Article

Detection of aflatoxin contamination in corn using The Simplified Gabor Wavelet algorithm

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Abstract:

The quality of corn is essential to determine whether it is still suitable for consumption and what type of corn it is. Corn is one type of vegetable that is indispensable for the nutritional needs of the Indonesian people today and is a mixture of other essential ingredients. Corn is rich in fiber, which is good for improving digestion and overcoming constipation, controlling blood sugar levels, maintaining heart health, overcoming depression, maintaining eye health, and preventing diverticulitis. In this research, image recognition is used to determine and detect the content of aflatoxin, one type of abnormality or disorder in corn. This affects the quality of corn, whether corn is suitable for human consumption, and what impact aflatoxin has on the human body. On testing using parameters Non-UV image, SGW Filter Image θ = 0, 90, 180, and 270, and The resulting SGW image with the number of orientations N = 4, θ = θ + pi/N, and θ = θ + 2*pi/N, The aflatoxin content in humans can cause carcinogenic or liver cancer and acute necrosis, cirrhosis, and carcinoma in the animal liver.

Keywords: corn quality, image processing, aflatoxin, detection

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1. INTRODUCTION

Corn is one of the food production commodities other than rice, one of the Indonesian people's staple foods. So that the need for corn is essential in addition to being a basic need for the Indonesian people, becoming an export commodity or a source of the community's economy, a source of nutrition or health, and other benefits. But one of the people is aflatoxin. This aflatoxin is found in corn. This aflatoxin is a toxic compound produced by *Aspergillus flavus* and *Aspergillus parasiticus*, and its growth depends on a specific humidity level. Conventional farmers have tried to eliminate Aspergillus flavus and Aspergillus parasiticus utilizing drying corn, but they are not optimal. The aflatoxin content in humans can cause carcinogenic or liver cancer and acute necrosis, cirrhosis, and carcinoma in the animal liver. In this study, an attempt was made to detect aflatoxins in corn using the simplified Gabor wavelet algorithm [1,2,3,4]. The aflatoxin detection process was carried out under ultraviolet light and in a dark environment. Other algorithms are used in telecommunication [17,18,19,23,24].

2. METHOD

A. The Simplified Gabor Wavelet (SGW) algorithm

The simplified Gabor Wavelet algorithm [5,6,7,8] detects corn edge objects on corn shells and performs calculations on corn objects indicated by aflatoxins. Moreover, Fig. 1 is a System Block Diagram that illustrates step-by-step image recognition in this research, and Fig. 1 will provide information on the percentage of aflatoxin content in corn.

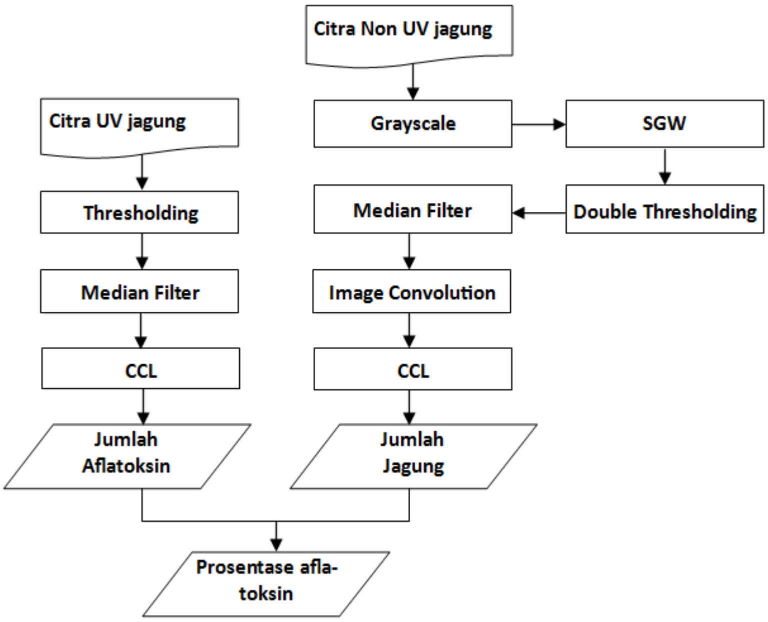


Fig 1. System Block Diagram

Equation 1 shows a formula that calculates edge detection in corn images using the Simple Gabor Wavelet (SGW) algorithm.

$$S(x,y) = \exp\left[-\frac{x^2+y^2}{2\sigma^2}\right]\sin\left[\omega(x\cos\theta + y\sin\theta)\right] \tag{1}$$

$$\psi_{\omega,\theta}(x) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{x^2}{2\sigma^2}\right)\exp(i\omega x). \tag{2}$$

Furthermore, equation 2, used to describe the dimensions or shape of the object with the Simple Gabor Wavelet (SGW) algorithm [20,21,22] Fig. 2 is an example of a simplified thing of the image-level quantization process. Equation 2 was developed for one of the case studies of an object in Fig. 2. Pseudocode 1 is the programming step to detect aflatoxin in this research. Pseudocode is essential to do to analyze any previous analysis [10,11,12,13,14].

```
1.  [Input UV image]
2.  [Take every pixel from the image to convert to binary pixels]
       while i < imageUV.width
       while j < imageUV.height
       takepixel = imageSGW.GetPixel(i,j)
       r = Convert.ToInt16(c.R);
       g = Convert.ToInt16(c.G);
       b = Convert.ToInt16(c.B);
       checkpixel = ((r + (g + b)) / 3)
3.  [Set minimum threshold=0 and maximum threshold according to input
    from users]
4.  [Change pixels that are 0 remain 0, otherwise 255]
       6.2 if pixels > thresMax then r=255, g=255, b=255;
       elseif pixel < thresMin then r=255, g=255, b=255;
       else r=0, g=0, b=0;
5.  [Change the obtained values of r, g, b into values of Pixels take
    pixels = Color.FormArgb(r,g,b)]
6.  [Change initial pixels from position i,j to value
    take a pixel for the coordinates of that pixel]
       imageBinerUV.SetPixel(i, j, take pixel)
7.  [Continue to repeat pixel check to all coordinates
       pixel to the last pixel in the image]
```

Pseudocode 1. Detection of aflatoxin by thresholding afla luminescence color]

TABLE 1. SGW QUANTITATIVE ANALYSIS COMPARISON

No	Algorithm	Average Run Time (ms)
1	Canny	76,5
2	Prewitt	23,4
3	Roberts	21,8
4	Sobel	78
5	Gabor Wavelet	47
6	Simplified Gabor Wavelet	31

The comparison between the *Simple Gabor Wavelet* (SGW) algorithm and other algorithms can be seen in table 1. Although not as fast as the average Run Time (ms) in Prewitt, Roberts, the Simplified Gabor Wavelet has good performance and data processing speed and is suitable for practical and real-time applications.

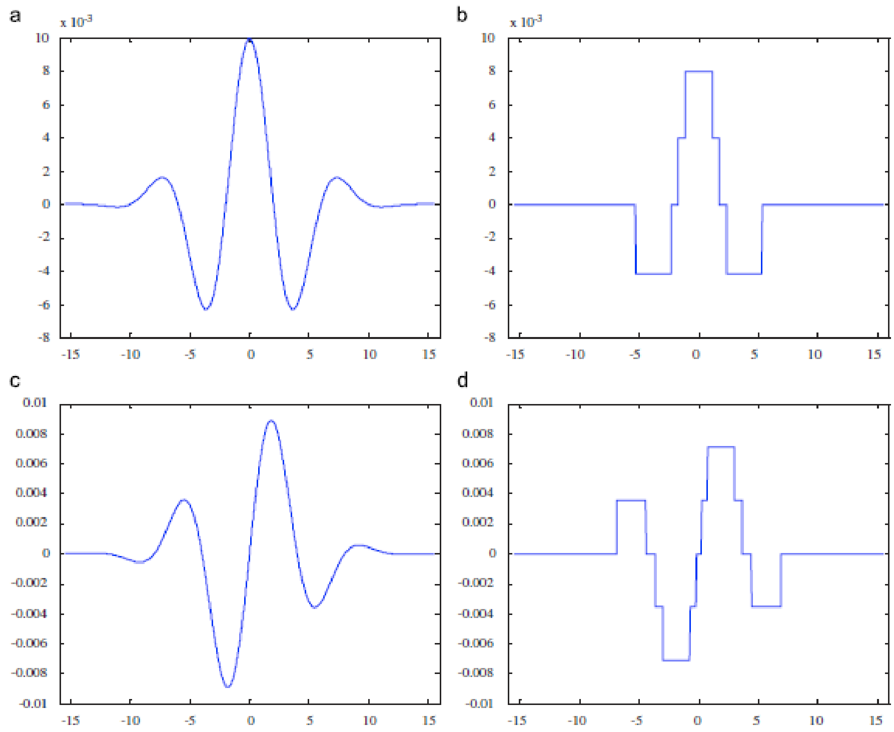


Fig.2 Gabor function on (a) Real 1-D GW section, (b) simplified version, (c) imaginary wavelet section, (d) simplified version of (c)

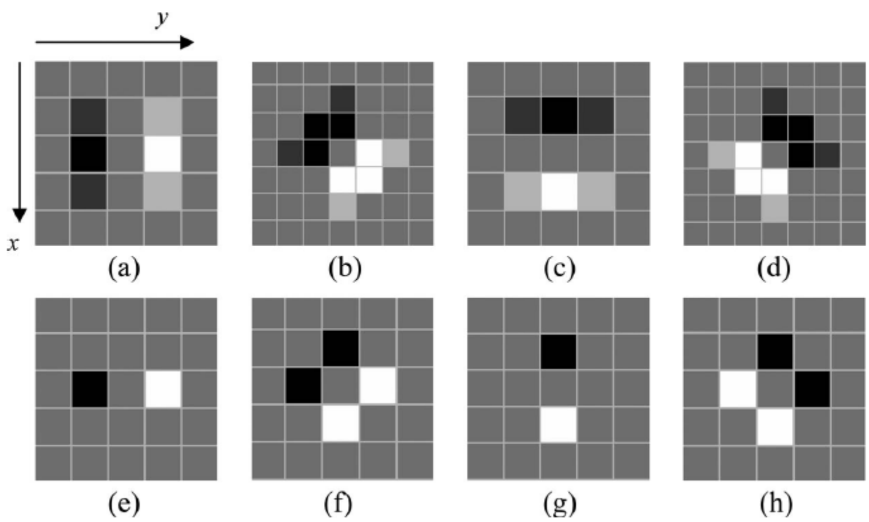


Fig 3. Mask from SGW with (a) ω =0.3 ; θ = 0, (b) ω = 0.3 ; $\theta = \pi/4$, (c) ω =0.3 ; $\theta = \pi/2$, (d) ω = 0.3 ; $\theta = 3\pi/4$, (e) ω = 0.5 ; θ = 0, (f) ω = 0.5 ; $\theta = \pi/4$, (g) ω = 0.5 ; $\theta = \pi/2$, and (h) ω = 0.5 ; $\theta = 3\pi/4$.

Fig. 3 is an example of using the SGW algorithm on specific objects or images with different parameters $\boldsymbol{\omega}$ and $\boldsymbol{\theta}$. Furthermore, this experiment will use the theoretical basis for detecting aflatoxins in corn.

B. Corn Image Capture Method

When taking the image of corn, it doesn't use Ultraviolet light. Still, when detecting aflatoxins, Ultraviolet light is used Fig. 4 is a photo of corn that does not use Ultraviolet light. Fig. 5, Fig. 6, and Fig. 7 are UV images of corn with ISO 400, 800, and ISO 1600.

Fig 4. Corn images that don't use Ultraviolet light

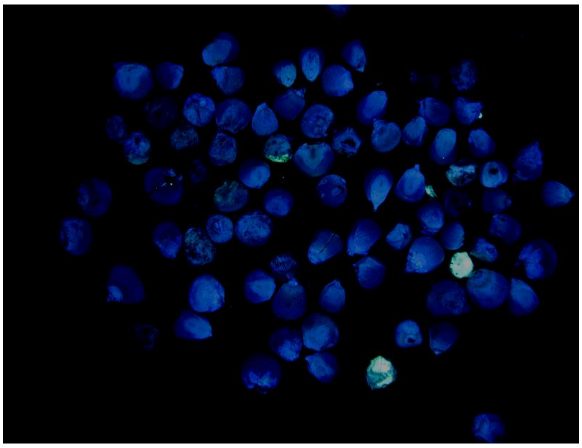


Fig 5. UV image of corn with ISO 400

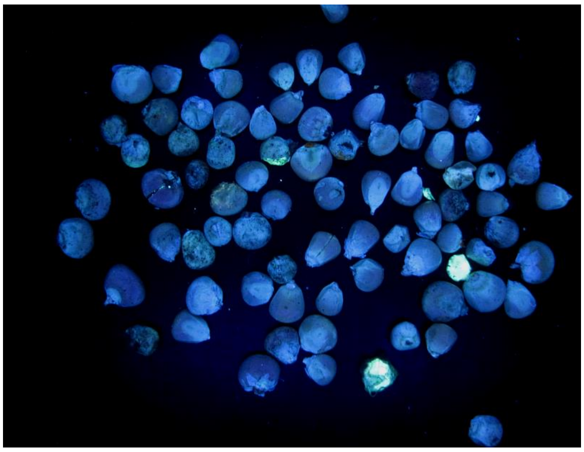


Fig 6. UV image of corn with ISO 800

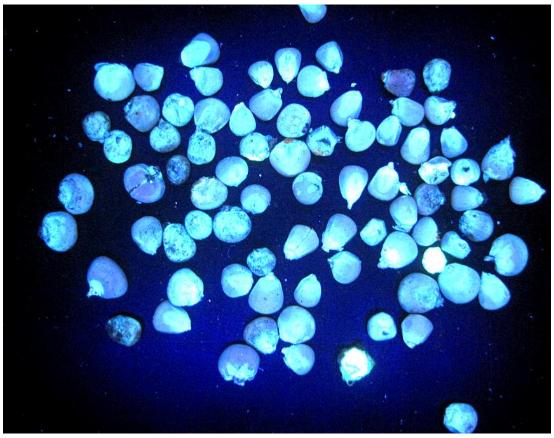
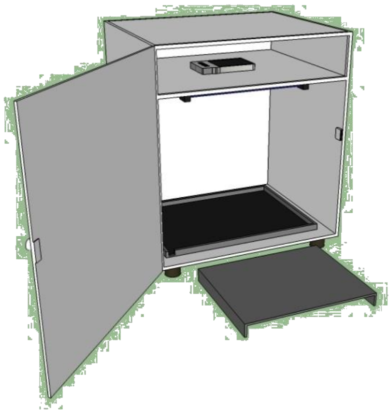


Fig 7. UV image of corn with ISO 1600

3. RESULT AND ANALYZES

3.1 Corn Image Capture Result

In this chapter, we discuss image processing results [9, 15, 16] using the Simplified Gabor Wavelet algorithm with different θ parameters in the filter image and value. Fig. 8 and Fig. 9 are the boxes used to serve as test kits for aflatoxin detection. Fig. 9 is the position of the UV lamp in the second drawer.



(a)

(b)

Fig 8. (a and b) Design a test kit with a camera drawer on top

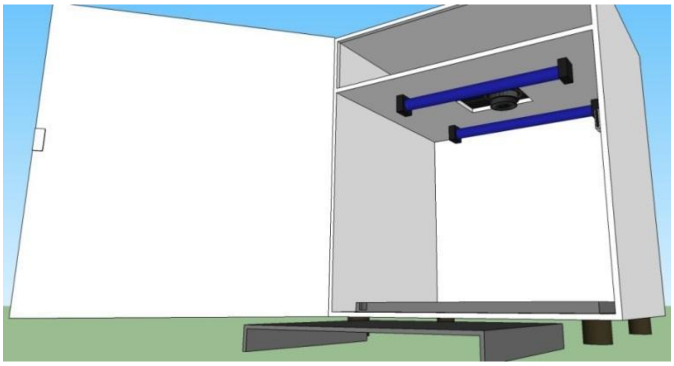
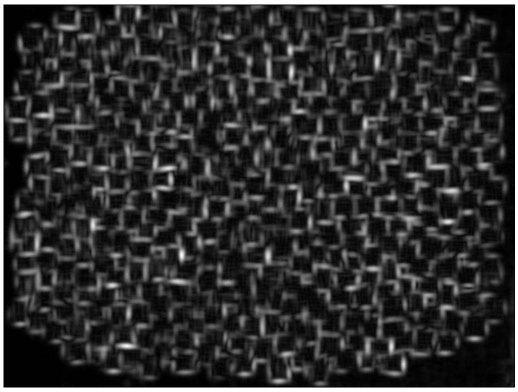


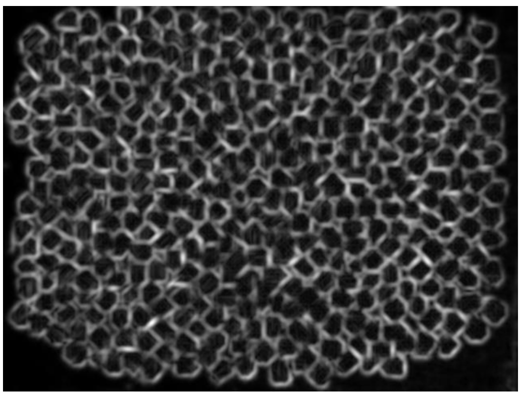
Fig 9. UV lamps in the second drawer

(a)

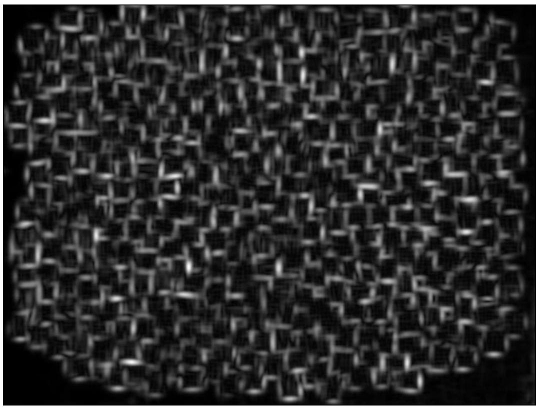


(b)

Fig 10. Non UV image, (b) SGW Filter Image θ = 0, 90, 180 and 270



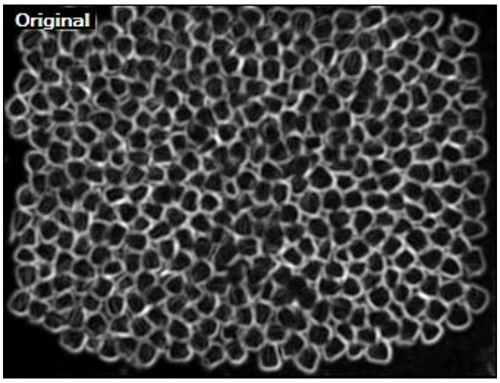
(a)



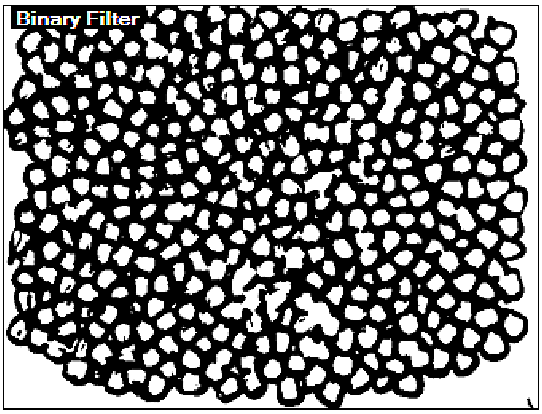
(b)

Fig 11. The resulting SGW image with the number of orientations N = 4, (a) $\theta = \theta + pi/N$, (b) $\theta = \theta + 2*pi/N$

Fig 10. and Fig 11. are corn sampling without using UV with different parameters θ. There are still no specific results or differences from this test between corn without aflatoxin and corn containing aflatoxin. So it was continued by using binary thresholding in Fig. 12 and taking corn samples using UV in Fig. 13.

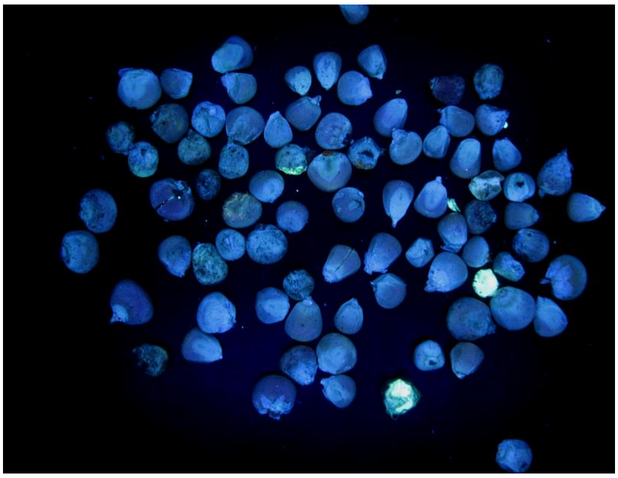


(a)

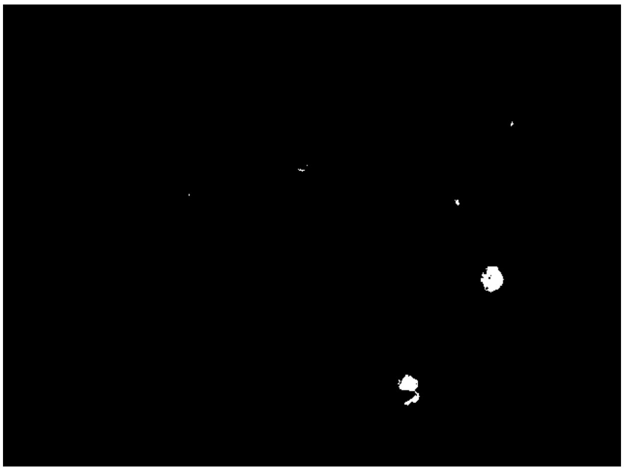


(b)

Fig 12. Example of Binary Thresholding on corn image, (a) SGW image, (b) binary thresholding results, (c) histogram thresholding



(a)



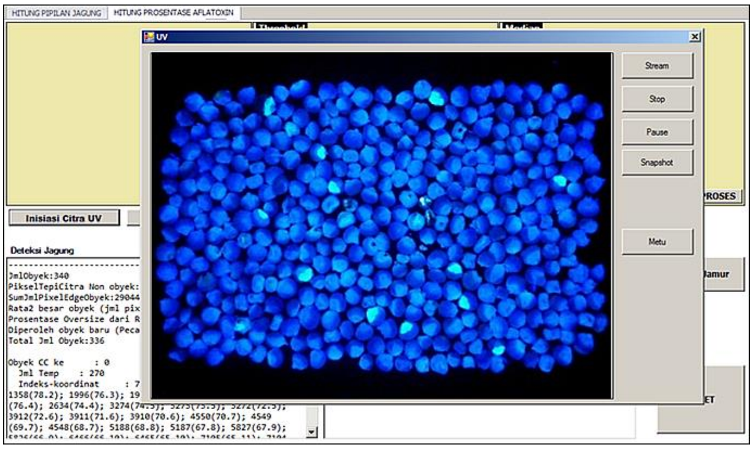
(b)

Fig 13. Example of thresholding to get aflatoxin, (a) Original image, (b) Thresholding result

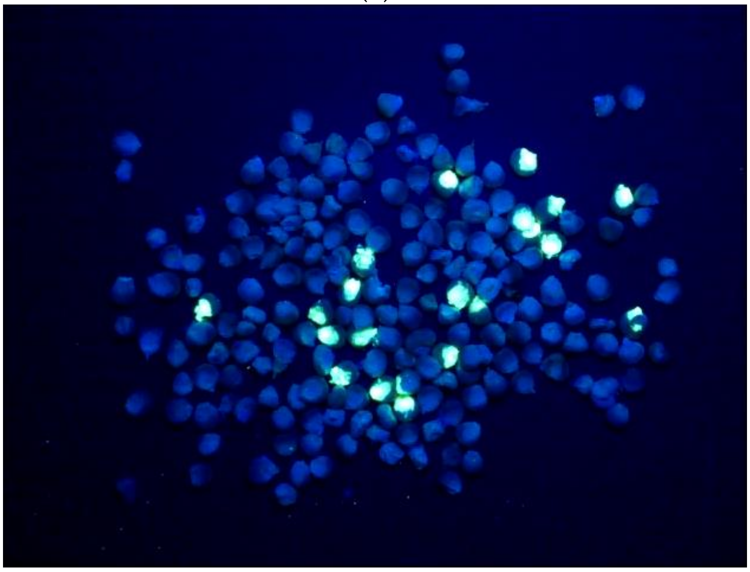
Fig. 13 shows the possibility of aflatoxin in corn quite; clearly, Fig. 13 results from UV light testing. In Fig. 13, part b, it is seen the potential of aflatoxin in corn.

3.2 Aflatoxin processing display

This section analyzes corn for aflatoxin content using UV light and software with different combinations of corn amounts. The number of corn, among others, is 200 ears and 390 ears. From the test, it was found that aflatoxin was significant from the thresholding process and processing display and calculation of the area of the whole corn.



(a)



(b)

Fig 14. Example of thresholding to get aflatoxin, (a) Original image, (b) Thresholding result

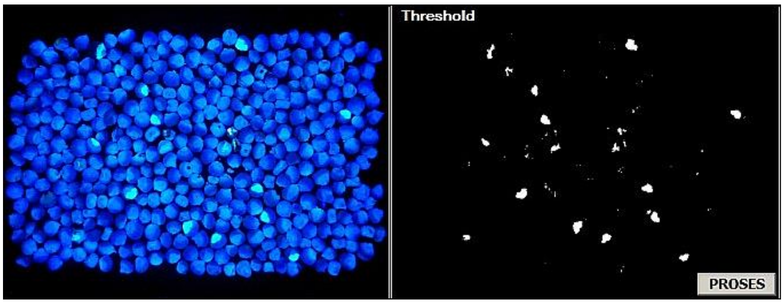


Fig 15. Example of thresholding to get aflatoxin

Fig. 14 is an example of thresholding to get aflatoxin, part (a) Original image and (b) Thresholding result, then Fig. 15 is an example of thresholding to get aflatoxin, and Fig. 16 is an Image of aflatoxin Noise on thresholding results and a Median filter results. Moreover, Fig. 17 is the Aflatoxin processing display and calculation, Finally, Fig. 18 is Aflatoxin processing display and calculation, and Table 2 is a test data to get the percentage of aflatoxin in corn.

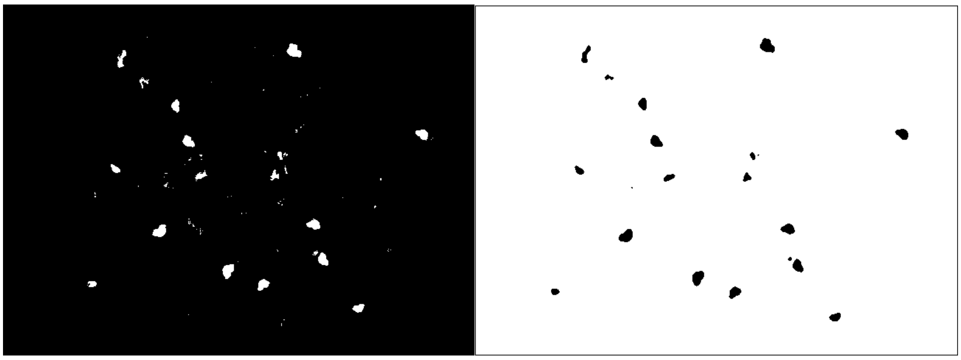


Fig 16. Image of aflatoxin Noise on thresholding results and Median filter results

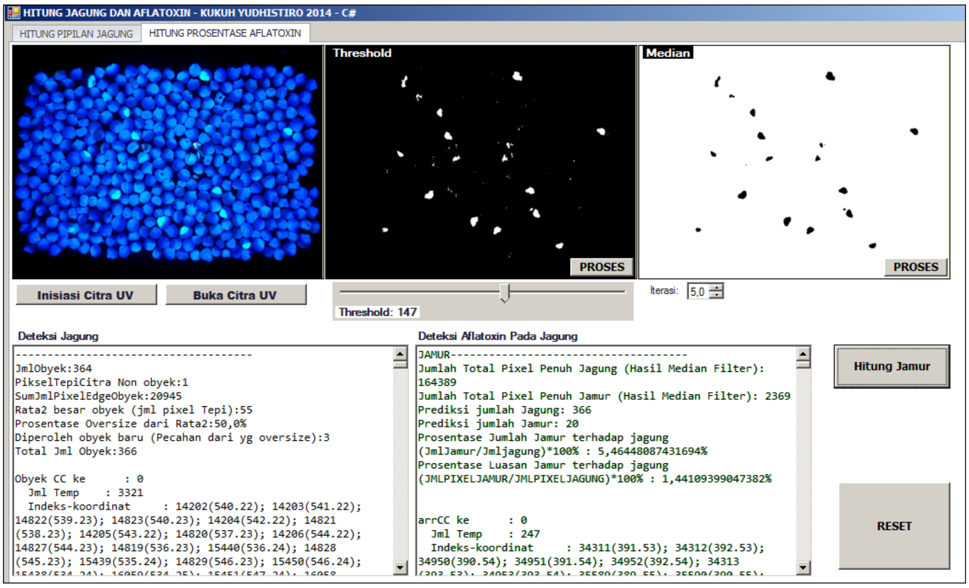


Fig 17. Aflatoxin processing display and calculation, the area of the whole corn

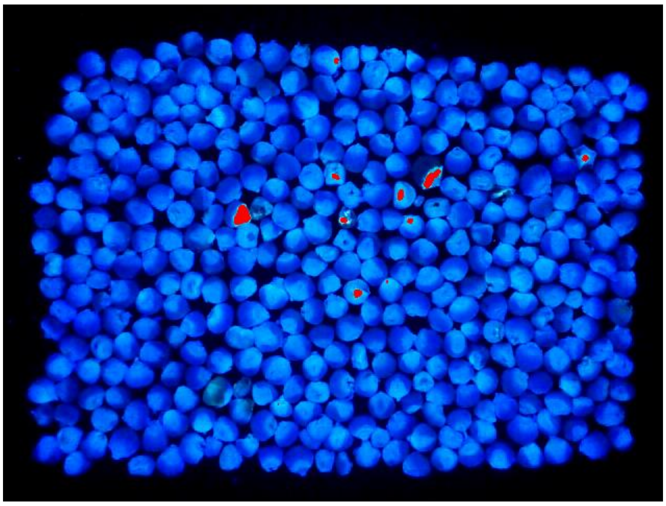


Fig 18. Aflatoxin processing display and calculation, the area of the whole corn

TABLE 2. A DATA TEST TO OBTAIN THE PERCENTAGE OF AFLATOXIN IN CORN

Aflatoksin					Jagung												% Prediksi Cemaran		% Selisih	%Akurasi
1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19	21
No DS UV	Threshold	Iterasi Median	Total Piksel	Prediksi	No DS nonUV hasil SGW	Double Thresholding		Iterasi Median	Prediksi awal	Obyek non jagung	Sum Piksel Tepi Obyek	Rata-rata besar obyek	% Oversize ukuran Rata-rata	Perolehan pecahan dari oversize	Total Piksel Penuh Jagung	Total prediksi	Based on area	Based on Qty	Based on Qty Prediksi vs Aktual	Jagung
						Min	Max													
1	147	4	737	9	**1**	44	255	4	364	1	20945	55	50%	3	164389	**366**	0,45%	2,46%	0,11%	94%
2	149	4	605	10	**2**	47	255	4	370	1	19244	50	50%	2	163039	**371**	0,37%	2,70%	-0,13%	95%
3	148	4	671	8	**3**	44	255	4	361	1	21690	57	50%	2	182159	**362**	0,37%	2,21%	0,35%	93%
4	147	5	673	10	**4**	43	255	4	351	1	20965	56	50%	2	186155	**352**	0,36%	2,84%	-0,28%	90%
5	149	5	1364	10	**5**	39	255	4	349	2	19214	52	50%	2	388568	**349**	0,35%	2,87%	-0,30%	89%
6	150	4	568	8	**6**	39	255	4	352	1	20781	56	50%	3	183454	**354**	0,31%	2,26%	0,30%	91%
7	147	4	1649	10	**7**	43	255	3	377	3	25894	60	50%	2	526876	**376**	0,31%	2,66%	-0,10%	96%
8	146	5	596	10	**8**	40	255	3	356	2	21263	47	50%	2	188920	**356**	0,32%	2,81%	-0,24%	91%
9	148	4	1757	8	**9**	41	255	4	320	7	19861	54	50%	2	525210	**315**	0,33%	2,54%	0,02%	81%
10	148	4	530	7	**10**	47	255	4	355	1	19245	51	50%	2	172024	**356**	0,31%	1,97%	0,60%	91%
11	147	4	560	7	**11**	41	255	4	351	1	19201	52	50%	3	186774	**353**	0,30%	1,98%	0,58%	91%
12	150	4	1162	9	**12**	41	255	3	380	2	23865	53	50%	2	378942	**380**	0,31%	2,37%	0,20%	97%
13	150	4	1269	8	**13**	47	255	4	376	1	22074	57	50%	2	353682	**377**	0,36%	2,12%	0,44%	97%
14	153	5	1229	9	**14**	47	255	4	358	1	26350	72	50%	2	327840	**359**	0,37%	2,51%	0,06%	92%
15	150	4	650	9	**15**	35	255	4	379	1	21663	54	50%	2	198735	**380**	0,33%	2,37%	0,20%	97%

4. CONCLUSION

With The Simplified Gabor Wavelet (SGW) algorithm and the help of Ultraviolet light, detailed aflatoxin results are obtained, and the percentage of aflatoxin in corn shells can be calculated. From several equations to produce a number of orientation angles, the equation $\theta = \theta + pi/N$ with N=8 orientation is quite accurate in finding the feature boundaries of corn kernel objects that overlap and overlap. So it has a fairly good accuracy compared to using only four orientations with the equation $\theta = \theta + 2 * pi/N$. The equation $\theta = \theta + pi/N$, N=8 has a more detailed angular density than the equation $\theta = \theta + 2 * pi/N$, N=4, so that the edge of the corn object can be detected more real even though the first equation undergoes computation and time, which is longer due to a number of iterations of N orientations. This research can continue to be developed with new, more sophisticated methods that can be applied to objects other than corn. And a more significant number of shelled corn can be analyzed using a larger container to produce a more specific analysis.

AUTHOR CONTRIBUTIONS

Conceptualization; Kukuh Yudistiro [K.Y], Gatot Suharto Abdul Fatah [G.S.A.F], Lasinta Ari Nendra Wibawa [L.A.N.W], Yudi Prastiyono [Y.P],
methodology; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
validation; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
formal analysis; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
investigation; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
data curation; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
writing—original draft preparation; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
writing—review and editing; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
visualization; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
supervision project administration; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
funding acquisition; [K.Y],[G.S.A.F],[L.A.N.W],[Y.P],
have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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