DEVELOPMENT OF RESEARCH-BASED BIOLOGICAL MODULES ON CHARACTERISTICS OF LEAVES EPIDERMIS AND ITS DERIVATIVES OF Solanum lycopersicum var. Cerasiforme and Solanum lycopersicum cv. Ranti FOR HIGH SCHOOL STUDENTS

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Abstract
The study aimed to determine the feasibility of the modules developed for class XI learning on the structure and function of plant tissues based on the results of research on the characteristics of the epidermis and epidermal derivatives of cherry tomato leaves and rose tomato leaves. The research was carried out in two stages. The first was exploratory research carried out by taking samples in the form of cherry tomato leaf organs and rose tomato leaves. Preparation of cherry tomato leaf and rose tomato leaf preparations using the leaf clearing method, observation with optilab-raster image application. Research data were analyzed descriptively. The second stage was preparing modules on the structure and function of plant tissue as biology teaching materials for class XI using the ADDIE development model, which was limited to ADD. Module quality data was collected using a data collection instrument in the form of a product assessment questionnaire. The average result of product evaluation by material experts is 82.14%, and media experts are 84.37%. Based on the results of this assessment, the module on the structure and function of plant tissue is feasible to be used for testing as high school biology teaching materials.

Keywords: Epidermis and Epidermic Derivates; Modul; Solanum lycopersicum var. Cerasiforme; Solanum lycopersicum cv. Ranti

INTRODUCTION
Biology as a subject with special aspects and characteristics requires unique methods and strategies to achieve learning objectives (Sari &
Ma’rifah, 2020). Learning is a process of teaching and learning activities that occur between students and teachers. In the learning process, there is intense interaction between students and teachers. Students are the main actors (subjects) of learning, while the teacher is a facilitator who accompanies students in achieving the desired learning goals.

The main problem that is often faced by education in schools is the weak mastery of the material by students, including in biology subjects and the lack of teaching material facilities that contain real images as learning media that can assist teachers in conveying material. Success in the learning process is supported by several factors, namely the availability of teaching materials, methods and approaches used by the teacher in learning (Hala et al., 2015). The teacher is not the only source of knowledge for students but rather as an indispensable facilitator, namely by creating a learning environment that is able to encourage students to be happy and excited to learn. One way that teachers can do this is by varying teaching materials as learning materials that can attract students' attention to read them (Yusa et al., 2023).

Teaching materials are a collection of various learning resources that are systematically arranged for learning purposes (Nuryasana & Desiningrum, 2020). Teaching materials are an important part in determining the quality of learning. The design of developing teaching materials needs to pay attention to the development model to ensure the quality of teaching materials in supporting the effectiveness of learning, because the development of teaching materials is basically a linear process with the learning process (Cahyadi, 2019). Teaching materials developed effectively to improve student learning outcomes (Wulandari et al., 2017). The function of teaching materials for educators is to improve the learning process to be more effective and interactive. The role of teaching materials for students is that they can learn at their own pace (Prastowo, 2015). Teaching materials are needed in all subjects in school, especially biology.

Based on the interview conducted by researchers with teachers at Muhammadiyah 4 Yogyakarta High School, information was obtained that there was still a lack of additional references to accompany textbooks in learning biology. The books used do not present many pictures of the anatomical structures of tissues in plants, so they are not varied enough to provide explanations to students. Studies related to the characteristics of the epidermis and epidermal derivatives from cherry tomato and rose tomato leaves can be used to add information regarding the importance of knowledge of plant tissue material. The teaching materials were less varied, especially biology teaching materials.

Regarding the difficulties in learning plant tissue material at Muhammadiyah 4 Yogyakarta High School, the teacher stated that there was still a lack of pictures in the textbook, especially plant tissue material, to provide a real example to students. There were limited facilities from laboratories in schools, so students could not do practical work on plant tissue material. There are no
module teaching materials regarding plant tissue material other than textbooks that can help the in-class learning to improve understanding and learning outcomes by using teaching materials. Well, one of the teaching materials that can be developed is modules. Learning using modules aims to increase the efficiency and effectiveness of learning in schools. Modules are printed teaching materials designed so students can study them independently (Ariana et al., 2020).

One way to improve understanding and student learning outcomes namely by developing teaching materials Good. One of the teaching materials that can be developed is a module (Setiyadi et al., 2017). Learning modules are teaching materials that are arranged in a systematic and interesting manner that include content, methods and evaluations that can be used independently to achieve the expected competencies (Nafaida et al., 2015). In the world of education today, there are two types of modules that are currently being developed, namely electronic modules and printed modules. Each of these module types has its advantages and disadvantages (Puspitasari, 2019).

The field of study aspects listed in the 2013 curriculum in KD 3.3 with plant tissue sub-material. The research results are adapted to KD 3.3 class XI, namely analyzing the relationship between cell structure in plant tissues and organ functions in plants and KI 4.3 presenting data from observations of the structure of tissues and organs in plants.

METHODS

The research was carried out through the first two stages: an exploratory analysis by taking samples from cherry tomato leaf organs and rose tomato leaves. Preparation of cherry tomato leaves and rose tomato leaves using the leaf-clearing method. Observations were performed using optilab, through the image raster application. Research data were analyzed descriptively. The second stage was the preparation of teaching materials based on the research results, then studying their potential as a source of biology learning and arranging into biology teaching materials in the form of modules.

Time and Location of Research

This research was conducted in the Salam Garden Gg. Mayang V Pringgolayaan, Banguntapan, Bantul, DIY. The cherry tomato and rose tomato leaf samples were observed at the Laboratory of Campus 4 of Ahmad Dahlan University.

Data Collection Technique

Data collection techniques used in this research are documentation, observation, unstructured interviews, and product validation instruments. Documentation using the instrument is a document guide containing the
required data categories. Observations were made to discover the physical condition and potential of the cherry tomato and rose tomato plants. Interviews were conducted with biology teachers to obtain in-depth information regarding the unknown problems and needs of the school. The validator validated the questionnaire sheet to determine the feasibility of the module product that the researcher had designed.

Tools and Materials
The tools and materials used in exploratory research were scissors, a camera, dropper, brush, object glass, cover glass, flacon bottles, optilab, burettes, binocular microscope, tweezers, binocular microscope, tweezers, and stationery, laptops, and editing applications (Canva). Samples used in this study were taken from cherry tomato and rose tomato leaves, chloralhydrate and distilled water (5: 2).

Research Procedure
The working procedure in this research are:
1. Exploration Research Stage
   a. Preparation for observing the location of the research site
   b. Leaf samples were taken in 2-3 pieces, and the leaves were taken by counting from the top to the 4th leaf. Leaf samples were cut 1 cm in length (tip of leaf, edge of leaf and middle of leaf).
   c. The observed morphological characteristics of the cherry tomato and rose tomato plants were plant length, leaf length, and leaf width.
   d. Leaf preparation
   e. Observation of preparations was observed using optilab, at 100x and 400x magnification with a specific field of view, then the structures of the epidermis, stomata and trichomes were seen.
2. Module Development Stage
   The research results were arranged into teaching materials in modules. The analysis of the potential of teaching materials refers to books (Suhardi, 2012). The method refers to ADDIE (Analysis, Design, Development, Implementation). However, this study is limited to ADD (Analysis, Design, and Development) because the research was used only to develop teaching materials, not for the implementation and evaluation stages. The module preparation stage is as follows:
   1. Analysis
      a. Analysis of student needs
      b. Competency analysis
      c. Analysis of potential research results as teaching materials
   2. Design
      a. Conduct curriculum analysis related to essential competencies and core competencies
      b. Formulate indicators that cover Basic Competency
      c. Determine the module title related to the subject matter of KD 3.3 class XI
      d. Collect references as material in the module to be developed
      e. Develop material according to learning objectives and complement it with the results of research on epidermis and epidermis derivatives on cherry tomato leaves and rose tomato leaves.
   3. Development
      The teaching material products that have been printed are then validated by experts, namely material...
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experts and media experts. Module assessment is done by filling in the validation instrument that the researcher has prepared. The results of teaching material validation are used as product improvements assessed by the validator so that these modules can be used as biology teaching materials for plant tissue material.

Data Analysis Technique
1. Descriptive Analysis
   Data were analyzed descriptively by interpreting or describing essential elements, such as the shape of the epidermis, the number of epidermal cells, the length and width of the epidermis, the type of stomata, the length and width of stomata, stomata index, the number of stomata, the shape of trichomes, the type trichomes, length and width of trichomes and a number of trichomes in cherry tomato and rose tomato leaf organs.

2. Analysis of Module Product Validation Data by Material Experts and Media Experts
   The assessment of teaching material uses a Likert scale to measure the validator's opinion of teaching materials.

RESULTS AND DISCUSSION
Exploratory Research
This study focused on leaf organs to observe their morphology and anatomy. The leaf morphology section measured the length and width of the leaf. After being observed as a whole, the leaves of cherry tomatoes and rose tomatoes have similar similarities, namely, green leaves fluffy. The leaf edges are notched pinnate (pinnatilobus), which follow the pinnate arrangement of the bones, with the tip of the leaf being pointed (acutus) and the base of the leaf being blunt (obtusus) and flat (truncatus). The foliolum of tomato includes pinnate compound leaves with an odd number of children, compound leaves where the children are on the right and left of the mother petiole and one leaf covering the tip of the mother stalk (Tjitosoepomo, 2013). The following is a morphological picture of the cherry tomato and rose tomato leaflet.

![Figure 1. a. Morphology cherry tomato leaves. b. Leaf morphology rose tomatoes.](image)

The epidermis is the outermost tissue found in plants which consists of a layer of cells that have function as a protective tissue or cover all plant organs (Sari & Herkules, 2017). Based on the observations of epidermal cells in cherry tomato and rose tomato leaves, it consists of two parts: the upper (adaxial) surface epidermis and the lower (abaxial) epidermal surface.
It is observed that the epidermal cells of tomato and rose tomato leaves, both on the leaves' upper surface and lower surface, have the same elongated, irregular shape with notched cell walls. The location of the epidermal cells is very tight, so the spaces between cells are narrow. Epidermal cell size significantly affects the number of stomata in a broad field of view. According to Dewi et al. (2015), epidermal cells are generally smaller and densely polygonal in the adaxial section and prominent in the abaxial section. The shape of the epidermis on cherry tomato leaves and rose tomato leaves are shown in figure 2.

![Figure 2](image-url)

**Figure 2.** a. Epidermal form cherry tomato leaves.  
b. Form epidermis of rose tomato leaves.

The epidermis on the leaves has several modified appendages; the leaf epidermis's derivatives include stomata and trichomes. Stomata are pores or holes in the epidermis, each of which is bounded by two guard cells or covering cells (Sutrian, 2011). Based on the results of research on the shape of the stomata on the leaflets of cherry tomatoes and rose tomatoes, they belong to the anisocytic type, with the characteristic of guard cells being surrounded by three neighboring cells, one of which is smaller than the other two cells. This research is important to do to broaden students' insights in learning about the structure and function of plant tissues, especially the epidermis and epidermal derivatives.

![Figure 3](image-url)

**Figure 3.** a. Foliolum's stomata cherry tomato leaves.  
b. Stomata rose tomato leaves

Trichomes are hairs that grow from epidermal cells whose shape, structure and function vary widely. Trichomes are found in almost all plant organs (Sutrian, 2011). Trichomes have more compact
structures such as protrusions, glandular structures, and spines consisting of epidermal cells or subepidermal tissue, which is called emergence. Trichomes can be grouped into two, namely non-glandular trichomes (non-glandular hairs) and glandular trichomes (glandular hairs) (Mulyani, 2019). Based on the experiment on cherry and rose tomatoes, they are glandular and non-glandular trichomes with needle-like hairs with pointed ends. There are also long and bottle-like, oval-shaped trichomes called hydathodes trichomes on the surface of the middle part of the leaf and the edges of the leaf.

![Figure 4. a. Foliolum’s trichomes cherry tomato leaves. b. Trichome rose tomato leaves](image)

**Educational Research Results**

The teaching materials developed using ADDIE development model (Analysis, Design, Development, Implementation, Evaluations). However, this research utilizes 3 stages of the model: (Analysis) In this stage, the main activity is to analyze the need for the development of teaching materials in learning objectives, (Design) The design stage includes several planning for the development of teaching materials, and (Development) Development in the ADDIE Model contains activities for the realization of product design, in this case teaching materials. It is because the study is limited to developing teaching materials and does not reach the implementation and evaluation stage. The analysis phase includes student needs, competency analysis, and research potential as teaching materials.

The needs of students are analyzed before determining the teaching materials to be made, aiming to see the possible causes of existing problems and the student's basic needs. Otilia (2020) reveals that needs analysis is the foundation for developing curriculum content, teaching materials and teaching methods that can increase student motivation and success. The results of the analysis of the needs of students are that they need practical teaching materials that contain solid, concise and clear material coverage so that they motivate students to study in class or study independently.

The next stage enters the Design stage. The researcher collected references and pictures taken from class XI high school plant tissue material at this stage. References for
the material were from journals, textbooks on plant anatomy, textbooks for class XI high schools, results from research on the epidermis and epidermal derivatives of cherry tomato leaves and rose tomato leaves and biology websites in preparing the module using the Canva application, because the Canva application is a graphic design platform that can be used for free and easily.

The Canva application has a variety of attractive designs. It is able to increase teacher creativity in designing learning media because many features are provided, saves time in practical learning media, and is easy to develop attractive materials without device limitations (Tanjung & Faiza, 2019). The results of the module arrangement are then printed using 210 gr glossy side paper as the cover and 100 gr glossy side paper as the module's contents by finishing the middle staples module. The following shows a module design display using Canva (Figure 5).

![Figure 5. Display of module design using the canva app](image)

The final stage is development. At this stage, it is the process of printing the module teaching materials that have been designed. The results of the modules that have been designed are developed based on existing references (Neno et al., 2022). This stage also assessed the module product, which aims to see its feasibility as a class XI biology teaching material on plant tissue material. The module assessment instrument is prepared based on the criteria for evaluating teaching materials by the National Education Standards Agency (BSNP), which is adjusted to the characteristics of the module. The aspects assessed are content feasibility, content presentation, language feasibility, and graphic feasibility. This module is assessed by two validators, material experts and media experts, by providing the assessment parameters on the instrument sheet.

<table>
<thead>
<tr>
<th>No</th>
<th>Aspects</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Content feasibility</td>
<td>87.5%</td>
</tr>
<tr>
<td>2.</td>
<td>Language</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>82.14%</td>
</tr>
</tbody>
</table>

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**Table 1. Results of material expert assessment**

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Based on table 1, the results of the assessment by experts material for the module, there are two aspects: the feasibility of the content and language. The feasibility aspect of the content gets an assessment percentage of 87.5% in the excellent category. The linguistic element gets a rating percentage of 75% in the outstanding category. The items for assessing the linguistic aspect are the readability of the language, the consistency and accuracy of writing terms/scientific names/symbols and words/sentences used following excellent and correct grammar per EYD. The opinion supports this (Nurlaili, 2011) the use of clear sentence structures can make it easier for students to understand messages from teaching materials. The results of the media expert's assessment are as follows (table 2).

<table>
<thead>
<tr>
<th>No</th>
<th>Aspects</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Presentation</td>
<td>91.67%</td>
</tr>
<tr>
<td>2.</td>
<td>Graphic</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>84.37%</td>
</tr>
</tbody>
</table>

Based on table 2, the assessment results by media experts on the module, there are two aspects: the feasibility of presentation and graphics. The presentation feasibility aspect gets a rating percentage of 91.67% in the excellent category. The graphical element gets a rating percentage of 80% in the excellent category. The following is the result of a recapitulation of the results of the assessment of material and media expert namely as follows (table 3).

<table>
<thead>
<tr>
<th>No</th>
<th>Validator</th>
<th>Percentage</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lecturer1</td>
<td>82.14%</td>
<td>Very good</td>
</tr>
<tr>
<td>2.</td>
<td>Lecturer2</td>
<td>84.37%</td>
<td>Very good</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>83.25%</td>
<td>Very good</td>
</tr>
</tbody>
</table>

Recapitulating the assessment results of material experts and media experts, the module teaching material products get an average score of 83.25% in the excellent category with revisions. According to Darmawan & Nawawi (2020), 81% -100% is categorized as very suitable for testing with revisions. The action taken by the researcher after getting an assessment and input from the validator was to improve the module teaching material product. Biological module products for plant tissue material that have been designed need revision to perfect the final results of the module to produce a better module product than before (Lubis et al., 2015).

Developed module each has special characteristics activities are highly stressed group collaboration and internal discussion find concept. This agrees with (Budiono & Susanto, 2006) which posited that the most way good at using the module is students actively learn together with friends in a group, temporarily the teacher checks intensive and provide assistance to...
students who have difficulty in learning module individually. Following are some of the results of the module product which has been revised (Sawitri & Ambarwati, 2014).

![Module Image](image1)

**CONCLUSION AND SUGGESTIONS**

Module teaching materials compiled based on the results of research on the characteristics of the epidermis and epidermal derivatives of cherry tomato leaves and rose tomato leaves were declared suitable for testing as biology teaching materials for class XI on plant tissue material.

Suggestions for further research because the module only reaches the development stage, it is necessary to implement or try out the use of plant tissue material modules for class XI high school students in several different schools.

**REFERENCES**


**Figure 6. Some parts of the resulting module.**

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