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Research Article

Geometric Modeling For Calculating Volume And Surface Area For Some Microstructures

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Abstract –Most living and non-living materials in nature have a geometric model. The geometric shapes of these structures, their positions of coming together, the areas they cover, and their durability affect the functionality of their entirety. Microstructures are formed within these geometric units, which are found in many living and non-living materials, as well as in tissue samples that form this complex material. They control and greatly assist the best and most efficient continuation of these geometric features of microstructures with geometric parts. With this study, we tried to determine the geometric modeling of some structures that we see around us and share our planet with. The method we applied was done by identifying geometric models or shapes that most closely resemble the actual shape of the microstructures. At the same time, literature information from similar studies was also used. On the other hand, literature information about the geometric models and mathematical formulas of these microstructures was evaluated. In addition, the structures of the geometric models obtained from these definitions were shown with figures. As a result, we were able to detect the plant tissues whose microscopic structures we examined, having geometric models such as prolate spheroid (Longitudinally spherical, Prolate spherical), ellipsoid, cylinder 2 hemispheres (Combination of the cylinder and two hemispheres).

Keywords – Geometric Modeling, Microstructure, Mathematical Formulas.

I. INTRODUCTION

We can easily observe that many living and non-living materials that share our planet with us have a geometric structure. In addition to the macro structures of the visible external appearances of these materials, there are also microstructures that we can only observe under a microscope, which form the whole of these structures. It is not possible to observe the microstructures of these materials with the naked eye.

In our research, it was determined in accordance with the literature information that the microscopic structures of some plant parts that we can only observe with a microscope have geometric models. It was observed that numerical values related to the geometric models of these microstructures examined under the microscope can be obtained. The numerical values of these microstructures can be obtained by measuring with the help of a microscope. In the study, mathematical formulas that can be used in calculating the properties of numerical data such as volume and surface area of these structures were expressed based on geometry data in the literature [1],[2],[3].

These geometric models, which are found in most living and non-living materials, as well as in the tissue samples that constitute the material of this research, constitute their microstructures. These geometric features of microstructures with geometric models control and greatly help them to continue their duties in the best and most efficient way [4].

II. MATERIALS AND METHOD

The microstructures of tissues belonging to different plants were used for the study. Microstructures with drug properties, which are the raw materials of drug production, were evaluated for the study. In the study, the numerical measurements of secretory hairs carrying drug raw materials and some other tissue cell microstructures, whose geometric models we determined, were determined and evaluated under the microscope in micrometer measurements. It was shown that geometric properties such as surface areas and volumes could be calculated using these determined values.

To obtain the microstructures of the samples in the study, cross-sections were taken from different parts of these samples to be examined under the microscope. To examine the microstructures, the preparations prepared by staining the sections were photographed under the microscope using different magnification objectives with a Leica brand (Leica DM3000) camera light microscope.

In the finding acquisition phase of our research, it was observed that they had some geometric models belonging to the microstructures we examined. These geometric models were determined by determining the most similar models to them in the light of the literature and the relevant formulas were shown [5],[6],[7].

III. RESULTS

Our study has shown that the micromorphological structures of some living tissues have different geometric models, and that these microstructures can be defined numerically and shown with formulas. In the study, information on the subject in the literature was obtained in the evaluation of microstructures within the geometric framework. As a result of our research, we found that the plant tissues whose microscopic structures we examined had geometric models such as prolate spheroid (Longitudinally spherical, Prolate spherical), ellipsoid, cylinder, half spheres (Combination of cylinder and two hemispheres). The geometric structures related to these geometric models, microscopic photographs showing their microstructures and the formulas of the numerical properties of these structures are given in the study (Figure 1-6).

1.Prolate spheroid (Longitudinal spheroid, Prolate spheroid):

A general geometric spheroid structure is called a geometric object that is not a perfect sphere but resembles a sphere. This geometric structure is also known as an ellipsoid of revolution. Another definition is that it is a quadratic surface obtained by rotating an ellipse around one of its main axes. In other words, it is an ellipsoid with two equal radii. A spheroid has circular symmetry [8].

Prolate spheroid (prolate spheroid) is expressed as a general definition in geometry as an elongated spheroid. Prolate spheroid is a surface of revolution obtained by rotating an ellipse around its main axis [2]. If an ellipse is rotated around its main axis, an elongated prolate spheroid geometric model is obtained.

The prolate spheroid geometric model is a structure that resembles a symmetrical egg (i.e. the same shape at both ends). The original microstructure photographs and geometric model of this geometric model are given in Figure 1,2.

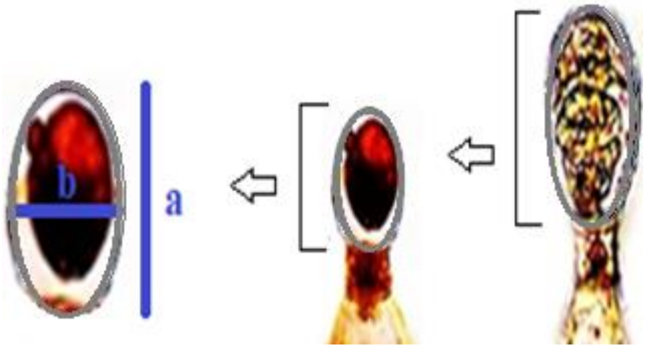


Fig. 1 Original microscope image of prolate spheroid microstructure.

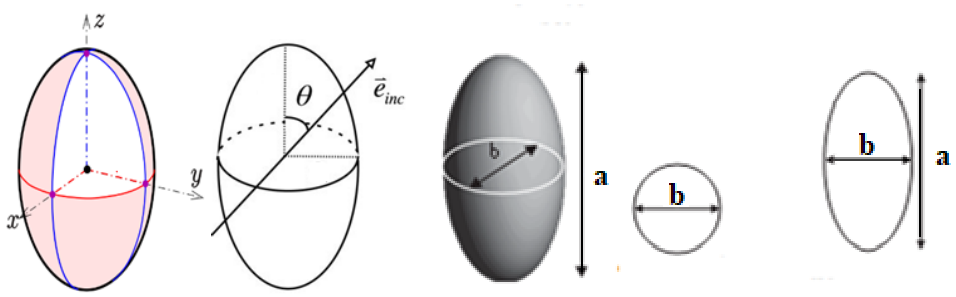


Fig. 2 Semi-axes and geometric modeling of the prolate spheroid geometric model [2], [5].

The area and volume values of this geometric model are calculated with the formulas shown below.

$$V = \frac{\pi}{6} . b^2 . a$$

$$A = \frac{\pi . b}{2}\left(b + \frac{a^2}{\sqrt{a^2 - b^2}} sin^{-1} \frac{\sqrt{a^2 - b^2}}{a}\right).$$

2. Ellipsoid:

An ellipsoid is a quadratic surface; that is, a surface that can be defined as the zero set of a quadratic polynomial in three variables. An ellipsoid is also defined as a three-dimensional figure in which all plane sections are ellipses or circles [7]. An ellipsoid has three axes that intersect at its centre. Each axis is perpendicular to the other two, and the ellipsoid is symmetrical about all three axes. An ellipsoid is often defined as a three-dimensional analogue of an ellipse. The term ellipsoid is a closed regular shape whose centre is at the origin of a three-dimensional rectangular coordinate system (xyz), with a semi-axis length a in the x-axis direction, a semi-axis length c in the y-axis direction, and a semi-axis length b in the z-axis direction. A general (three-axis) ellipsoid with semi-axes a, b, and c is shown in Figure 3,4.

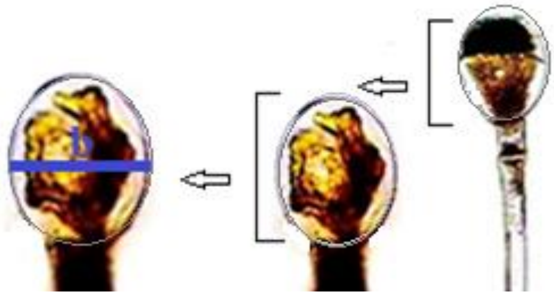


Fig. 3 Original microscope image of ellipsoid microstructure.

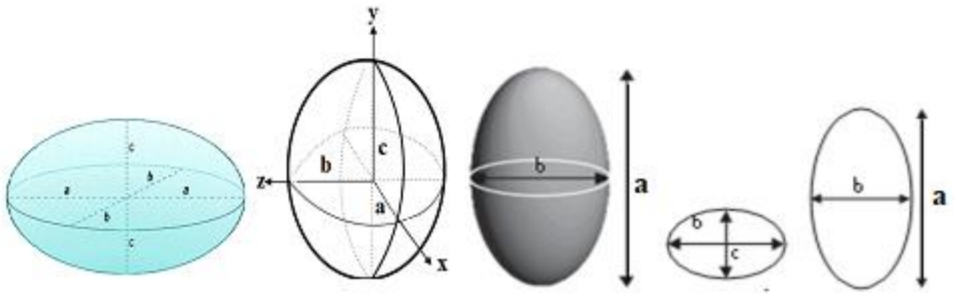


Fig. 4 Semi-axes and geometric modeling of the ellipsoid geometric model [5], [7].

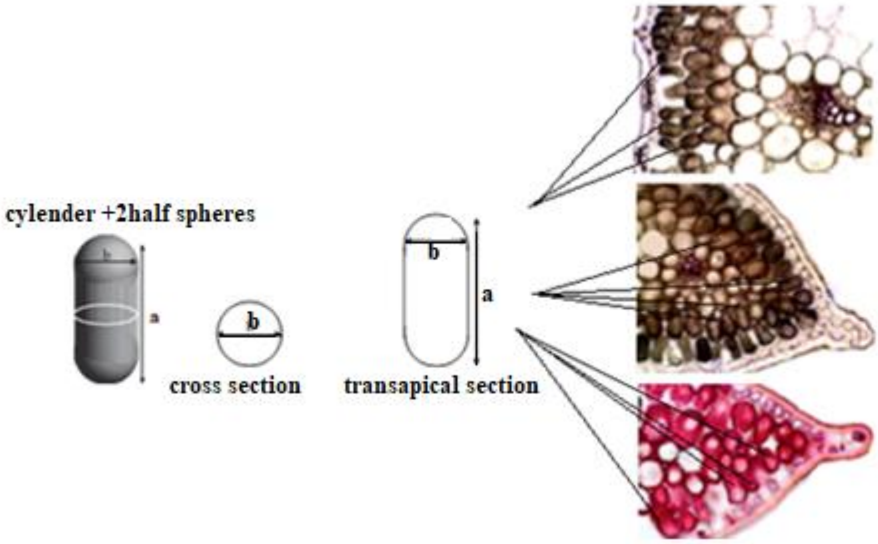
The area and volume formulas of the ellipsoid geometric model are shown below [5].

$$V = \frac{\pi}{6} a.b.c$$

$$A \approx \frac{\pi}{4}.(b+c).\left[\left(\frac{b+c}{2}\right) + \frac{2a^2}{\sqrt{4a^2-(b+c)^2}} sin^{-1}\frac{\sqrt{4a^2-(b+c)^2}}{2a}\right].$$

3. Cylinder +2 half spheres (Combination of cylinder and two hemispheres - Capsule):

The geometric model called the combination of cylinder, and two hemispheres is also defined with the term capsule, which comes from the Latin word capsula, "small box or chest". A capsule is formed by combining two hemispheres into a cylinder, with one hemisphere at each end. Another definition is that this geometric structure is a basic three-dimensional geometric shape consisting of a cylinder with hemispherical ends [9],[10]. A capsule geometry consisting of a cylinder with hemispherical ends capsule geometry is also typically used for composite overwrapped pressure vessels. It should not be forgotten that the capsule geometry is a cylinder closed by hemispheres (Figure 5,6). The area and volume formulas of the geometric model are shown below.



a **b**

Fig. 5 a: Cylinder+2 half sphere general view, geometric representation [5].
b: Original microscopic images with geometric model in microstructures

Volume of the capsule:

$$V = \pi \left(\frac{b}{2}\right)^2 a + \frac{4}{3}\pi \left(\frac{b}{2}\right)^3$$

$$V = \pi b^2 \left(\frac{a}{4} + \frac{b}{6}\right).$$

Area of the capsule: $A = \pi ba + 4\pi \left(\frac{b}{2}\right)^2$

$$A = \pi b(a + b).$$

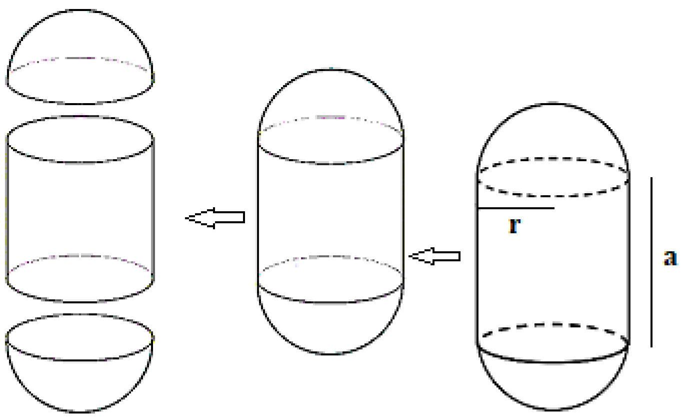


Fig. 6 General view of the cylinder+2 half sphere (capsule) geometric modelling.

Here, r is the capsule radius and a is the height of the cylindrical part of the capsule.

Volume of the capsule: When $r = \frac{b}{2}$ is $b = 2r.$

Accordingly,

$$V = 4\pi r^2 \left(\frac{a}{4} + \frac{r}{3}\right).$$

Area of the capsule: $A = 2\pi r(a + 2r).$

IV. DISCUSSION

In this study, the geometric structures of the micro features of some plant tissue samples used as microstructure material were investigated. It was observed that some microscopic structures of the samples that constitute the subject of the study had different geometric features. It was observed that the microscopic structures belonging to different geometric models observed in the investigated microstructures came together in a certain order and formed the integrity. These microscopic structures, which come together in the order of defined mathematical formulas and geometric models, form the entire tissue and enable them to fulfill their functions in the most efficient way.

The physical, biological and functional properties of many living and non-living materials around us depend on the size, shape, arrangement and settlement patterns of their microscopic structures. By revealing the geometric model features of these hidden structures that can only be observed under the microscope in the light of mathematical concepts, we can ensure the use of these structures as sample draft models in many different areas.

There are similar studies in the literature on the micromorphological structures of plants having geometric models [11],[12],[13], [14],[15],[16],[17].

In addition, there are similar geometric studies on macro structures [18],[19],[20], [21].

When the results were evaluated, it was determined that some microstructures, as in macro structures, have geometric models that can be evaluated with mathematical concepts. Quantitative properties such as volume and area of these models, which can be defined in geometry, will be determined with mathematical formulas and will enable us to obtain clear information about their functions.

V. CONCLUSION

This study has attempted to reveal the usability of some microstructures whose geometric properties have been revealed as sample models in many areas. Thus, a different perspective has been tried to be brought to the relevant field for future research on similar subjects.

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