reflection of the glass slides on which the sesame samples are placed. The classification process implemented to separate the sesame paste texture from normal and abnormal texture. The abnormal texture appears when the bacteria has been grown on the sesame paste after being left for two days in the air, unsupervised k-mean classification process used to classify the infected region, the normal region and the treated region. The bacteria treated with cold plasma, the time exposure is two minutes. The textural features related to gray level co-occurrence matrix are calculated for the normal, abnormal and the treated texture, it is obvious that the treated texture class has the best features compared with the other classes. The result shows the sesame paste treated with plasma has good result compared with nano sesame paste treated with plasma. This is because the plasma provides the sesame paste with heat and makes the sesame nano particle congregate together.

Keywords: Co-occurrence matrix, Image Classification, Image segmentation, K-mean clustering.

Introduction:

Sesame is a plant with several features and properties for food, industry and medicine applications. The by-product that remains after oil extraction from sesame seeds, also known as sesame oil meal contains high amount of protein (35-50 %) and is used as poultry and livestock feed [1,2,3]. Nanotechnology is a general term related to all nano-scale technology and research. The term refers to the scientific concepts with new properties which can be discovered and perfected while working within this context. Nanotechnology operates at nanometer-scale dimensions (1-100 nm) and can be used for a wide variety of applications and development of various types of nano materials and nano devices. A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix. Harlick in 1970 proposed four features that can be calculated from the matrix, energy, homogeneity, contras, and correlation [4]. The textural features used to investigate the effect of cold plasma on bacteria grown on the sesame paste and nano sesame paste. The unsupervised K-mean classification method is used to classify paste sesame images. K-means is usually used to decide the natural pixel groupings present in an image. In practice, it's attractive because it's straightforward, and generally very quick. The input dataset is partitioned into clusters [5,6].

In 2017 Mazhir et. al. used the textural features from the co-occurrence to study the effect of plasma on smear of leukemia blood cells, the gray level matrix is used to ensure the effect of cold plasma on the leukemia cells [7]. In 2017 Mazhir et. al. used the co-occurrence matrix to find the effect of the plasma on the Leukemia Blood Cells[8]. In 2019 Muryoush et. al. used the co-occurrence matrix to study the effect of cold plasma on bone infected by osteoporosis[9]. In 2019 Ali et. al. used the co-occurence matrix to find the effect of Nano-curcumin which has been enhanced by using microwave plasma on the mice infected with diabetes, the result depends on calculating the textural features contrast, correlation, homogenous and energy[10].

The aim of the search: The novelty of this search is studying the effect of cold plasma on sesame particle and nano sesame particle using image processing technique which based on co-occurrence matrix and its textural feature a combination between the nano technology, the cold plasma and the digital image processing.

Methodology: The methodology based on analyze the effect of cold plasma on the nano particle and normal particle of the sesame paste through the co-occurrence matrix starting from leaving the sesame paste in its both form nano and normal particles two days in air, kinds of bacteria growing on it, then treating them with plasma and taking the microscope images. The threshoding technique is applied as first step in image segmentation, coloring the images using the Hot color preparing them for image classification, using k-mean clustering method to classify the infected region and normal region, and using the co-occurrence matrix to study the texture of the sesame paste

Thresholding: Thresholding is one of the easiest and simplest ways of segmentation. It depends on grouping the intensity according to the threshold value, it can remove the object from the context. The resulting image for one threshold as calculated by [11]

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) \le T \end{cases} \quad ....(1)$$

Where T is value for threshold. This can produce a binary image. The thresholding can be used to transform the image with a gray scale into a binary image.

Gray Level Co-occurrence Matrix: The co-occurrence matrices are constructed by considering that every pixel have eight neighbors (horizontally, vertically and diagonally at 45 degrees). It is also assumed that the matrix of relative frequencies of gray levels co-occurrence can specify the texture-context information. Some of the texture features can be obtained from these matrices [12,13].

- Contrast: It gives the local variations in the gray level co-occurrence matrix. It determines the intensity difference between a pixel and its neighborhood [12,13]

$$\text{Contrast} = \sum_{i,j=0}^{G-1} (i-j)^2 \; p(i,j) ....(2)$$

$$P(i,j) = \frac{1}{N_\theta} P(i,j)$$

P (i, j) is a digital image histogram with intensity levels [0, G-1] where

G: represents the gray level value from (0-255 or 1-256) [14].

- Energy: it is the sum of squared elements. Its range is from 0 to 1. It represents the number of occurrence for the gray level in the image, the high energy value the gray level is small otherwise it is high. The energy equation can be represented as follows [15]:

$$Enargy = \sum_{i,j=0}^{G-1} (p(i,j))^2 \quad .... \quad (3)$$

- Homogeneity: It gives the distribution value of the closeness of elements of the gray level co-occurrence matrix. It gives the value between the range of 0 and 1[16].

$$\text{Homogeneity} = \sum_{i,j=0}^{G-1} \frac{p(i,j)}{1+(i-j)^2} \quad ....(4)$$

- Correlation: It measures how a pixel is correlated to its neighborhood pixels. Its value lies between (-1 and +1). Its value is (-1) for perfectly negatively correlated image and (+1) for positively correlated image [16].

$$\text{Correlation} = \sum_{i,j=0}^{G-1} \frac{i\,p(i,j) - \mu_x\,\mu_y}{\sigma_x\,\sigma_y}$$

μ_x, μ_y: mean value in the x and y direction.

σ_x, σ_y: variance of x,y

Classification by K-means

The most common clustering based partitioning technique is the K-means algorithm. It is an unsupervised algorithm used in clustering. K- mean clusters are formed by identifying the data points closest to the clusters. The K-means steps are [17,18]:

1. Randomly select k number of points, and make them initial centroids [19].
2. Select a data point from the array, compare it with each centroid, then assign it to the closest centroid cluster if the data point is found to be identical with the centroid [20].
3. When assigning each data point to one of the clusters, determine the Centroid value for each cluster k-number.
4. Repeat phases 2 and 3, until no data point transfers to any other cluster from its previous cluster

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HOT Color Space (Fig.1):

Color map "Hot" also known as "warm color" refers to the smooth color changes from black to white, through shades of yellow, orange and red. The adjacent color in this map is of equal distance; as an extension of the 16-step color scale, a 256 color scale is implemented [21,22]. Let 'Ri, Gi, Bi' and 'Ri+1, Gi+1, Bi+1' represent any two adjacent base colors and li and li+1 denote their corresponding gray leve l1 (li < l < l i+1 for 1 ≤ i ≤ 15), the associated with the color (R,G,B) which represented by the following equation [23].

$$R = (R_{i+1} - R_i)\left[\frac{I-I_i}{I_{i+1}-I_i}\right] + R_i \ldots \qquad \ldots\ldots (6)$$

$$G = (G_{i+1} - G_i)\left[\frac{I-I_i}{I_{i+1}-I_i}\right] + G_i \qquad \ldots\ldots(7)$$

$$B = (B_{i+1} - B_i)\left[\frac{I-I_i}{I_{i+1}-I_i}\right] + B_i \qquad \ldots(8)$$

Figure 1. The HOT color space [22].

Microwave Plasma:

Microwave plasma is operated by electromagnetic wave at frequencies greater than 300 MHZ and wavelength at (mm to cm), generating non-equilibrium (non-thermal) plasma with continuous energy wave (watt to kilowatt) and operating pressure range (10^{-5} torn up to atmospheric pressure) which used in many medical applications without damaging the surrounding tissue [24,25]. In the search, the microwave plasma is used as a treatment tool to treat the bacteria that was created on the past sesame after leaving it in the air for two days, the duration of time exposing was two mints.

Results and Discussion:

The present search deals with18 images (sesame paste, nano sesame paste, sesame paste treated with plasma and nano sesame paste treated with plasma). Bacteria grows on sesame past which has been left in air for two days, a microscopic image with 100x power magnification. Figure 2 displays sesame paste images with their threshold before left them in the air for two days. The threshold is used to discard from the glass reflection of the slide that the sesame placed on it and some noise that the microscopic image creates. The texture features are shown in Table 1 and image 3 has low contrast and higher energy. Figures 3,4 and 5 present sesame paste after two days with their classification region, the Hot color is used to simplify the classification process . Tables 2,3 and 4 show texture features for sesame paste after two days in the air. Figures 6,7 and 8) display sesame paste treated with plasma with their classification region. Tables 5,6 and 7) show the texture features for sesame paste treated with plasma

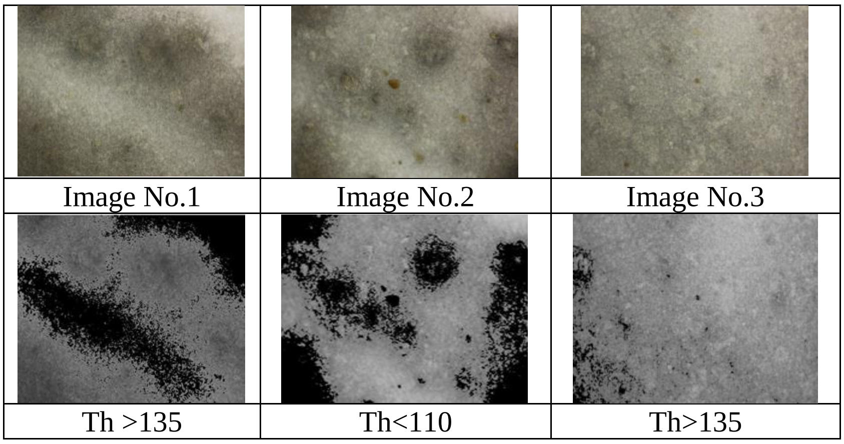

Figure 2. Image No.1, No.2, No.3 and their threshold for sesame paste

Table 1. Texture features of sesame paste images shown in figure (2)

Image No.	**Contrast**	**Correlation**	**Energy**	**Homogeneity**
1	1.8004	0.55835	0.172	0.8044
2	1.0214	0.8363	0.2054	0.86695
3	0.54725	0.6969	0.2137	0.849

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	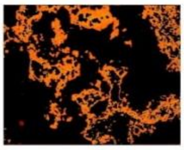	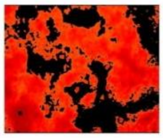	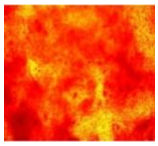
Image No.4	Class2(Bactria)	Class3(sesame past)	(HOT color image)

Figure 3. Image No.4 for sesame paste after two days with their classification region.

Table 2. Texture features for sesame paste after two days in the air

Image No	Contrast	Correlation	Energy	Homogeneity
Imag4	0.2023	0.84535	0.2591	0.9022
Class2	1.3675	0.8112	0.4995	0.8929
Class3	0.6646	0.8287	0.2343	0.9212

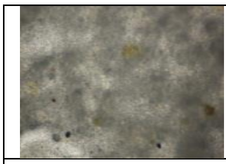	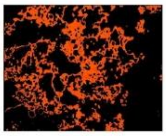	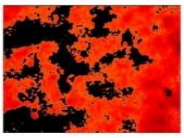	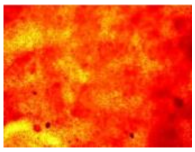
Image No.5	Class1(Bactria)	Class3 (sesame past)	HOT color image)

Figure 4. Image No.5 for sesame paste after two days with their classification region.

Table 3. Texture features for sesame paste after two days in the air

Image No.5	Contrast	Correlation	Energy	Homogeneity
Class1	0.213858	0.8387	0.2507	0.899
Class2	0.6646	0.8287	0.2343	0.9212
Class3	1.3675	0.8112	0.4995	0.8929

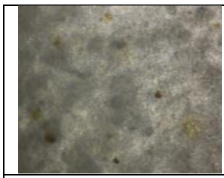	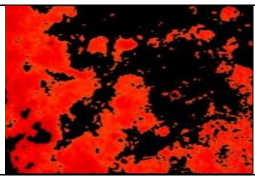	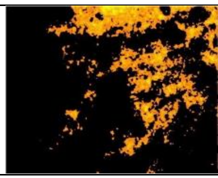	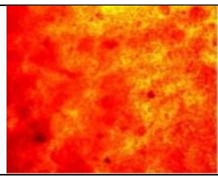
Image No.6	Class1(sesame)	Class2(Bactria)	HOT color image)

Figure 5. Image No.6 for sesame paste after two days with their classification region.

Table 4. Texture features for sesame paste after two days in the air

Image No	Contrast	Correlation	Energy	Homogeneity
Imag6	0.2249	0.81005	0.25415	0.8906
Class1	0.5587	0.8441	0.2969	0.9137
Class2	1.1696	0.8735	0.5898	0.9171
Class3	0.4345	0.8134	0.3246	0.9121

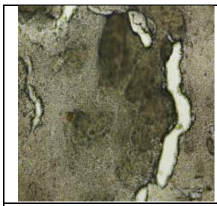	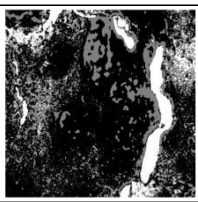	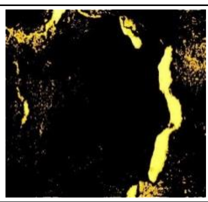	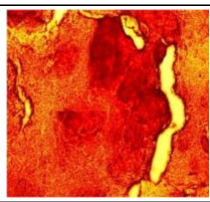	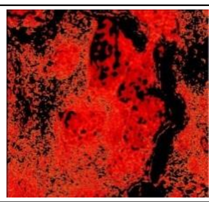
Image No.7	Class 1	Class 2(the Bactria image)	Class 3 (image with Bactia)	Class 4 (after removing the bactria)

Figure 6. Image No.7 for sesame paste treated with plasma with their classification region.

Table 5. Texture features for sesame paste treated with plasma

Image No	Contrast	Correlation	Energy	Homogeneity
Imag7	1.0070	0.7202	0.0760	0.7156
Class2	1.1017	0.8339	0.734	0.937
Class4	1.1116	0.6089	0.12795	0.7628
Class1	2.31415	0.7865	0.26485	0.7749

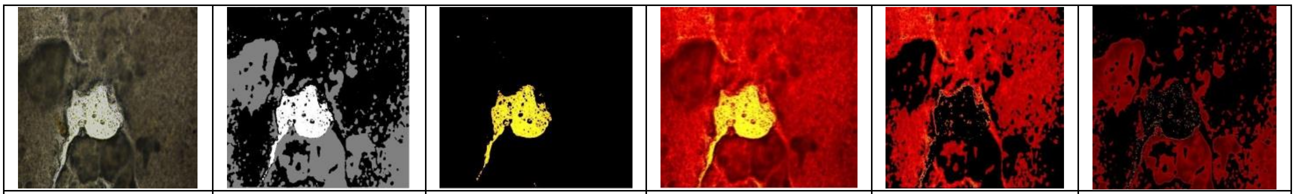

Image No.8	Class1	2(Bactria)	3(sesame with Bactria)	4(sesame)	Class5

Figure 7. Image No.8 for sesame paste treated with plasma with their classification region.

Table 6. Texture features for sesame paste treated with plasma.

Image No8	Contrast	Correlation	Energy	Homogeneity
Imag8	0.3352	0.8782	0.2583	0.8768
Class2	0.36515	0.91405	0.86745	0.97305
Class1	1.0827	0.88745	0.33175	0.87665
Class4	0.24965	0.8104	0.2746	0.91335
Class5	0.15055	0.6747	0.51915	0.9517

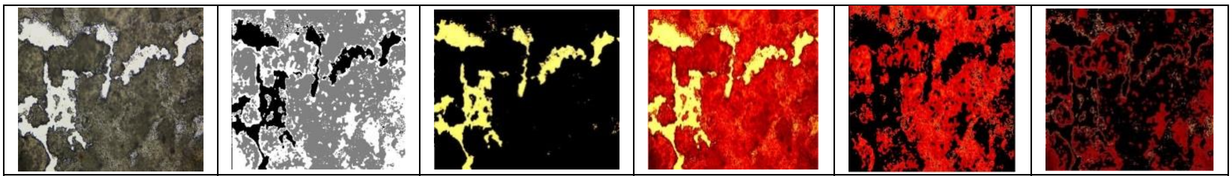

Image No.9	Class1	class 2 Bactria	class3 sesame with Bactria)	class 4(sesame)	Class5

Figure 8. Image No.9 for sesame paste treated with plasma with their classification region.

Table 7. Texture features for sesame paste treated with plasma

Image No	Contrast	Correlation	Energy	Homogeneity
Image 9	1.2850	0.7539	0.0672	0.6735
Class5	0.66775	0.5018	0.43425	0.89935
Class4	0.6086	0.75435	0.20855	0.84635
Class2	0.88655	0.92055	0.7038	0.95775
Class1	2.31735	0.76735	0.1297	0.7678

The sesame paste was converted into nano sesame using Vibra-Cell Ultrasonic Liquid Processors device 750 Watt and 20 kHz, its main object is to convert the sesame into nano particles. Figure 9 shows the microscope images for the nano sesame paste and their threshold. Table 8 presents texture features for nano sesame paste. Figures 10,11 and 12, represent nano sesame paste after two days with their classification region. Tables 9,10 and 11, display texture features for nano sesame paste after two days in the air. Figsures 13,14 and 15, represent nano sesame paste after treating with plasma, Tables 12,13, and 14 show texture features for nano sesame paste after treating with plasma.

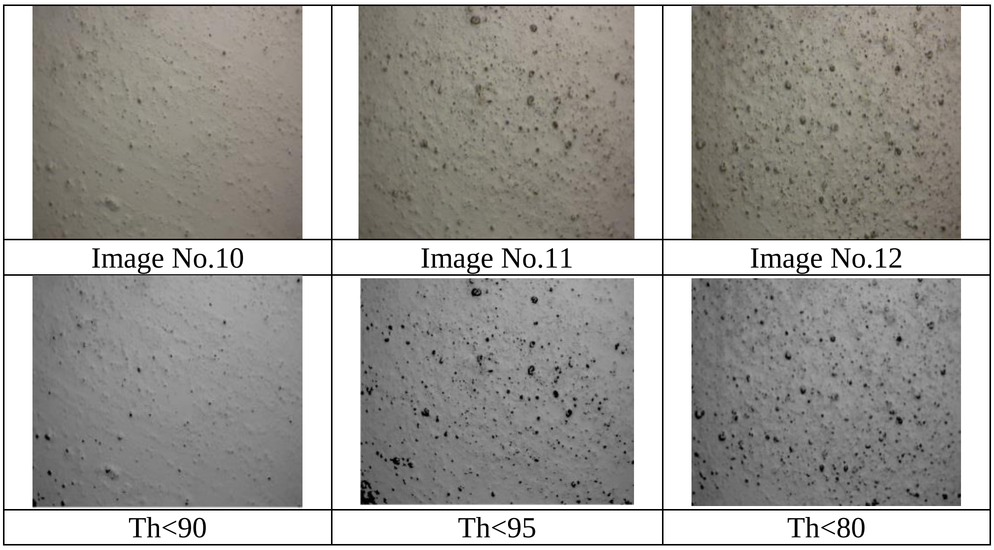

Figure 9. The microscope images for the nano sesame paste and their threshold

Table 8. Texture features for nano sesame paste.

Image No	Contrast	Correlation	Energy	Homogeneity
10	0.126	0.82475	0.41365	0.9491
11	0.39835	0.68075	0.33365	0.90885
12	0.36195	0.6885	0.29385	0.8875

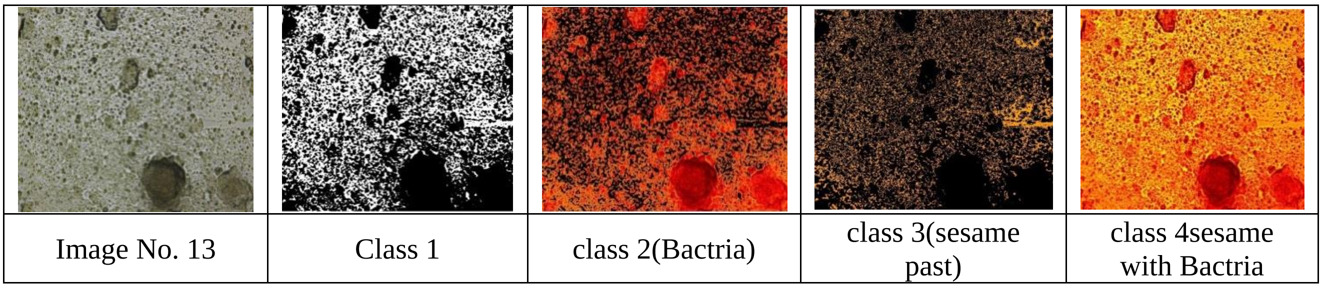

Figure 10. Image No.13 for sesame paste after two days with their classification region.

Table 9. Texture features for nano sesame paste after two days in the air

Image No	Contrast	Correlation	Energy	Homogeneity
Img13	2.2904	0.3554	0.0506	0.5974
Class1	9.8346	0.5698	0.2079	0.7125
Class2	2.5446	0.4346	0.0809	0.6627
Class3	4.3773	0.2462	0.2502	0.6837

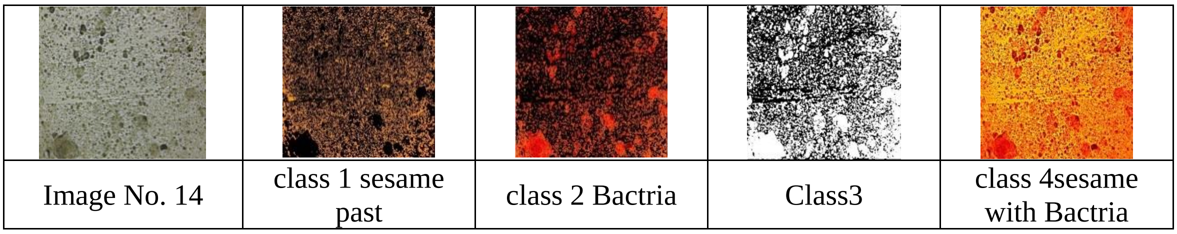

Figure 11. Image No.14 for sesame paste after two days with their classification region.

Table 10. Texture features for nano sesame paste after two days in the air

Image No	**Contrast**	**Correlation**	**Energy**	**Homogeneity**
Image14	2.3137	0.2787	0.0572	0.5974
Class1	5.3417	0.2724	0.1392	0.6104
Class2	1.8796	0.5079	0.2003	0.7374
Class3	10.1940	0.5582	0.1905	0.7005

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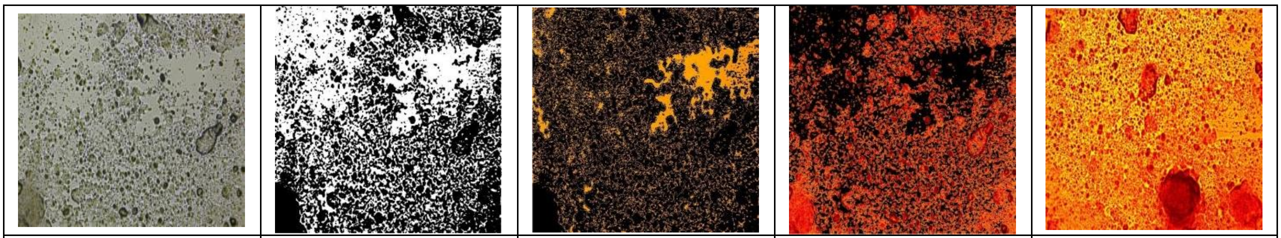

Image No. 15	Class 1	Class 2 (Bactria)	Class 3 (sesame past	Class 4sesame with Bactria

Figure 12. Image No.15 for sesame paste after two days with their classification region.

Table 11. Texture features for nano sesame paste after two days in the air

Image No	Contrast	Correlation	Energy	Homogeneity
Image15	2.0861	0.3026	0.0513	0.5917
Class1	10.1940	0.5582	0.1905	0.7005
Class2	9.3018	0.5158	0.1816	0.6823
Class3	10.1940	0.5582	0.1905	0.7005

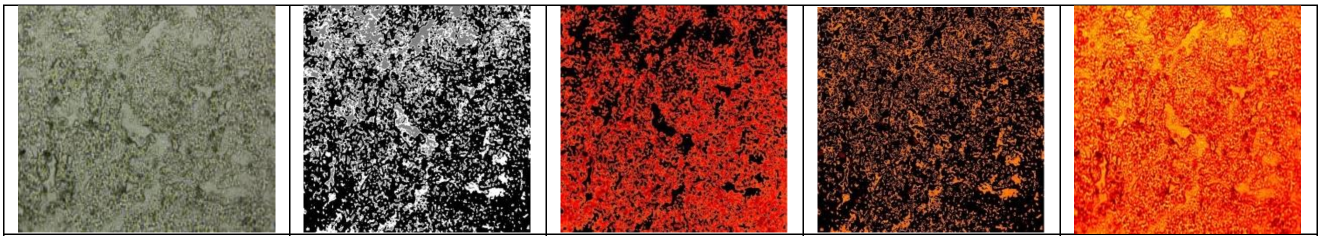

Image No. 16	Class 1	Class 2 sesame	Class 3 Bactria	Class 4 sesame with Bactria

Figure 13. Image No.16 for sesame paste after treating with plasma with their classification region.

Table 12. Texture features for nano sesame paste after treating with plasma

Image No	Contrast	Correlation	Energy	Homogeneity
Image16	0.8679	0.5495	0.0983	0.7096
Class1	8.3187	0.4299	0.1643	0.6572
Class2	1.8167	0.4615	0.1115	0.7026
Class3	2.8549	0.5128	0.5489	0.8444

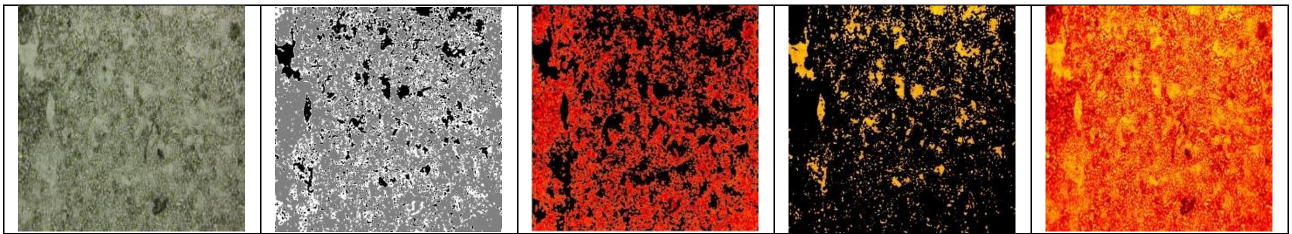

Image No. 17	Class 1	Class 2 sesame	Class 3 Bactria	Class4sesame with Bactria

Figure 14. Image No.17 for sesame paste after treating with plasma with their classification region.

Table 13. Texture features for nano sesame paste after treating with plasma

Image No	Contrast	Correlation	Energy	Homogeneity
Image17	0.8568	0.5454	0.1002	0.7100
Class1	6.6492	0.3159	0.0771	0.6142
Class2	1.5677	0.5449	0.1261	0.7260
Class3	3.0723	0.5540	0.5566	0.8553

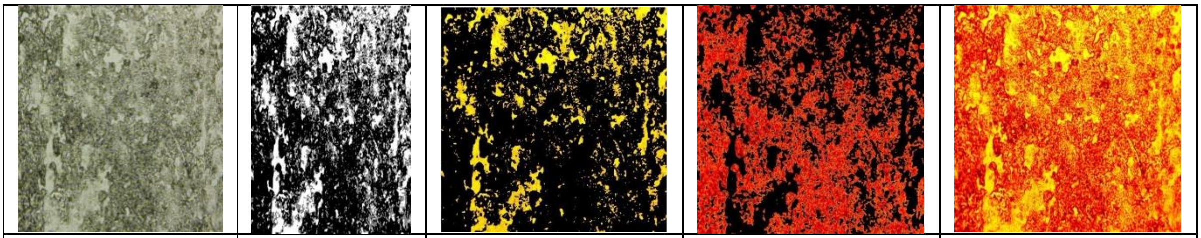

Image No. 18	Class 1	Class 2 Bactria	Class 3 sesame	Class4sesame with Bactria

Figure 15. Image No.18 for sesame paste after treating with plasma with their classification region.

Table 14. Texture features for nano sesame paste after treating with plasma

Image No	Contrast	Correlation	Energy	Homogeneity
Image18	1.0983	0.5930	0.0717	0.6824
Class1	3.7360	0.7539	0.1746	0.7251
Class2	3.4467	0.6901	0.4827	0.8481
Class3	1.5988	0.5759	0.1615	0.7380

Tables 15,16 and 17 the value of the contrast for the sesame with bacteria after leaving it two days in air has highest value, because the contrast indicates that there is a high difference between the adjacent pixels, high random intensity this comes from the bacteria which grows on the sesame. The sesame paste treated with plasma after removing the (bacteria) has the lowest value of the contrast because plasma regularized the pixels and the intensity of adjacent pixel will approach nearly the same value. The correlation for sesame paste treated with plasma is higher than that for sesame paste after two days in the air, the lower value is that when the sesame treated with plasma and the bacteria is removed, the correlation has highest value if the neighboring pixels are highly correlated and the correlation approach its maximum value. The energy of the sesame paste treated with plasma, has the maximum value as the sesame without treating it with plasma. The energy represents the gray levels number in the image, the high energy value with the gray level is low, when the gray level is low the texture is more regular, the homogeneity indicated the regularity of the texture the maximum value is for the sesame paste treated with plasma (this result is based on average value of table 17 comparing it with average value of Tables 15 and 16. Tables 18,19 and 20 show the contrast value for the nano-sesame paste with bacteria after leaving it in air for two days is of the highest value, since the contrast indicates that there is a high difference between the adjacent pixels, high random intensity. This comes from the bacteria that that grows on the sesame. Plasma-treated, nano-sesame paste gives lowest contrast value, because plasma gives heat to the particles the pixels of the neighboring pixels' intensity approach each other. The correlation for plasma-treated nano sesame paste is higher than that for nano sesame paste with bacteria, the correlation has high value if the adjacent pixels are highly correlated. The energy of the plasma-treated nano sesame paste has the max value comparing with the sesame without treating with plasma, since the energy indicates the amount of gray levels in the image. The less gray level in the texture indicate that its pure from bacteria. The homogeneity which shows the regularity of the texture has maximum value for the plasma-treated nano sesame paste (this result conclude as comparing Tables 18, 19 and 20.

Table 15. Texture features for sesame paste after two days in the air(Bacteria)

Image No	Contrast	Correlation	Energy	Homogeneity
4	1.3675	0.8112	0.4995	0.8929
5	0.21385	0.8387	0.2507	0.899
6	1.1696	0.8735	0.5898	0.9171
average	0.916983	0.841133	0.446667	0.903

Table 16. Texture features for sesame paste after removing (Bactria)

Image No	Contrast	Correlation	Energy	Homogeneity
4	0.6646	0.8287	0.2343	0.9212
5	1.3675	0.8112	0.4995	0.8929
6	0.5587	0.8441	0.2969	0.9137
average	0.8636	0.828	0.343567	0.909267

Table 17. Texture features for sesame paste treated with plasma.

Image No	Contrast	Correlation	Energy	Homogeneity
7	1.1017	0.8339	0.734	0.937
8	0.36515	0.91405	0.86745	0.97305
9	0.88655	0.92055	0.7038	0.95775
average	0.784467	0.8895	0.768417	0.955933

Table 18. Texture features for nano sesame paste (Bactria).

Image No	Contrast	Correlation	Energy	Homogeneity
13	2.5446	0.4346	0.0809	0.6627
14	1.8796	0.5079	0.2003	0.7374
15	9.3018	0.5158	0.1816	0.6823
average	4.575333	0.4861	0.154267	0.694133

Table 19. Texture features for nano sesame paste removing (Bactria).

Image No	Contrast	Correlation	Energy	Homogeneity
13	4.3773	0.2462	0.2502	0.6837
14	5.3417	0.2724	0.1392	0.6104
15	10.1940	0.5582	0.1905	0.7005
average	6.637667	0.358933	0.1933	0.664867

Table 20. Texture features for nano sesame paste treated with plasma.

Image No	Contrast	Correlation	Energy	Homogeneity
16	2.8549	0.5128	0.5489	0.8444
17	3.0723	0.5540	0.5566	0.8553
18	3.4467	0.6901	0.4827	0.8481
average	3.124633	0.585633	0.5294	0.849267

Conclusion:

The texture features which are calculated from co-occurrence matrix are energy, correlation, contrast and homogeneity, they describe the sesame through the textural features. The present search contains hybrid technique in using image processing (textural analysis) with the nano particles and plasma application, the texture feature used to study the effect of cold plasma on the sesame paste in both form nano particle and normal particle. The low contrast value indicated that the sesame paste texture is more regular. This is an indication for less or no bacteria presents in the texture, the energy, correlation and homogeneity provide us with information about the sesame texture, the result indicate the high value of these features is for the sesame paste treated with plasma comparing with the other cases used. This result is good and means that the plasma treated the bacteria. The time exposure to plasma is two minutes its suitable time to treated the sesame texture. The same result could be concluded with nano sesame. Comparing the two results, the sesame paste with plasma and nano sesame paste with plasma the result is best for the sesame paste with plasma than the nano sesame paste with plasma, because the plasma provides the paste with heat and makes the sesame nano particle congregate together.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' contributions:

All authors contributed to the design and implementation of the research, to the analysis of the results and to the writing of this manuscript.

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تأثير البلازما الباردة على راشي السمسم وراشي السمسم نانو اعتمادا على مصفوفة Co-occurrence

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الخلاصة:

يهدف البحث الى معرفة تأثير البلازما الباردة على البكتيريا المزروعة على راشي السمسم في جسيماته الطبيعية وحجم جسيمات النانو. بدءًا من استخدام عملية تجزئة الصور اعتمادًا على طريقة العتبة، يتم استخدامها للتخلص من انعكاس الشرائح الزجاجية التي توضع عليها عينات السمسم. تم تنفيذ عملية التصنيف لفصل راشي السمسم الطبيعي عن غير الطبيعي. الراشي غير الطبيعي يظهرعندما نمت البكتيريا على راشي السمسم بعد تركه لمدة يومين في الهواء، ان عملية التصنيف الموجه معدل k- استخدمت لتصنيف المنطقة المصابة والمنطقة الطبيعية والمنطقة المعالجة. والبكتريا المعالجة بالبلازما الباردة، مدة التعرض دقيقتان. تم حساب الميزات التركيبية المتعلقة بمصفوفة التدرج اللوني ذات المستوى الرمادي للنسيج الطبيعي وغير الطبيعي والمعالج، ومن الواضح أن مجموعة النسيج المعالج لها أفضل الميزات مقارنة باالمجاميع الأخرى. أظهرت النتيجة أن راشي السمسم المعالج بالبلازما له نتائج جيدة مقارنة مع راشي السمسم النانوي المعالج بالبلازما. وذلك لأن البلازما تزود راشي السمسم بالحرارة وتجعل جزيئات السمسم النانوية تتجمع معًا.

الكلمات المفتاحية: مصفوفة co-occurrence Matrix ، تصنيف الصورة، تجزئة الصورة، معدل K.