



Lectora Inspire: Boosting environmental awareness with chicken bone cracker e-module

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ABSTRACT

Green skills are skills needed by students to support sustainable development goals. Environmental awareness and innovation skills, which are parts of green skills, have become essential competencies for participants of the Agribusiness in Agricultural Product Processing (APHP). The enhancement of environmental awareness and innovation skills can be achieved through the learning process using instructional media. The instructional media developed in this study is an e-module based on Lectora Inspire. This research aims to determine the suitability of the e-module for chicken bone cracker processing based on Lectora Inspire, to assess the environmental awareness and innovation skills of the learners. The development of this e-module follows the ADDIE model (Analyze, Design, Development, Implementation, and Evaluation) and employs a pre-experimental design method with a one-group pretest-posttest design during its implementation. The research findings indicate that the e-module is considered "highly suitable" for use, as validated by subject matter experts, language experts, media experts, and learner responses. The results show that the learners' environmental awareness, as measured by average scores, has increased from the "low" to the "high" category using the e-module. Similarly, the learners' innovation skills, as measured by average scores, have improved from the "high" to the "very high" category.

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ABSTRAK

Green skills merupakan keterampilan yang dibutuhkan oleh peserta didik untuk mendukung tujuan pembangunan berkelanjutan. Environmental awareness dan innovation skill yang merupakan bagian dari green skills menjadi salah satu skill yang harus dimiliki oleh peserta didik APHP. Peningkatan environmental awareness dan innovation skill dapat dilakukan melalui proses pembelajaran dengan bantuan media pembelajaran. Media pembelajaran yang dikembangkan pada penelitian ini adalah e-modul berbasis Lectora Inspire. Tujuan penelitian ini adalah untuk mengetahui kelayakan e-modul pengolahan kerupuk tulang ayam berbasis Lectora Inspire, mengetahui environmental awareness dan innovation skill peserta didik. Pengembangan e-modul ini menggunakan model ADDIE (Analyze, Design, Development, Implementation, dan Evaluation) dan menggunakan metode pre-eksperimental design dengan rancangan one group pretest-posttest design pada penerapannya. Hasil penelitian menunjukkan bahwa e-modul dinyatakan "sangat layak" digunakan berdasarkan hasil validasi ahli materi, ahli bahasa, ahli media, serta respon peserta didik. Hasil environmental awareness peserta didik dengan e-modul mengalami peningkatan "sedang" berdasarkan uji n-gain dan hasil innovation skill peserta didik mengalami peningkatan "tinggi" berdasarkan uji n-gain.

Kata Kunci: e-module; kema kepekaan lingkungan; kerupuk tulang ayam; lectora inspire

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INTRODUCTION

Kurikulum Merdeka is a curriculum concept based on the Sustainable Development Goals (SDGs) currently implemented in vocational high schools (SMK), which emphasizes student independence. Education for *Pembangunan Berkelanjutan* or Education for Sustainable Development (ESD) one of the goals in the sustainable development agenda or SDGs, is built upon three fundamental pillars: environmental sustainability, economic progress, and the socio-cultural aspects of society (Mulyadi *et al.*, 2023). In fulfilling the SDGs, particularly in the areas of quality education and environmental sustainability, various stakeholders—from the government to academics—have initiated programs often prefixed with the word “green,” which denotes environmental friendliness. One such initiative is green skills. Green Skills refer to the competencies required to adapt products, services, and processes to be environmentally friendly, as outlined in the OECD Green Growth Studies published in 2014 under the title “Greener Skills and Jobs” (see: https://read.oecd-ilibrary.org/industry-and-services/greener-skills-and-jobs_9789264208704-en#page5).

Agribusiness in agricultural product processing, or APHP, is one of the skill spectrums operating in the field of food processing and contributes to the achievement of the SDGs. The APHP expertise program is expected to develop and optimize new food processing products in accordance with the potential possessed by the school. However, food processing at SMKN 5 Pangalengan only covers the production process from raw materials to finished products, without considering the potential for sustainable processing. The low level of understanding and green skills among students is one of the causes of this issue. This is supported by a study which states that green skills competencies among vocational students in SMK APHP—specifically in waste management as a form of technological mastery, communication skills as interpersonal competencies, and innovation skills as intrapersonal competencies—are still categorized as weak (Handayani *et al.*, 2020). Environmental awareness and innovation skills, which are components of green skills, are essential skills that must be possessed by APHP students. Environmental awareness and innovation skills help students develop attitudes and readiness to learn about sustainable development by addressing current environmental issues and challenges. Students are expected to identify opportunities to create new strategies in response to greening challenges (Pavlova, 2011).

Waste management in agricultural product processing is one of the elements in the *Kurikulum Merdeka* for SMK APHP, serving as a method to address waste generated from food production processes—such as chicken bone waste, a by-product from meatball production in the animal-based processed product element. One example of utilizing chicken bones is in the production of crackers. Crackers is a snack product made from a dough of tapioca flour with the addition of other permitted food ingredients (Rizki *et al.*, 2018). Crackers is a popular snack among all segments of society in Indonesia and is often consumed as a light bite or as a side dish complement.

Innovation is necessary to enhance motivation and effectiveness in learning, whether through media, learning resources, strategies, or teaching methods (Handayani *et al.*, 2021; Ghifari *et al.*, 2022; Suwandi *et al.*, 2022). Based on interviews with APHP teachers at SMKN 5 Pangalengan, there are currently no learning resources or instructional media available for the Waste Management in Agricultural Product Processing element. Therefore, it is essential

to develop teaching materials that emphasize food processing based on the waste management hierarchy, aimed at sharpening students' environmental awareness and innovation skills, using chicken bone crackers processing as an example. One form of instructional media that can be utilized is an electronic module (e-module) as an innovative approach. The type of e-module developed by the researcher as a learning medium is an application supported by Lectora Inspire. In one study, based on descriptive data analysis, conclusions drawn from the evaluation of E-Module media based on the Lectora Inspire application and student responses from previous studies on E-Module development using Lectora Inspire indicate that the media is highly suitable as a learning tool. This highlights the importance of using E-Modules with the Lectora Inspire application to evaluate other aspects of classroom learning (Kusuma & Mahardi, 2021). This becomes a crucial point and should be considered in this research, as it provides an overview of e-modules that can later be applied beyond the educational context, thereby fostering awareness and skill development among students to utilize agricultural waste media.

LITERATURE REVIEW

E-Module

A module can be defined as a written learning tool arranged systematically, containing material, methods, learning objectives, activity instructions, and exercises for students to self-assess. The use of modules in the learning process can activate students, making learning no longer centered on the instructor. In efforts to produce modules that enhance learning motivation, the module must consider several essential characteristics: Self Instructional, Self Contained, Stand Alone, Adaptive, and User Friendly (Syela & Prabawati, 2022). Meanwhile, an e-module is a digital module that may consist of text, images, audio, or animations, accessible via computers or other digital reading devices (Handayani *et al.*, 2023; Efendi & Untari, 2022). As a learning medium, e-modules offer advantages in improving the effectiveness and flexibility of learning without being bound by space and time. They can make the learning process more engaging through various interactive features, as conveyed by Triyono in 2021 in his book titled "*Dinamika Penyusunan E-modul*".

Lectora Inspire

Lectora Inspire is a computer program that serves as a tool in electronic learning (*e-learning*), developed by Trivantis Corporation in 1999 in the United States. Lectora Inspire includes numerous features that support educational needs, as it is used to develop digital teaching content in the form of interactive multimedia. It is user-friendly and high-quality, without requiring expertise in art or graphic design (Alwi *et al.*, 2022). Lectora Inspire is an application similar to Microsoft PowerPoint but offers more comprehensive content. It includes several menus that facilitate users in creating interactive learning media, such as menus for directly adding buttons to the learning media, menus for creating evaluation questions with various options, menus for editing images, videos, and animations within the learning media, and a wide range of templates as foundational elements for instructional design (Anharuddin & Prastowo, 2023).

Waste Management in Agricultural Product Processing

Waste management in agricultural product processing is one of the elements in Phase F of the compulsory subject for the APHP specialization. The first step in reducing food waste is to establish ambitions and actions for governments and companies to set food waste reduction targets in accordance with SDGs 12.3, based on the report "SDG Target 12.3 On Food Loss And Waste: 2019 Progress Report" (see: <https://champions123.org/sites/default/files/2020-09/champions-12-3-2019-progress-report.pdf>). The concept of *waste hierarchy* can be used to manage waste. This concept was first introduced in 1975 through the European Union's *Arahan Kerangka Kerja Limbah 15* policy, based on the regulation Directive 2008/98/EC of the European parliament and of the council of 19 November 2008 on waste and repealing certain directives, accessible <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098>. The waste hierarchy concept published by UNEP in the document titled "Mercury—Time to Act" outlines five actions (see: http://www.unep.org/PDF/PressReleases/Mercury_TimeToAct.pdf): 1) Waste prevention (Prevention), 2) Reduction, 3) Recycling, 4) Recovery, and 5) Disposal.

Crackers

Crackers is a dry material in the form of thin sheets made from a dough whose main ingredient is starch. Various starchy materials can be processed into crackers, including cassava, sweet potatoes, rice, sago, wheat flour, tapioca, and taro. Products categorized as crackers have long been known to the Indonesian public, both in traditional forms and industrial-scale production, such as fish crackers, shrimp crackers, cassava crackers, skin crackers, or *rambak* crackers (Danil *et al.*, 2022). The raw materials used in crackers production are divided into two groups: main raw materials and additional raw materials. Main raw materials are those used in large quantities and whose function cannot be replaced by other ingredients, such as tapioca flour or sago flour. Additional raw materials include auxiliary ingredients and flavor enhancers. In general, the ingredients used in crackers production will influence the characteristics of the final product (Anggraeni *et al.*, 2020). In the crackers production process, starch must undergo gelatinization due to the addition of water and heat treatment applied to the formed dough. Starch is composed of at least three main components: amylose, amylopectin, and protein, along with a small amount of fat referred to as intermediate material **Table 1**.

Table 1. Quality Standards for Crackers

Test criteria	Unit	Requirements for non-protein crackers	Requirements for protein crackers
Smell, taste, color	-	Normal	Normal
Foreign object	%b/b	Not real	Not real
Ash	%b/b	Maks 2	Min 5
Water	%b/b	Maks 12	Min 5

Test criteria	Unit	Requirements for non-protein crackers	Requirements for protein crackers
Proteins	%b/b	-	Min 5

Source: SNI 0272-1990

Chicken Bones

Chicken bones are food waste materials commonly found in community environments. Until now, *chicken bones* have been considered to have low economic value, making them rarely utilized or even completely neglected. *Chicken bones* are one of the waste products generated from *rumah potong ayam* (RPA), with a considerable volume of waste. According to data from the *Direktorat Jenderal Peternakan dan Kesehatan Hewan, Kementerian Pertanian Republik Indonesia*, the estimated population of broiler chickens in Indonesia over five consecutive years was 892 million in 2007, 902 million in 2008, 1 billion in 2009, 987 million in 2010, and 1 billion in 2011 (Fynnisa & Rodiansah, 2019). The highest bone percentage of 30.27% was found in chickens weighing between 851–1050 grams, while the lowest average of 22.49% was recorded in chickens weighing between 1,451–1,700 grams (Patriani & Hafid, 2019). Poorly managed chicken bone waste tends to accumulate and end up in *Tempat Pembuangan Akhir* (TPA), which then produces methane gas (CH₄) that can pollute the environment—soil, air, and water—and contribute to global warming (Bennbaia, 2018). The chemical and physical composition of bones can be seen in **Table 2**.

Table 2. Chemical and Physical Composition of Bones

Compound	Composition
Gelatin	33,3%
Calcium carbonate	3,85%
Calcium phosphate	57,35%
Magnesium phosphate	2,05%
Sodium carbonate	3,45%
Specific gravity	1,9 g/cm ³
Tensile strength	20000 lb/in ²
Compressive strength	15000 lb/in ²

Source: Septriansyah in the research entitled "Kajian Proses Pembuatan Gelatin dari Hasil Ikutan Tulang Ayam dalam Kondisi Asa"

The composition of the chicken skeleton bones of animals can be seen in **Table 3**.

Table 3. Composition of Chicken Bones Animal Skeleton

Components	Content (%)
Water	1,8 - 44,3
Fat	1,2 - 26,9
Collagen	15,8 - 32,8
Inorganic substances	28 -56,3

Source: Retno (2012)

Environmental Awareness and Innovation Skill

Environmental awareness and innovation skill are components of green skills. Green skills (GS) have become one of the most widely discussed topics globally, especially in the development of industrial demand related to green jobs—environmentally friendly and sustainable occupations. This is closely tied to the skills needed to operate and develop green technology (Fitriyanto *et al.*, 2020). Concern for the environment, or environmental awareness, can be effectively instilled through education in schools. Education significantly influences human physical development, mental faculties (intellect, emotion, and will), social behavior, and morality, and serves as the most important tool for self-preservation and maintaining positive values. The percentage of environmental awareness among students in schools is only at 53.95%, which falls into the “moderate” category (Jumirah *et al.*, 2021). The indicators of environmental awareness include understanding environmental problems, understanding solutions to environmental problems, caring about environmental issues, and having habits that support environmental preservation (Handayani *et al.*, 2020).

Meanwhile, innovation is defined as changes made within an organization that involve creativity in generating new products, services, ideas, or processes—either those already existing within the organization or those developed externally (Nugraha, 2020). Innovation itself has become a national agenda, as stated in *Undang-Undang Nomor 18 Tahun 2002 tentang Sistem Nasional Penelitian, Pengembangan, dan Penerapan Ilmu Pengetahuan dan Teknologi*. In article 1 point 9, it is stated that “*Inovasi adalah kegiatan penelitian, pengembangan dan/atau perekayasaan yang bertujuan mengembangkan penerapan praktis nilai dan konteks ilmu pengetahuan yang baru, atau cara baru untuk menerapkan ilmu pengetahuan dan teknologi yang telah ada ke dalam produk atau proses produksi*”. The inadequate management of waste or garbage necessitates improved handling efforts compared to previous practices. As outlined in *Pasal 3 Undang-Undang Nomor 32 Tahun 2009 tentang Perlindungan dan Penanganan Lingkungan Hidup (PPLH)*, one of the objectives of environmental management is to achieve sustainable development, including in the area of waste management. The indicators of innovation skill include identifying opportunities to support green growth, developing creative strategies to promote green growth, and proposing innovative solutions to address environmental problems (Handayani *et al.*, 2020).

METHODS

The product developed in this study is an e-module chicken bone crackers using the Lectora Inspire application, aimed at enhancing environmental awareness and innovation skill among students. The method used in this research is the Research and Development method, which is employed to produce a specific product and test its effectiveness. The development model applied in this study is the ADDIE model, which consists of five steps: Analyze, Design, Development, Implementation, and Evaluation. The implementation of the e-module was carried out using a pre-experimental design with a one-group pretest-posttest technique. This research was conducted at SMKN 5 Pangalengan, with research subjects consisting of 31 students from class XII APHP during the development phase and 30 students from class XI APHP during the implementation phase. The instruments used in this study

include a validation sheet, student response sheet, and objective tests (pretest-posttest). The results of the pretest-posttest improvement were analyzed using the n-gain test, based on the formula found in Sugiyono's book "*Metode Penelitian Kuantitatif, Kualitatif dan R&D*" as follows:

$$g = \frac{\text{Skor posttest} - \text{skor pretes}}{\text{skor maksimum} - \text{skor pretes}}$$

RESULTS AND DISCUSSION

E-Module Development

This study produced an e-module for processing chicken bone crackers under the Waste Management in Agricultural Product Processing element, using the Lectora Inspire platform. The e-module was developed based on the challenges currently faced by students. The product was designed to facilitate student learning and enhance their environmental awareness and innovation skill. Based on interviews with relevant teachers and observations of student conditions and capabilities in processing chicken bone crackers, it was found that the Waste Management in Agricultural Product Processing element lacked instructional media and practical worksheets. Additionally, students—especially those in class XI—prefer gadget-based learning. Therefore, an electronic learning medium containing practical worksheets in the form of an e-module is needed.

The development phase began with creating the e-module, which includes material on waste and practical worksheets. The e-module was compiled using the Lectora Inspire 17 application. Before being implemented with students, the e-module was validated by subject matter experts, media experts, and language experts. Validation was conducted using a rating scale from 1 to 4.

Validation by subject matter experts covered aspects such as alignment with learning outcomes, material accuracy, and material relevance. The results of the material validation are presented in **Table 4**.

Table 4. Results of Subject Matter Expert Validation

Aspect	Score	Interpretation (%)	Category
Alignment with learning outcomes	4	100	Highly feasible
Material accuracy	3,4	85	Highly feasible
Material relevance	3,5	87,5	Highly feasible
Average	3,63	90,83	Highly feasible

Source: Research 2023

Based on the total score from the material validation results, the percentage interpretation was 90.83%, which falls into the "highly feasible" category. The highest-rated aspect was alignment with learning outcomes, as BNSP establishes this indicator as a key requirement

in the development of learning resources. The presentation of material must be aligned with the formulated indicators to provide direction in developing effective learning content that suits the characteristics of the subject and the needs of both students and schools (Rahmawati *et al.*, 2024; Thohari, 2019). The subject matter expert suggested adding trigger question to the e-module and including packaging material. Trigger question are questions used to increase student participation and help them engage with the topic being discussed. In classroom learning activities, *pertanyaan pemantik* are used to activate students' prior knowledge related to the material to be studied. Another crucial point is that the use of *pertanyaan pemantik* can enhance cognitive abilities, including memory, and foster students' courage and skills in answering questions and expressing opinions (Pandu *et al.*, 2023). In addition, the inclusion of packaging material is considered important, given that vocational high school students are being prepared for careers. Therefore, the learning process should cover everything from product creation to making the product ready for sale.

Media validation covered aspects such as design appearance, ease of use, consistency, graphic quality, usefulness, and completeness of the e-module. The results of the media expert validation are presented in **Table 5**.

Table 5. Results of Media Expert Validation

Aspect	Score	Interpretation (%)	Category
Design appearance	3,5	87,5	Highly feasible
Ease of use	3,67	91,67	Highly feasible
Consistency	4	100	Highly feasible
Graphic quality	3,67	91,67	Highly feasible
Usefulness	3,33	83,33	Highly feasible
Completeness of E-module	4	100	Highly feasible
Average	3,69	92,36	Highly feasible

Source: Research 2023

Based on the total score from the media validation results, the percentage interpretation was 92.36%, which falls into the "highly feasible" category. The media expert provided suggestions regarding consistency in the use of images or illustrations. In developing instructional media such as this e-module, the selection of illustrations, size, font, and font type must be carefully considered to ensure consistency.

Language validation covered aspects such as clarity, communicativeness, dialogic and interactive quality, alignment with student development, adherence to linguistic conventions, and the use of terms/symbols/icons. The results of the language expert validation are presented in **Table 6**.

Table 6. Results of Language Expert Validation

Aspect	Score	Interpretation (%)	Category
Clarity	4	100	Highly feasible
Communicativeness	4	100	Highly feasible
Dialogic and interactive quality	3,5	87,5	Highly feasible
Alignment with student development	3,5	87,5	Highly feasible
Conformity with linguistic rules	4	100	Highly feasible
Use of terms, symbols, or icons	4	100	Highly feasible
Average	3,83	95,83	Highly feasible

Source: Research 2023

Based on the total score from the language validation results, the percentage interpretation was 95.83%, which falls into the “highly feasible” category. The language used in the e-module must meet standards to ensure that the sentences comply with proper Bahasa Indonesia conventions and do not lead to ambiguous interpretations. Standard sentences use correct structure, spelling, and word choice, enabling the sentence to effectively convey its intended message to the listener or reader (Anwar, 2017).

Before being implemented in class XI APHP, a preliminary implementation was conducted in class XII APHP to assess student responses to the developed e-module, including aspects such as application quality, material presentation, e-module appearance, and usefulness. The results of student responses are presented in **Table 7**.

Table 7. Results of Student Responses

Aspect	Score	Interpretation (%)	Category
Quality of the e-module app	3,29	82,26	Highly feasible
Material presentation	3,39	84,68	Highly feasible
E-module appearance	3,28	82,10	Highly feasible
Usefulness	3,21	80,24	Highly feasible
Average	3,29	82,32	Highly feasible

Source: Research 2023

Based on the table presented above, student responses to the e-module fall into the “very good” category, with an average interpretation of 82.33%. Overall, student responses to the Lectora Inspire-based e-module were positive, categorized as “highly feasible.” At this stage of student response, no suggestions or revisions were provided regarding the e-module application. This indicates student satisfaction with the e-module developed by the

researcher. As a learning medium, the e-module offers advantages in enhancing the effectiveness and flexibility of learning without being bound by space and time. It can make the learning process more engaging through various interactive features, as described by Triyono in his book. The developed e-module also needs to consider the components of student needs, including content, media, and evaluation (Putra, 2024; Dewanty & Farisya, 2023).

Environmental Awareness and Innovation Skill

Implementation was carried out using the Project Based Learning (PJBL) model in accordance with the teaching module that had been developed. The pretest-posttest results were used to measure students' abilities before and after learning with the Lectora Inspire-based e-module for processing chicken bone crackers. The results of the environmental awareness pretest-posttest are presented in **Table 8**.

Table 8. Pretest-Posttest Results for Environmental Awareness

Score Range	Pretest	Posttest
	Frequency	Frequency
0-25	0	0
26-50	15	0
51-74	15	24
75-100	0	6
Total	30	30
N-Gain	0,39	
N-Gain Category	Moderate	

Source: Research 2023

The results of the innovation skill pretest-posttest are presented in **Table 9**.

Table 9. Pretest-Posttest Results for Innovation Skill

Score Range	Pretest	Posttest
	Frequency	Frequency
0-25	0	0
26-50	12	0
51-75	15	0
76-100	3	30
Total	30	30
N-Gain	0,89	
N-Gain Category	High	

Source: Research 2023

The data presented in **Table 8** and **Table 9** indicate that there is a difference in the improvement of environmental awareness and innovation skill among students, as calculated

using the N-Gain test. The improvement in environmental awareness falls into the “moderate” category, while the improvement in innovation skill falls into the “high” category.

The difference in N-Gain may occur because environmental awareness involves changes in thinking patterns, recognizing the impact of activities on the environment, and a sense of responsibility toward it. Environmental awareness is a deep understanding of environmental issues as well as solutions to problems within the environment. It includes knowing and understanding the causes and effects that occur in the environment due to human activities, consistently having strategic plans for environmental preservation, and always maintaining environmental sustainability by avoiding actions or activities that could cause damage. Fostering environmental awareness requires a non-instantaneous process—starting from having knowledge about the environment (theory) without action, evolving into environmental awareness, then progressing from knowledge to awareness, from awareness to attitude, and finally from attitude to conscious action to protect the environment (Thor & Karlsudd, 2020; Edsand & Broich, 2020; Marpa, 2020).

The aspects of environmental awareness and innovation skill are interconnected. Environmental awareness and innovation skills help students develop attitudes and readiness to learn about sustainable development by paying attention to current environmental issues and challenges. Students are expected to identify opportunities so they can create new strategies to respond to greening challenges (Pavlova, 2011). Environmental awareness can encourage students to seek innovative solutions to environmental problems. Students who possess environmental awareness and concern will be inspired to develop technologies, products, or services that are more environmentally friendly. Innovation capabilities may include product design, production processes, and technologies that help reduce waste, conserve energy, and minimize negative environmental impacts. This aligns with Amandasari’s statement in her dissertation titled “*Inovasi Berbasis Lingkungan dan Kinerja Perusahaan Serta Peran Mediasi Keunggulan Bersaing Perusahaan*,” which asserts that green innovation can protect the environment from harmful waste. Green innovation may include technological innovations such as energy conservation, pollution prevention, and recycling of production waste. Innovation in waste processing is a concrete example of how innovation skills can be used to address environmental problems (Takalo & Tooranloo, 2021; Hsu et al., 2021).

In addition, students’ innovation *skills* can also be observed through the results of hedonic testing conducted by each group using a scale of 4 (very like), 3 (like), 2 (dislike), and 1 (strongly dislike). The assessment was carried out through hedonic testing, which included appearance, color, aroma, taste, and texture of chicken bone crackers. Hedonic testing is a method that indicates consumer preference levels for a product, based on the Guidelines for Organoleptic and/or Sensory Testing (SNI 01-2346-2006). The results of the students’ hedonic testing are presented in **Figure 1**.

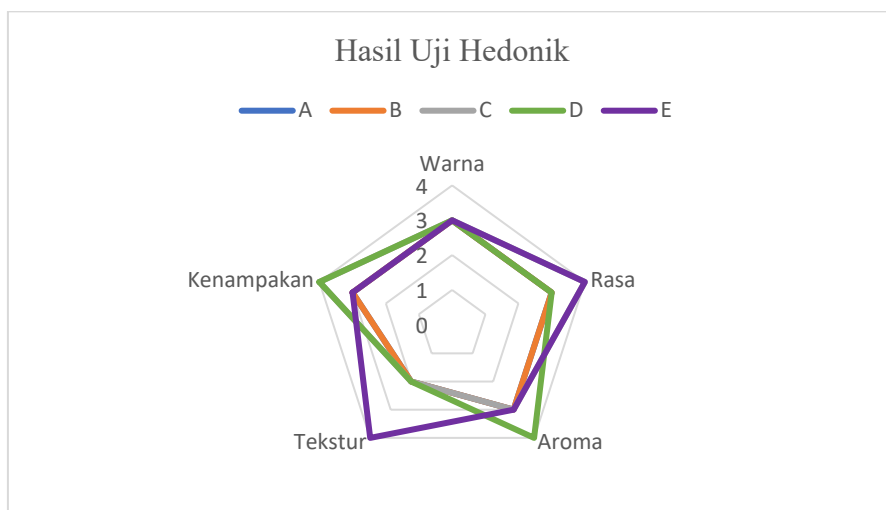


Figure 1. Hedonic Test Results of the Product
Source: Author Documentation 2023

Based on **Figure 1**, it is known that the most preferred crackers was from Group E. The crackers produced had a characteristic appearance typical of crackers. The addition of chicken bone to the crackers had a significant effect on its appearance. Crackers with chicken bone substitution tends to have a darker color due to the browning process of protein and carbohydrates, which is a non-enzymatic browning reaction. Therefore, the more bone flour is added—as a protein source—the browner the crackers becomes (Deborah, 2016).

The resulting crackers color was yellowish brown. The color of the crackers is caused by the added ingredient, namely chicken bone. Inside the bone, there is red marrow (myeloid tissue). Fresh red marrow is bright red and contains protein, fat, and minerals. However, when heated or cooked, the red marrow coagulates and changes color to brown (Raharja, 2016).

The aroma of the crackers produced was typical of crackers with a slight chicken bone scent. The aroma of chicken bone in the crackers was not too strong due to the mixture of other ingredients and seasonings. Additionally, the chicken bone aroma diminished further after the frying process. This is consistent with Herawati's research in her undergraduate thesis titled "*Pengaruh Penambahan Pisang terhadap Hasil jadi Kerupuk,*" which states that crackers undergoing frying experiences heating that reduces or even eliminates its aroma. The taste of the crackers produced was savory with a slight chicken bone flavor. The taste of the crackers comes from the ingredients used, including chicken bone, which has a distinctive flavor. The taste of the crackers will follow the flavor characteristics of the additive ingredients used in the production process—the more additive ingredients are included, the more distinct the flavor becomes, in accordance with the characteristics of those additives.

The texture of the crackers produced was crispy but slightly under-expanded. The crackers did not expand well during frying. This was due to the dough being cut too thick and the drying process being incomplete, resulting in a high moisture content in the crackers. Low moisture content increases the crispiness of the product, because the more water that escapes from the material, the more empty spaces are formed within the structure. As a

result, when the crackers is fried, it expands to a certain degree and becomes crispier (Nugroho & Sukmawati, 2020).

Discussion

The development of an e-module for processing chicken bone crackers within the element of *Penanganan Limbah Pengolahan Hasil Pertanian* based on Lectora Inspire is an innovative step in education that integrates technology with the practical needs of learners. Through this e-module, the researcher successfully created a learning product that not only facilitates access and understanding of the material for learners but also has a positive impact on their environmental awareness and innovation skills.

The development stages of this e-module included a comprehensive process, starting from problem formulation, material development including practical worksheets, and validation by subject matter, media, and language experts. The validation results indicated that the e-module met the criteria of "very feasible" in all assessed aspects. This signifies that the e-module is not only of high quality in terms of content and design but is also well understood by learners.

The implementation of the Project Based Learning (PJBL) model using this e-module yielded significant results in improving learners' environmental awareness and innovation skill. Pretest-posttest data showed a notable increase in both aspects, with innovation skill even reaching the "high" category. This demonstrates that the e-module is not only effective in delivering information but also capable of encouraging learners to think critically, create innovative solutions, and enhance awareness of the importance of environmental protection. Furthermore, the hedonic test on the chicken bone crackers product produced by learners showed success in applying the practical skills learned through the e-module. The resulting crackers was not only favored by learners but also possessed characteristics that align with good product standards.

CONCLUSION

The development of an e-module for processing chicken bone crackers within the element of *Penanganan Limbah Pengolahan Hasil Pertanian* based on Lectora Inspire highlights innovation in education that integrates technology with the practical needs of learners. This e-module not only provides ease of access and understanding of the material but also has a positive impact on learners' environmental awareness and innovation skills.

The development process of this e-module followed comprehensive stages, starting from problem formulation to validation by subject matter, media, and language experts, which demonstrated high quality in terms of content and design. The implementation of the Project Based Learning (PJBL) model using this e-module successfully enhanced learners' environmental awareness and innovation skill, as evidenced by pretest-posttest data.

Moreover, the hedonic test on the chicken bone crackers product produced by learners showed success in applying the practical skills learned through the e-module. Overall, the development of this e-module not only created an innovative and effective learning product but also succeeded in improving learners' environmental awareness and innovation skills.

This affirms the great potential of integrating technology in education to shape a generation that is environmentally conscious and capable of facing future challenges with creative and innovative solutions.

AUTHOR'S NOTE

The author declares that there is no conflict of interest related to the publication of this article. The author affirms that the data and content of the article are free from plagiarism.

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