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Measurement of Projected Areas in Some Confectionery Sunflowers (*Helianthus annuus* L.) Seeds by Image Processing Technique

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HIGHLIGHTS

- The continuous development of image processing methods increases the possibilities of obtaining data with digital images of sunflowers and similar flat seeds.
- Low-cost and open-source image processing applications beneficial for studies on agricultural grain products and important for smart farming practices and precision agriculture.

Abstract

This study aimed to demonstrate the practical and low-cost usability of image processing techniques in agricultural grain products by making a sample application in confectionery sunflower seeds. A desktop scanner and an open source software ImageJ were used. Local sunflower cultivars, which were obtained from Manisa, Denizli and Kayseri provinces, were used as a material. After the seeds were scanned with a scanner, their projected areas were calculated in 2D with ImageJ software. Afterward, the dimensions of the seeds were measured with a precision scale and caliper to compare with their projected areas. As a result of the statistical analysis, very high correlations could not be reached between the calculated projected areas and the other measured dimensions. Seed weight, seed length, seed width and hull weight were found to be highly or moderately correlated with the projected area values in all three seed types. Research findings show that the most important reason for not finding very high correlations was the use of local cultivars and the low level of seed purity.

Keywords Image processing, Sunflower seeds, Confectionery sunflower, Seed projected area, ImageJ

1. Introduction

Determination of physical properties such as length, thickness, width, surface area, volume weight and projected area of agricultural products that do not resemble basic geometric shapes and have irregular structures is necessary for the design of new machines. It is difficult to measure them manually. Therefore, modern technologies such as image processing techniques should be used in the measurements. The projected area, which is one of the features above, is an important engineering parameter that should be known for the classification and cleaning of agricultural products (Tunalıgil 1993; Dursun 2001; Demirbaş and Dursun 2007). In the image processing technique, images produced with cameras and scanners are analyzed on computers through customized software (Demirbaş and Dursun 2007).

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Advancements in image processing are vital to science and technology, but as images get larger and more complex, more advanced techniques are needed. In this case, the automation of image processing is getting important. Various image processing software is currently available. ImageJ is one of them, which is open source and written in Java to run on most computer operating systems. ImageJ has advanced image processing tools that range from data visualization to advanced image processing and statistical analysis (Abràmoff et al. 2004; Bourne 2010; Broeke et al. 2015; Hartig 2013; Schindelin et al. 2015).

Sunflower is an important oilseed crop in the World and confectionery consumption is also very common (Akkaya 2006). Although confectionery sunflower seeds are usually long and large, oil-type sunflower seeds are small, short, plump and navel, and the hull rate is low (Terzioğlu 1987). Polatlı (2013), stated that low oil content, high protein content, low hull ratio and wide seed width are accepted by many researchers as the defining features of the confectionery sunflower. The seed weight, which varies according to the genetic structure of the sunflower variety, seed holding efficiency, and hull interior ratio, increases when planting with irrigation and fertilization in fertile soils (Kıllı 2004).

Dursun (2001), used barley, wheat, chickpea, corn, lentil, soybean, bean, and kidney bean seeds as trial material in his study to determine the projected areas of grain products with an image processing technique. The projected areas of the products on three different axes were determined with the "UTHSCSA Image Tool" software. The researcher concluded that the projected areas of small grain products can be determined precisely with the image processing technique.

Demirbaş and Dursun (2007), used UTHSCSA Image Tool software to determine the physical properties of wheat seeds. Atar (2013), measured some leaf properties with ImageJ software in his study to determine germination and morphological characteristics of common hornbeam.

Kabaş and Oten (2015), used image processing techniques with Adobe PhotoShop 6.0, AutoCAD and Global Lab Image software to determine some size and area properties of alfalfa leaves. Özlü and Güner (2016), used ImageJ and Myriad image processing software to detect the projected areas of canola seeds with different moisture contents. Hakimi (2019), calculated the surface areas of adult almond leaves with ImageJ. Cirit et al., (2022) determined that there is a high correlation between the measurements made with image processing software and traditional methods in maize plants.

This study was carried out to determine the feasibility of a low-cost and practical image processing application for dimensional properties of granular agricultural materials due to the increasing interest in the determination of various properties of agricultural products using image processing techniques in recent years. For this purpose, open-source ImageJ software was preferred as image processing software. In addition, confectionery sunflower seeds were used as an example of granular agricultural materials, since they have a flat shape that is more suitable for scanning in desktop scanners. In addition, the projection areas were statistically compared with other manually measured physical dimensions.

2. Materials and Methods

Three different types of local confectionery sunflower seeds collected from agricultural enterprises in Denizli, Kayseri, and Manisa and harvested in 2021 were used as measurement material. Figure 1, shows samples from seeds collected from Denizli (a), Kayseri (b) and Manisa (c).

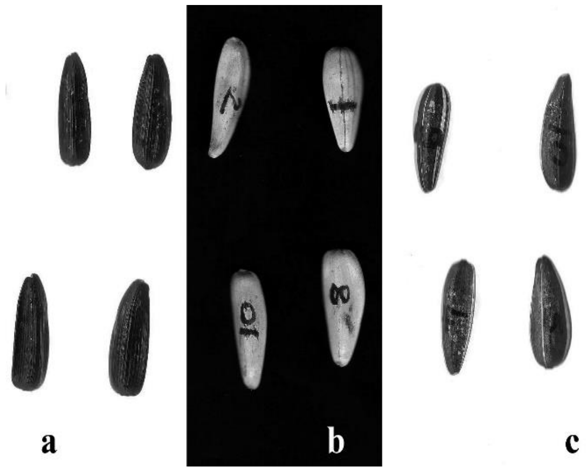

Figure 1. Seeds collected from Denizli (a), Kayseri (b) and Manisa (c)

2.1. Obtaining digital images

From the sample seeds collected for measurements, the damaged ones were removed and the remaining seeds were randomly numbered by taking 50 seeds for each location. The seeds were arranged in 10 pieces on the rectangular area of 5×10 cm determined in the scanning region of the scanner and their flat surfaces were scanned.

Epson RX520, an example of a commonly used desktop scanner, was used to obtain digital images to be used for image processing in the study. The purpose of using a desktop scanner is to measurement measure as practical, fast and low-cost as possible. Scans were made at 300 dpi resolution and 24-bit RGB color.

To create sufficient color contrast between the seeds and the ground in the scanning process; black background paper was used for light-colored seeds of Kayseri origin, and the white background paper was used for dark-colored Denizli-origin seeds. Since the seeds of Manisa origin are in multi-colored tones, sufficient contrast could not be created with white or black paper, and therefore additional illumination was made with a desktop lamp together with white paper.

2.2. Size measurements

After the scanning process was completed, the kernels and hulls of the seeds were separated from each other in the laboratory and weighed separately. Precisa 205A-SCS, accredited by TÜRKAK, precision digital balance with an accuracy of ± 0.0001 grams was used for weight measurements.

Simultaneously with the weighing, the characteristic dimensions of seeds and kernels in length were measured with a digital caliper with a sensitivity of ± 0.01 mm. The characteristic dimensions of sunflower seed (Figure 2) are given by Santalla and Mascheroni (2003). The straight lines show the dimensions of the seed and the dashed lines show the dimensions of the kernel inside the seed. Seed width, seed length, seed thickness, kernel width, kernel length, and kernel thickness are denoted by the abbreviations W, L, T, w, l and t, respectively.

2.3. Image process

The open-source ImageJ software (Version 1.5.3) was used to process the scanned digital images. Scanned images of seeds were opened with the software. Since the scanned images are in standard A4 page size (210 x 297 mm) and a 5 x 10 cm area is used to cover 10 seeds in the images, these areas were determined with the ImageJ selection tool and the images were cropped with the Crop function.

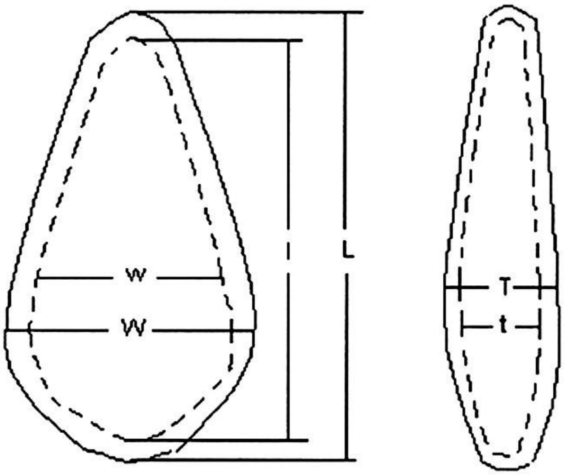

Figure 2. Characteristic dimensions of sunflower seed (Santalla and Mascheroni, 2003)

Since the cropped images are 24-bit RGB color, for image processing; They are converted to 8-bit Black & White (Image>>Type>> 8-bit). Then, by selecting the Threshold function in the software (Image>>Adjust>>Threshold), the most appropriate settings for the separation of seeds and ground were selected. Next; by selecting the Analyze Particles function (Analyze>>AnalyzeParticles), the 2-dimensional projected areas of the flat surface of each particle were found in pixels. The image of the software after the completion of the operations is shown in Figure 3.

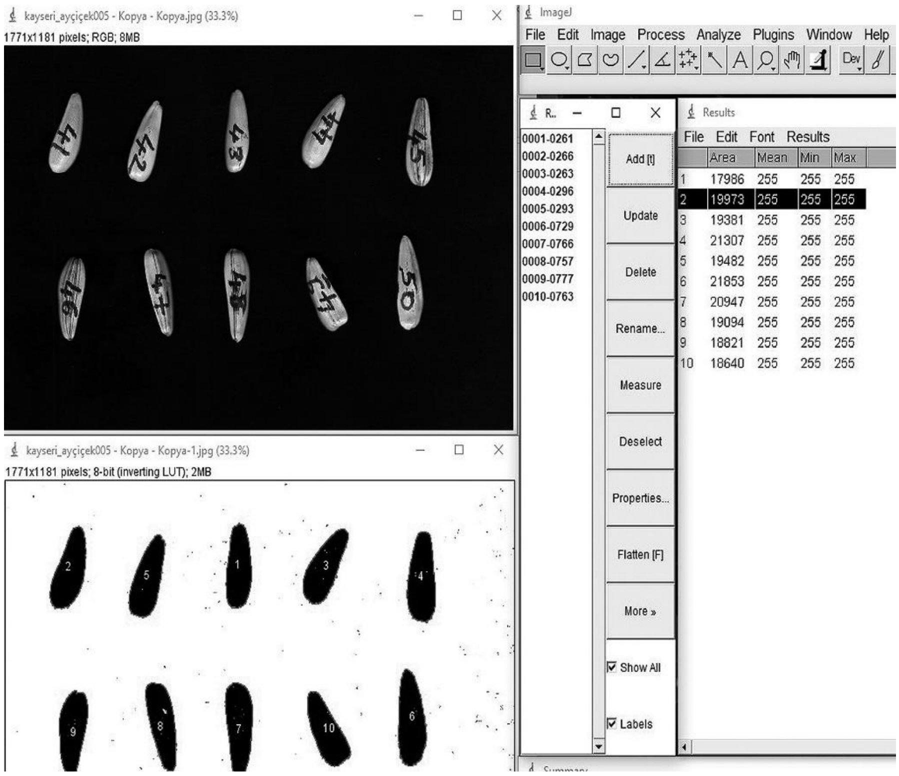

Figure 3. Areas of seeds calculated in ImageJ software.

2.4. Converting pixel values to cm²

A coefficient was calculated to convert the seed areas determined in pixels to cm² units. The measured pixel values are multiplied by this coefficient (6.970311×10-5). To find the coefficient; 623.7 cm2, which is the area value of a standard A4 paper, is divided into 8947950 (2550 x 3509), which is the pixel value of the A4 area scanned in the scanner.

2.5. Statistical Analyses

Descriptive statistics were calculated for each group of sunflower seeds. As in the research of Cirit et al. (2022), Pearson Correlation analysis was performed on values obtained by image processing and conventionally obtained.

3. Results

Descriptive statistics of confectionery sunflower seeds collected from Manisa, Denizli and Kayseri are given in Tables 1-3, respectively. A total of 150 seeds were used, 50 from each group.

Table 1. Descriptive statistics of sunflower seeds collected from Manisa

Dimensions	Abbreviations	N	$\bar{x}$	SD	Min.	Median	Max.
Seed width (mm)	W		8.96	0.78	7.62	8.87	11.43
Seed length (mm)	L		24.39	1.75	19.90	24.49	28.46
Seed thickness(mm)	T		4.06	0.57	3.04	4.02	5.23
Kernel width (mm)	w		5.19	0.69	1.94	5.22	6.43
Kernel length (mm)	l		14.35	1.40	11.09	14.14	19.64
Kernel thickness (mm)	t	50	2.48	0.27	1.86	2.45	3.22
Kernel weight (g)	K		0.1036	0.0180	0.0699	0.1020	0.1491
Hull weight (g)	H		0.0989	0.0195	0.0682	0.0981	0.1460
Seed weight (g)	S		0.2026	0.0296	0.1488	0.2016	0.2810
The ratio of kernel/seed weight	K/S		0.51	0.05	0.33	0.52	0.60
Seed projected area (cm²)	PA		1.70	0.20	1.35	1.67	2.17

Table 2. Descriptive statistics of sunflower seeds collected from Denizli

Dimensions	Abbreviations	N	$\bar{x}$	SD	Min.	Median	Max.
Seed width (mm)	W		9.46	1.08	7.05	9.48	11.43
Seed length (mm)	L		24.03	3.47	18.91	23.12	31.85
Seed thickness(mm)	T		4.87	0.78	3.21	4.94	6.65
Kernel width (mm)	w		5.32	0.55	3.54	5.36	6.48
Kernel length (mm)	l		14.17	1.15	11.53	14.06	16.33
Kernel thickness (mm)	t	50	2.63	0.40	1.64	2.55	4.02
Kernel weight (g)	K		0.1073	0.0197	0.0539	0.1094	0.1364
Hull weight (g)	H		0.1001	0.0285	0.0450	0.1000	0.1796
Seed weight (g)	S		0.2075	0.0359	0.1304	0.2026	0.3007
The ratio of kernel/seed weight	K/S		0.5222	0.0837	0.3521	0.5310	0.6832
Seed projected area (cm²)	PA		1.69	0.37	1.08	1.63	2.59

Table 3. Descriptive statistics of sunflower seeds collected from Kayseri

Dimensions	**Abbreviations**	**N**	$\bar{x}$	**SD**	**Min.**	**Median**	**Max.**
Seed width (mm)	W		8.37	0.83	6.95	8.16	10.35
Seed length (mm)	L		23.06	2.28	18.39	22.80	27.62
Seed thickness(mm)	T		4.12	0.67	2.91	4.10	5.55
Kernel width (mm)	w		4.94	0.54	3.27	4.89	6.40
Kernel length (mm)	l		13.68	1.55	10.99	13.45	17.46
Kernel thickness (mm)	t	50	2.42	0.29	1.63	2.41	2.88
Kernel weight (g)	K		0.0944	0.0221	0.0325	0.0944	0.1487
Hull weight (g)	H		0.0866	0.0203	0.0517	0.0804	0.1288
Seed weight (g)	S		0.1811	0.0353	0.0964	0.1726	0.2488
The ratio of kernel/seed weight	K/S		0.5200	0.0677	0.2930	0.5236	0.6518
Seed projected area (cm^2)	PA		1.61	0.24	1.19	1.55	2.18

3.1. Seeds collected from Manisa

Pearson Correlation Coefficients of seeds collected from Manisa are given in Table 4. As a result of the correlation analysis made on the measured features; very high correlations (0.90-1.00) or high correlations (0.70-0.89) were not found between the measured seed projected area values and other measurements.

Medium relations with seed projected area (0.50-0.69); seed length (0.688), seed width (0.627), hull weight (0.614), and seed weight (0.647). In addition, a high correlation (0.806) was found between seed weight and hull weight. Intermediate relations (0.50-0.69); between seed weight and seed width (0.572), kernel thickness and seed thickness (0.644), kernel weight and kernel thickness (0.616), seed weight and kernel thickness (0.508), and the ratio of kernel/seed weight and kernel weight (0.527). A negative moderate correlation was found between the ratio of kernel/seed weight and hull weight (-0.688).

The above-mentioned relationships of seeds collected from Manisa were found to be statistically significant at the P<0.001 level.

Table 4. Pearson correlation coefficients of seeds collected from Manisa

	W	L	T	H	w	l	t	K	S	K/S
L	0.033									
T	0.463**	-0.004								
w	0.429**	0.463**	0.415**							
l	0.499***	-0.205	0.272	0.067						
t	-0.057	0.312*	-0.105	0.030	-0.034					
K	0.234	0.092	0.644***	0.201	0.198	0.144				
H	0.476***	0.162	0.456**	0.244	0.381**	0.487***	0.616***			
S	0.572***	0.404**	0.550***	0.806***	0.277	0.317*	0.508***	0.770***		
K/S	-0.019	-0.297*	-0.005	-0.688***	0.230	0.312*	0.278	0.527***	-0.131	
PA	0.627***	0.688***	0.256	0.614***	0.219	0.134	0.173	0.399**	0.647***	-0.242

*: P<0.05;**: P<0.01;***: P<0.001

3.2. Seeds collected from Denizli

Pearson Correlation Coefficients of seeds collected from Denizli are given in Table 5. As a result of the correlation analysis made on the measured features; very high correlations (0.90-1.00) were not found between the measured seed projected area values and other measurements.

High (0.70-0.89) relations with seed projected area; seed length (0.878) and hull weight (0.812). Medium relations with seed projected area (0.50-0.69); seed width (0.668) and seed weight (0.583). A negative median relationship (0.50-0.69) was found between the seed projected area and the ratio of kernel/seed weight (-0.692). Besides, other high correlations (0.70-0.89); seed weight and hull weight (0.837), seed weight and kernel weight (0.770), hull weight and seed width (0.726), hull weight and seed length (0.710). In addition, a negative high correlation was found between the ratio of kernel/seed weight and hull weight (-0.785). Intermediate relations (0.50-0.69); seed weight and seed width (0.642), kernel weight and seed weight (0.613), the ratio of kernel/seed weight and kernel weight (0.524). In addition, a negative median relationship (-0.546) was found between the ratio of kernel/seed weight and the seed width.

The above-mentioned relationships of seeds collected from Denizli were found to be statistically significant at the P<0.001 level.

Table 5. Pearson correlation coefficients of seeds collected from Denizli

	W	L	T	H	w	l	t	K	S	K/S
L	0.397*									
T	0.424**	-0.303*								
w	0.726***	0.710***	0.151							
l	0.331*	-0.136	0.252	0.076						
t	-0.029	0.232	-0.193	0.039	-0.161					
K	0.052	-0.292*	0.378**	0.046	-0.030	-0.104				
H	0.120	-0.149	0.264	0.082	0.451**	0.301*	0.494***			
S	0.642***	0.481***	0.264	0.837***	0.308*	0.196	0.308*	0.613***		
K/S	-0.546***	-0.612***	-0.027	-0.785***	0.149	0.191	0.231	0.524***	-0.334*	
PA	0.668***	0.878***	-0.109	0.812***	0.026	0.127	-0.201	-0.110	0.583***	-0.692***

*: P<0.05;**: P<0.01;***: P<0.001

3.3. Seeds collected from Kayseri

Pearson Correlation Coefficients of seeds collected from Kayseri are given in Table 6. As a result of the correlation analysis made on the measured features; very high correlations (0.90-1.00) were not found between the measured seed projected area values and other measurements.

High (0.70-0.89) relations with seed projected area; seed length (0.830), and hull weight (0.792). The medium relations with the seed projected area (0.50-0.69); seed width (0.676), and seed weight (0.673). Besides, other high correlations (0.70-0.89); seed weight and kernel weight (0.848), seed weight and hull weight (0.817), kernel weight and kernel length (0.758), hull weight and seed length (0.718), and seed weight and seed length (0.708). Intermediate relations (0.50-0.69); hull weight and seed width (0.533), kernel length and seed length (0.555), kernel weight and kernel width (0.569), seed weight and kernel width (0.535), seed weight and kernel length (0.669), the ratio of kernel/seed weight and kernel weight (0.605).

The above-mentioned relationships of seeds from Kayseri were found to be statistically significant at the P<0.001 level.

Table 6. Pearson correlation coefficients of seeds collected from Kayseri

	W	L	T	H	w	l	t	K	S	K/S
L	0.265									
T	0.315	0.124								
w	0.533***	0.718***	0.415**							
l	0.324*	0.220	0.318**	0.311**						
t	-0.053	0.555***	0.159	0.340*	0.278					
K	-0.092	0.095	0.137	0.131	0.091	0.215				
H	0.063	0.472**	0.278	0.388**	0.569***	0.758***	0.610***			
S	0.346*	0.708***	0.412**	0.817***	0.535***	0.669***	0.456**	0.848***		
K/S	-0.384**	-0.198	-0.091	-0.471**	0.321*	0.401**	0.464**	0.605***	0.108	
PA	0.676***	0.830***	0.284*	0.792***	0.356*	0.365**	-0.005	0.348*	0.673***	-0.366**

*: P<0.05;**: P<0.01;***: P<0.001

3.4. Common parameters of seeds

When the evaluation is made by looking at all three seed groups; It is seen that the parameters that have a high, moderate and P<0.001 level relationship with the seed projected areas (PA) in all three groups are: hull weight (H), seed weight (S), seed length (L) and seed width (W) (Table 7).

Table 7. Common parameters with a high and medium-level relationship with projected areas

Correlation	Manisa	Denizli	Kayseri
Seed projected area × Hull weight	Median	High	High
Seed projected area × Seed weight	Median	Median	Median
Seed projected area × Seed length	Median	High	High
Seed projected area × Seed width	Median	Median	Median

4. Discussion

Cirit et al., (2022) on maize, were able to determine the grain size with a high level of correlation using ImageJ and one other image processing software. This study shows that the ImageJ program is still used to get efficient and precise results for morphological seed evaluations.

Atar (2013), Kabaş and Oten (2015), and Hakimi (2019) measured basic dimensions, areas and similar features with image processing software by scanning some leaves with a flatbed scanner. These researchers found that the measurements made with image processing software were successful.

Atar (2013) and Hakimi (2019) used ImageJ software, and differently, Kabaş and Oten (2015) used Adobe PhotoShop 6.0, AutoCAD and Global Lab Image software. Leaves are one of the best examples of flat plant parts. A combination of a desktop scanner and image processing software can be used successfully in flat seeds as well as in leaves.

Considering the statistical analysis, it was concluded that the most important reason for not finding very high correlations in this study was the use of local cultivars and the low level of seed purity.

5. Conclusions

It is important to find relationships between the digitally measured seed projected areas and conventionally measured dimensions. Considering this relationship, the potential to obtain important information from digital images of confectionery sunflower seeds and similar flat seeds will increase as image processing methods improve and become cheaper.

In this framework, progress will be made in the field of sowing and harvesting machinery, which requires information about the projected area, and in agricultural technologies related to storage and food production. In light of the results obtained in the study; It has been concluded that low-cost image processing applications will be beneficial for studies on agricultural grain products and also important for smart farming practices and precision agriculture.

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