Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES
P-ISSN 2581-1657
E-ISSN 2581-2203

Development of Student Worksheet (LKPD) on Conventional Biotechnology Material for Grade X of Senior High School Through Bekasam Fermentation as Local Wisdom

Hazirah Febrina*, Imam Mahadi, Wan Syafi'i
Biology Education, Universitas Riau, Pekanbaru, 28293, Indonesia

ARTICLE INFO

Article history:

Received: 12 Nov 2025
Revised: 24 Nov 2025
Accepted: 12 Dec 2025
Published online: 20 Dec 2025

Keywords:

Bekasam,
Fermentation Time,
Rasbora argyrotaenia Blkr,
Salt Concentration,
Student Worksheet

* *Corresponding author:*

E-mail: hazirah.febrina1948@student.unri.ac.id

Article Doi:

https://doi.org/10.31258/jes.9.6.p.6570-6584

A B S T R A C T

Bekasam is a traditional fermented food made from fish, salt, and carbohydrate sources. The fish used in making bekasam are usually freshwater fish, one of the freshwater fish that can be used as the main ingredient in making bekasam is seluang fish (Rasbora argyrotaenia Blkr). This study aims to developing a student worksheet (LKPD) as alternative teaching materials for the conventional biotechnology in grade X senior high school, using findings from research on the effects of salt concentration and fermentation duration on bekasam made from seluang fish. This research is a quantitative study with a 3x3 factorial RAL experimental method with 3 replications so that a total of 27 treatments were obtained. The results showed that the best organoleptic and hedonic were in the P2T2 treatment (salt concentration of 20% and fermented for 10 days) namely a rather dull color (light brown), a distinctive bekasam aroma and a very strong aroma, the fish shriveled and soft, and the taste was very tasty. Furthermore, the development of LKPD was carried out using the ADDIE model, from the analysis, design, to development stages. From the validation results, it is known that the Student Worksheet (LKPD) for making bekasam seluang fish (Rasbora argyrotaenia Blkr) can be used in conventional biotechnology learning for class X SMA.

1. Introduction

Kurikulum merdeka is an educational policy that emphasizes learning flexibility and adapts materials to local contexts and student needs. One of its characteristics is providing space for educational units and educators to develop meaningful, relevant, and contextual learning. The independent curriculum, which incorporates elements of local wisdom, is one effort to create a relevant and contextual learning process tailored to student needs, one of which is through the development of teaching materials. According to Mahmud (2023), teaching materials based on local wisdom can increase learning interest and strengthen cultural identity, thereby shaping student character. Teaching materials designed by teachers and often used

in learning are student worksheets (LKPD). LKPD are sheets containing activities for students to carry out in real-life activities with the objects and problems being studied (Hairani & Setiawan, 2022). The use of LKPD can make learning more effective and efficient because they contain assignments that have been prepared in accordance with the learning objectives that must be achieved (Cahyani et al., 2024; Rukmanah et al., 2022). Based on interviews with biology teachers at SMA Negeri 1 Kampar Timur, the application of conventional biotechnology concepts based on local wisdom in biology learning has never been implemented, and student worksheets (LKPD) based on local wisdom have never been designed. The products students have created through practical activities on biotechnology include tape, donuts, and tempeh. Therefore, it is necessary to develop LKPDs that highlight local wisdom to facilitate students in the learning process of conventional biotechnology material. One local wisdom based on fermentation is known by the local community as bekasam.

Bekasam, also known as wadi, is fermented fish mixed with a carbohydrate source and salt in a sealed container for a period of time (Wikandari et al., 2012). Common carbohydrate sources used are roasted rice, white rice, or sticky rice tape (Lestari et al., 2018). Currently, the younger generation tends to be unfamiliar with bekasam. Therefore, bekasam can be reintroduced as part of local local wisdom through biology learning within the kurikulum merdeka. In making bekasam, the people of Kampar generally use freshwater fish such as catfish or snakehead fish. Both types of fish are commonly used because they are abundant and easy to obtain. In addition to these two types of fish, another type of fish that is also commonly found in the Kampar River is the seluang fish. Seluang fish (*Rasbora argyrotaenia* Blkr) is a freshwater fish with a small but slender and long body, slightly flattened on the belly but slightly bulging on the back, thin scales, and a yellowish-white color. Unlike catfish and snakehead fish, which have thick flesh, seluang has a type of flesh that tends to be thin. Despite this, it is abundant, easy to find, and has a fairly high nutritional content, making it an alternative type of fish in making bekasam. The use of different types of fish will produce different numbers of Lactic Acid Bacteria (LAB) and will affect the microbiological, sensory, and chemical properties of the resulting product (Arfianty et al., 2017; Koesoemawardani et al., 2013).

To produce high-quality bekasam from seluang fish, research is needed to determine the appropriate salt concentration and fermentation time. This is because local people have never used small fish like seluang fish to make bekasam. This study focuses on developing a student worksheet (LKPD) for the conventional biotechnology in grade X senior high school, using findings from research on the effects of salt concentration and fermentation duration on bekasam made from seluang fish. Unlike previous studies that mainly examined the quality aspects of bekasam, this work applies its research result to create an instructional tool, providing a novel contribution both to learning material development and to the study of bekasam seluang fermentation.

2. Methodology

Research Design

This research involved experimental activities in making seluang fish bekasam and designing Student Worksheets (LKPD). This research was conducted at the PMIPA Laboratory, Faculty of Teacher Training and Education, University of Riau, from September 2024 to February 2025. For making bekasam from seluang fish, the first factor was variation in salt concentration, while the second factor was fermentation time. This quantitative study used a 3x3 factorial RAL experiment with three replications, resulting in a total of 27 treatments. Parameters observed in this study included organoleptic tests (color, aroma, texture, and taste) and hedonic tests (level of preference). To design LKPD, the ADDIE model is used, which consists of the analysis, design, and development stages.

Tools and Materials

The required ingredients were : seluang fish (*Rasbora argyrotaenia* Blkr), salt, roasted rice, and asam kandis. The tools used were : jars, knives, scales, blenders, frying pans, spatulas, basins, label paper, organoleptic score sheets, and stationery

Procedure

The research procedure for making bekasam is: 1) Fresh seluang fish are cleaned of the stomach contents, scales and gills using running water; 2) 250 grams of clean fish were weighed for each treatment and put into a basin to add 12.5 grams of asam kandis and salt according to the treatment (15%, 20% and 25%); 3) The salted fish is then mixed with the prepared roasted rice. The fish is coated with roasted rice until the entire surface of the fish is evenly coated; 4) The fish that has been mixed with salt and roasted rice is put into a jar and closed tightly so that it is airtight. Then fermented for 5, 10, and 15 days.

Meanwhile, the procedure for designing LKPD uses the ADDIE development model but is limited to the analysis, design, and development stages. The analysis stage includes analyzing the curriculum, learning materials, and student needs; the design stage includes designing Alur Tujuan Pembelajaran, teaching modules, assessment instruments, and LKPD; while the development stage includes the development and validation of LKPD by material experts and media experts.

Data Collection and Analysis Techniques

Data collection in this study was conducted through organoleptic and hedonic observations of seluang fish bekasam. Assessments were conducted by 10 panelists using an organoleptic and hedonic score sheet on a 1-4 scale. The collected data were then analyzed descriptively. For the LKPD design, validation was conducted using a validation sheet on a 1-4 scale, covering the material (content suitability, presentation suitability, and language) and media (size, cover design, and content design).

3. Result anda Discussion

Organoleptic and Hedonic Testing

Organoleptic testing is a subjective method that uses the human senses as the primary means of assessing food acceptability. Organoleptic testing is conducted using a score sheet on a scale of 1-4. The criteria assessed are color, aroma, texture, and taste.

a. Organoleptic Color

Color can reflect the taste of a food because it appears first and often determines consumer acceptance of a product. The average results of the organoleptic color test for bekasam seluang fish are shown in Table 1 below:

Table 1. Organoleptic Test Results for Seluang Fish Bekasam Color

Treatment (Salt Concentration (%) dan fermentation (days))	Favorability	
	Mean	Criteria
P1T1 (15 and 5)	2,6	Good color but uneven (Dark Brown)
P2T1 (20 and 5)	2,5	Good color but uneven (Dark Brown)
P3T1 (25 and 5)	2,5	Good color but uneven (Dark Brown)
P1T2 (15 and 10)	2,4	Slightly dull color (Light Brown)
P2T2 (20 and 10)	2,3	Slightly dull color (Light Brown)
P3T2 (25 and 10)	2,3	Slightly dull color (Light Brown)
P1T3 (15 and 15)	2,5	Good color but uneven (Dark Brown)
P2T3 (20 and 15)	2,4	Slightly dull color (Light Brown)
P3T3 (25 and 15)	2,3	Slightly dull color (Light Brown)

(P = Salt Concentration, T = Fermentation Time)

It is known that the color produced in the treatment is a slightly dull color (light brown) and a good but uneven color (dark brown), so it is known that the color of all treatments has met the bekasam standard, which is yellowish. The brown color of the bekasam seluang fish is influenced by the use of roasted rice as a source of carbohydrates which is blackish brown due to roasting, the roasted rice is absorbed into the fish's body so that the bekasam is also brown. Bekasam with little salt tends to be dark brown, while bekasam with high salt is lighter in color. This is because high salt can denature the protein structure that forms the color pigment, causing the color to be unstable or fade. According to Marantika et al. (2020) the more salt added, the color of the bekasam will fade because salt can fade the original color of the fish. The longer the fermentation time, the less brown the bekasam color will be because during the fermentation process chemical and microbiological changes.

b. Organoleptic Aroma

Bekasam has a distinctive aroma resulting from the fermentation process. The results of the organoleptic aroma test for bekasam seluang fish are as shown in Table 2 below:

Table 2. Result of The Organoleptic Aroma Test for Bekasam Seluang Fish

Treatment (Salt Concentration (%) dan fermentation (days))	Favorability	
	Mean	Criteria
P1T1 (15 and 5)	2,3	It has a typical Bekasam aroma but not too strong.
P2T1 (20 and 5)	2,3	It has a typical Bekasam aroma but not too strong.
P3T1 (25 and 5)	2,6	It has a typical Bekasam aroma and the aroma is starting to become strong
P1T2 (15 and 10)	3,5	It has a typical Bekasam aroma and the aroma is very strong
P2T2 (20 and 10)	3,7	It has a typical Bekasam aroma and the aroma is very strong
P3T2 (25 and 10)	3,5	It has a typical Bekasam aroma and the aroma is very strong
P1T3 (15 and 15)	3,6	It has a typical Bekasam aroma and the aroma is very strong
P2T3 (20 and 15)	3,5	It has a typical Bekasam aroma and the aroma is very strong
P3T3 (25 and 15)	3,6	It has a typical Bekasam aroma and the aroma is very strong

(P = Salt Concentration, T = Fermentation Time)

The resulting aroma is known to be a typical bekasam aroma but not too strong, a typical bekasam aroma with a starting strong aroma, and a typical bekasam aroma with a very strong aroma. All treatments have met the quality requirements for bekasam, namely a sour aroma and a typical fermentation. It is known that a salt concentration that is not too high and a long fermentation time will produce a sour aroma because there is an increase in total acid so that the pH will be acidic/low. The sour aroma appears due to a decrease in pH and an increase in total acid. Fermentation breaks down carbohydrates into simple compounds such as lactic acid, propionic acid, and ethanol, thus creating a sour taste and acting as a natural preservative. According to Rahmawati et al. (2021), this is caused by the presence of organic acid compounds formed from fermentation by Lactic Acid Bacteria (LAB). This is also in line with research by Gania et al. (2023), the longer the fermentation time and the lower the salt concentration, the more sour the aroma.

c. Organoleptic Texture

Texture is the sensation experienced through the mouth (taste) or through the fingers (touch). The results of the organoleptic texture test of seluang fish bekasam can be seen in Table 3 below.

Table 3. Organoleptic Test Result for Seluang Fish Bekasam Texture

Treatment (Salt Concentration (%) dan fermentation (days))	Favorability	
	Mean	Criteria
P1T1 (15 and 5)	1,6	The fish is slightly shrunken and somewhat soft
P2T1 (20 and 5)	1,6	The fish is slightly shrunken and somewhat soft
P3T1 (25 and 5)	1,8	The fish is slightly shrunken and somewhat soft

P1T2 (15 and 10)	2,5	The fish is shrunken and somewhat soft
P2T2 (20 and 10)	3,4	The fish is shrunken and somewhat soft
P3T2 (25 and 10)	3,1	The fish is shrunken and somewhat soft
P1T3 (15 and 15)	3,3	The fish is shrunken and somewhat soft
P2T3 (20 and 15)	3,2	The fish is shrunken and somewhat soft
P3T3 (25 and 15)	3,1	The fish is shrunken and somewhat soft

(P = Salt Concentration, T = Fermentation Time)

The texture of food is greatly influenced by its water content. Using high concentrations of salt will cause water to escape from the meat. Salt has a high osmotic pressure, drawing water from the fish flesh and fluid from microbial cells, resulting in plasmolysis and microbial cell death. Salt also triggers coagulation and denaturation of proteins and enzymes, leading to shrinkage of the fish flesh, squeezing out water (Puspita et al., 2019). The resulting texture, which is softened, is influenced by the length of fermentation. The longer the fermentation, the less dense the resulting structure. This change is caused by Lactic Acid Bacteria (LAB), which break down proteins, thus affecting the structure of the fish flesh (Junianto et al., 2024). With the help of salt, the texture of fish can be improved because salt strengthens the tissue structure, making the meat compact and not disintegrating. Higher salt concentrations can harden the structure of the fish flesh, making it less easily disintegrated (Aulia et al., 2018).

d. Organoleptic Taste

Taste is a key factor in determining whether a product is acceptable. According to Rinto et al. (2022), bekasam contains the amino acid glutamic acid, which plays a key role in the development of a savory or umami flavor. The results of the organoleptic test for the taste of bekasam seluang fish are summarized in Table 4 below:

Table 4. Result of The Organoleptic Test for Bekasam Seluang Fish Flavor

Treatment (Salt Concentration (%) dan fermentation (days))	**Favorability**	
	Mean	**Criteria**
P1T1 (15 and 5)	2,4	A bit savory
P2T1 (20 and 5)	3,0	Tasty
P3T1 (25 and 5)	3,1	Tasty
P1T2 (15 and 10)	3,5	Very tasty
P2T2 (20 and 10)	3,7	Very tasty
P3T2 (25 and 10)	3,6	Very savory
P1T3 (15 and 15)	3,5	Very savory
P2T3 (20 and 15)	3,5	Very savory
P3T3 (25 and 15)	3,5	Very savory

(P = Salt Concentration, T = Fermentation Time)

Bekasam with a high salt concentration tends to be less popular because it tastes too salty and too sour. However, if the salt concentration is too low, the product may be less durable. Therefore, the panelists preferred treatment with a 20% salt concentration. During fermentation, flavor changes occur due to the breakdown of carbohydrates, fats, and proteins into simple compounds, resulting in bekasam's distinctive salty, sour, and savory flavor. The salty taste of bekasam is caused by

salt. Salt functions not only to select unwanted bacteria but also to impart a salty flavor to bekasam (Waty et al., 2019). The sour taste is produced by the activity of Lactic Acid Bacteria (LAB), which produce lactic acid. Carbohydrates that are broken down into simple compounds such as ethyl alcohol, lactic acid, and propionic acid give the product a sour taste and function as a preservative (Mahadi et al., 2024).

e. Hedonic Test

The hedonic test aims to determine the panelists' overall level of preference for seluang fish bekasam. The hedonic scale used was transformed into a numeric scale ranging from lowest to highest, with the criteria being dislike, somewhat like, like, and very much like. The results of the hedonic quality test for seluang fish bekasam are shown in Table 5 below:

Table 5. Hedonic Test Results for Seluang Fish Bekasam

Treatment (Salt Concentration (%) dan fermentation (days))	Favorability	
	Mean	Criteria
P1T1 (15 and 5)	2,7	Like
P2T1 (20 and 5)	2,7	Like
P3T1 (25 and 5)	2,6	Like
P1T2 (15 and 10)	3,6	Like Very Much
P2T2 (20 and 10)	3,8	Like Very Much
P3T2 (25 and 10)	3,0	Like
P1T3 (15 and 15)	3,5	Like Very Much
P2T3 (20 and 15)	3,3	Like
P3T3 (25 and 15)	2,8	Like

(P = Salt Concentration, T = Fermentation Time)

Treatment P2T2 (20% salt and 10 days) with a preference level of "like very much" had the highest average. While P3T1 (25% salt and 5 days) with a preference level of "like" had the lowest average of all treatments. These results indicate that the 20% salt concentration with a fermentation period of 10 days was preferred by the panelists of seluang fish bekasam because it had a better aroma, color, texture, and taste than the other treatments, although the color was less brownish but still attractive in terms of appearance.

Potential Analysis and Development of Student Worksheet Design

a. Analysis Stage

This stage includes an analysis of the curriculum and learning materials. The process begins with a review of the independent curriculum for high school level, specifically the Learning Outcomes (CP) Phase E in biology relevant to the topic of biotechnology. Next, the Learning Objectives (TP) are analyzed to form a Learning Objective Flow (ATP). Then, a teaching module, assessment instruments, and Student Worksheets (LKPD) are designed for the seluang fish bekasam activity. The results of the analysis are shown in Table 6 below:

Table 6. Analysis of Materials to be Developed into LKPD Research Results

Learning Outcomes	Class	Material/Sub Material	Learning Goals	Meeting
Students understand the classification process of living things; the role of viruses, bacteria, and fungi in life; ecosystems and the interactions between components and their influencing factors; and **the use of biotechnology in various areas of life.** Students understand measurement systems in scientific work; alternative energy sources and their use to address energy availability issues. Students understand atomic structure and its relationship to the properties of elements in the periodic table; and chemical reactions, the basic laws of chemistry, and their role in everyday life. Students apply their understanding of science to address issues related to climate change	X	Coventional biotechnology / Conventional Biotechnology Product	10.3.4 Students are able to make biotechnology-based food products through experiments in making seluang fish paste 10.3.5 Students are able to present the results of the practical work on making seluang fish bekasam in the form of a report.	2 and 4

b. Design Stage

To design the Student Worksheet (LKPD), the LKPD format according to Prastowo (2019) was used, namely:

1. Cover

The cover is presented attractively with a choice of turquoise, yellow, and orange colors. It contains information describing the contents of the Student Worksheet (LKPD): the title of the LKPD, information about the material and class, images of seluang fish (*Rasbora argyrotaenia* Blkr) and bekasam that made from seluang fish, and the names of the compiler and the two supervisors are listed in the center left corner of the cover (Figure 1).

Figure 1.LKPD Cover Design

2. Identity

Identity is the section that provides information regarding the LKPD, which consists of the following components:

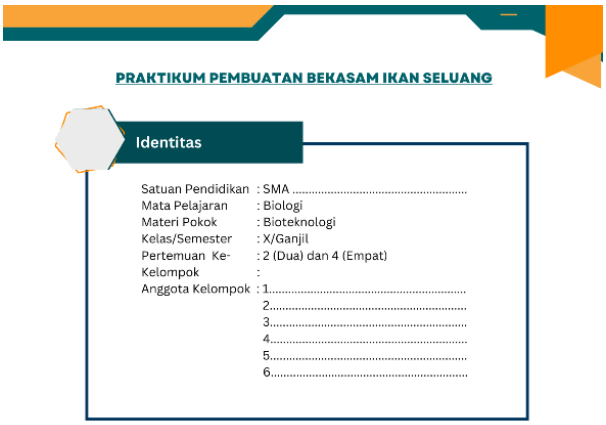

Figure 2. LKPD Identity Design

3. Objectives

Objectives are points that students must achieve during learning. The objectives in the Student Worksheet are listed as in Figure 3.

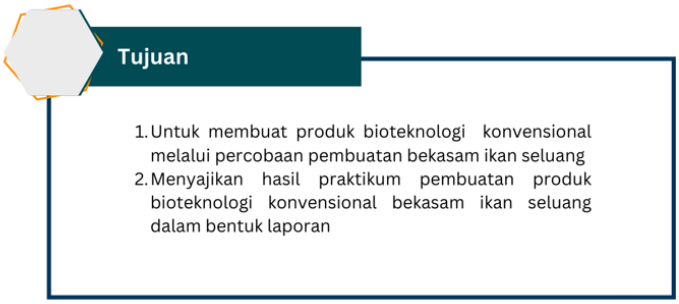

Figure 3. Design Objectives

4. Discourse

The discourse contains background information about the material to be studied, including supporting information relevant to the learning activities. The discourse contained in the Student Worksheet (LKPD) can be seen in Figure 4 below.

Figure 4. Discourse Design

5. Learning Resources

Learning resources are sources of information that students can use as references to complete the assignments provided in the Student Worksheet (LKPD). The learning resources used in the LKPD can be seen in Figure 5 below:

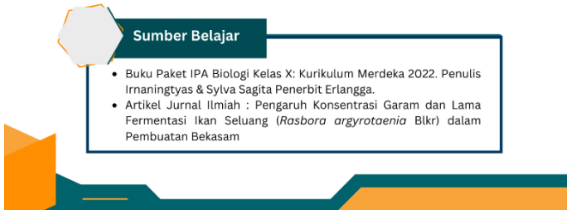

Figure 5. Learning Resource Design

6. Instruction

The instructions contain the steps for students to complete the LKPD. The instructions aim to facilitate students' understanding of how to use the LKPD. The activity instructions are structured procedurally so that students can carry out the practical activities properly and correctly. The design of the instructions can be seen in Figure 6 below

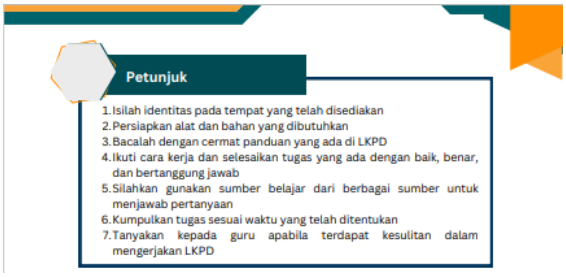

Figure 6. Student Worksheet Instructions Design

7. Tools, Materials, and Methods

Contains what students must prepare and carry out, including tools and materials, methods, and observation results. This can be seen in Figure 7 below:

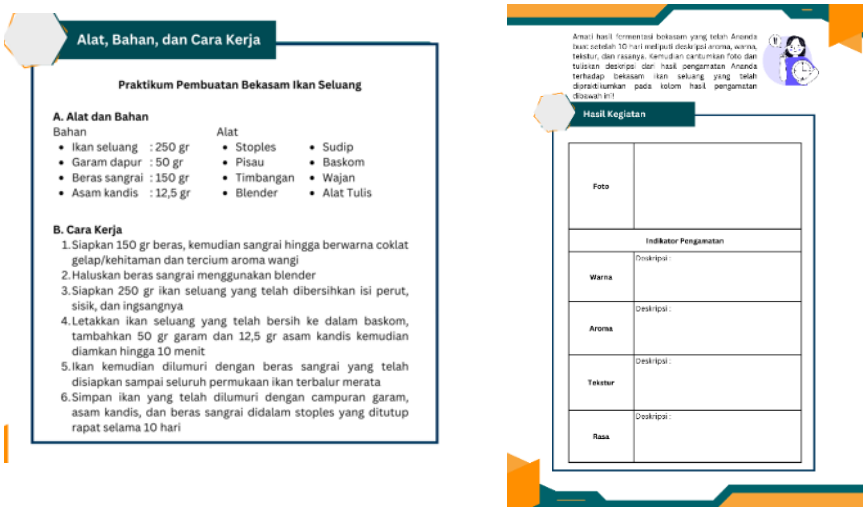

Figure 7. Student Worksheet Learning Activity Design

8. Questions

The questions section (Figure 8) contains questions designed to encourage students to think critically and reflectively about the material they have learned. These questions can also be used as a tool to evaluate student understanding.

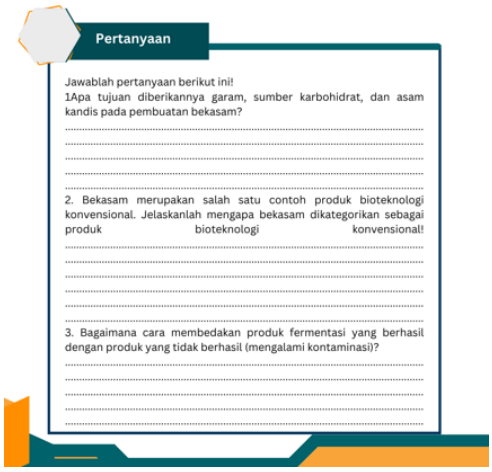

Figure 8. Student Worksheet Question Design

9. Conclusion

The conclusion (Figure 9) summarizes the results of the learning activities. Students can reflect on what they have learned in the space provided.

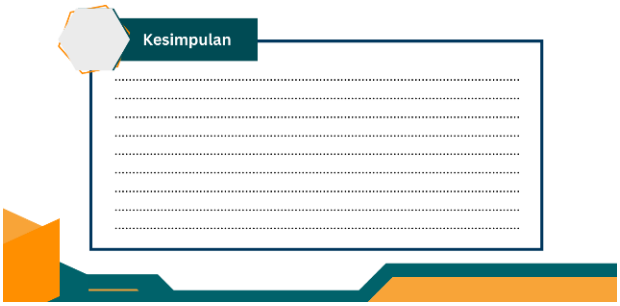

Figure 9. Conclusion Design

c. Development Stage

The final stage is validating the developed product. Validation aims to ensure that the designed Student Worksheet (LKPD) meets the established standards. A product is considered valid if it is adequate and all designed components meet the established criteria (Tika, 2022). Validation results serve as the basis for product improvements and refinements before implementation in the learning process. The results of the validity results from the subject matter experts can be seen in Table 7 below:

Table 7. Percentage Score from Subject Matter Expert Validity Result

Item	Aspect Value	Obtained	Maximum Value	∑ Score	Average	Category
Content Suitability	1	4	4	19	3,80	Very Valid
	2	4	4			
	3	4	4			
	4	3	4			
	5	4	4			

Presentation Suitability	1	4	4	15	3,75	Very Valid
	2	4	4			
	3	3	4			
	4	4	4			
Language	1	4	4	19	3,80	Very Valid
	2	4	4			
	3	4	4			
	4	3	4			
	5	4	4			
Total					11,35	Very Valid
Average					3,78	

Based on Table 7, the validation results for the LKPD material across all three aspects were 3.78. This score falls into the very valid category, meaning the material presented in the LKPD meets the eligibility standards. The results of the media expert's validation are shown in Table 8 below:

Table 8. Percentage Score from Media Expert Validity Result

Item	Aspect Value	Obtained	Maximum Value	∑ Score	Average	Category
Learning Material Size	1	4	4	8	4	Very Valid
	2	4	4			
Learning Material Cover Design	1	4	4	20	4	Very Valid
	2	4	4			
	3	4	4			
	4	4	4			
	5	4	4			
LKPD Content Design	1	4	4	27	3,86	Very Valid
	2	4	4			
	3	4	4			
	4	3	4			
	5	4	4			
	6	4	4			
	7	4	4			
Total					11,86	Very Valid
Average					3,95	

Based on Table 8, the validation results of the LKPD media were obtained from the aspects of the size of the teaching materials, the design of the teaching materials cover, and the design of the LKPD content of 3.95 (Very valid). According to Tika (2022), LKPD is said to be valid if the three requirements (construction requirements, didactic requirements, and technical requirements) obtain a validity score percentage of ≥75%. This means that the designed LKPD is in accordance with the learning media standards and can be used as teaching materials for conventional biotechnology material for class X.

4. Conclusion

Based on the results of the study, it can be concluded that salt concentration and fermentation time affect the quality of bekasam seluang fish (*Rasbora argyrotaenia*

Blkr) in terms of organoleptic and hedonic. Bekasam seluang fish with a salt concentration of 20% and a fermentation time of 10 days (P2T2) is the best treatment and most preferred by the panelists, namely a rather dull color (light brown), has a typical Bekasam aroma and a very strong aroma, the fish is shrunken and somewhat soft texture, the taste is very tasty, and the level of preference is like very much. Then, the design of the Student Worksheet (LKPD) from the study of the Effect of Salt Concentration and Fermentation Time of Seluang Fish in Making Bekasam Seluang Fish (*Rasbora argyrotaenia* Blkr) is very valid and can be used as an alternative teaching material in conventional biotechnology learning.

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How to cite this article:

Febrina, H., Mahadi, I., & Syafi'i, W. (2025). Development of Student Worksheet (LKPD) on Conventional Biotechnology Material for Grade X of Senior High School Through Bekasam Fermentation as Local Wisdom. *Journal of Educational Sciences*, *9(6)*, 6570-6584.