SUS-PDAT in Applied Science Learning: Making Red Oncom as a Food Innovation for a Healthy and Prosperous Life Without Hunger

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Abstract. Innovation in the food sector to support national development in alleviating hunger and creating a healthy and prosperous life can be carried out in various fields, one of which is education. The aim of the implementation of SUS-PDAT in this applied IPA learning is to give practical experience to students in the process of making red oncoms. This research uses a qualitative approach with a descriptive type. Data collection is carried out through the study of literature from various sources, including national and international journals relevant to research topics. Research shows that by introducing food innovations like red oncom to students, it can raise awareness of the importance of healthy and sustainable food consumption in society. Besides, this learning can also be a source of inspiration for the younger generation to engage in the innovative and environmentally friendly food industry of the future. Therefore, red oncom is included in healthy food with affordable economic value. It is hoped that the red oncom innovation which has an umami taste can help the government in sustainable development for a healthy and healthy life without hunger.

Keywords: Red oncom, SUS-PADT

Introduction

Education plays a vital role in achieving the sustainable development goals (SDGs) and has been established by the United Nations (UNESCO, 2017). One of the goals of the SDGs is to ensure quality, inclusive and equitable education and to promote lifelong learning opportunities for all (United Nations, 2015). This goal, known as SDG 4, aims to address the many challenges facing the global education system, including unequal access, poor quality of education, and lack of learning opportunities for marginalized groups (UNESCO, 2016). Therefore, the development of a sustainability-oriented learning model has become crucial in preparing the younger generation to face global challenges related to environmental, social, and economic issues (Kioupi & Voulvouli, 2019; Versteijlen & Wals, 2023). The development of a sustainable learning model not only focuses on improving the quality of education, but also emphasizes the importance of integrating sustainability aspects into the curriculum (UNICEF, 2019). Thus, education can play a key role in preparing individuals who are not only knowledgeable and skilled, but also conscious of their responsibility to the environment and society (Tilbury, 2004).
SDGs are global development guidelines in overcoming societal problems in various areas of life. The three main problems of human development are stunting and malnutrition experienced by toddlers and obesity in adulthood (Unicef, 2023). The problem of food insecurity affects children's growth and development (Ngo & Serra-Majem, 2018). Indonesia, through the Deputy for Food and Agribusiness Coordination at the Coordinating Ministry for Economic Affairs, called for a commitment to reducing child malnutrition from 10.2% to 7% by 2024. Experts in various sectors of life are working together to carry out various innovations in the food sector.

The main cause of problems in the food sector which are closely related to health is that the food generally consumed by the public focuses on producing energy but contains little micronutrients (Fauziyah, 2017). Oncom is categorized into red oncom and black oncom which have different basic ingredients. Red oncom is made using Neurospora sitophila, while black oncom uses Rhizopus oligosporus (Andayani et al., 2020). Red oncom is a traditional food from West Java, Indonesia. Red oncom is a food innovation that comes from the fermentation of complex chemicals into simpler ones so that they become a potential source of nutrition (Kurnia et al., 2023). Fermentation in the process of making red oncom has benefits as a preservation technique to improve sensory properties and nutritional value (Pratiwi et al., 2021). Peanuts, with the help of the Neurospora sitophila fungus, produce the red color that is characteristic of red oncom (Mulyani & Wisma, 2016). The content of 13 grams of protein, 6 grams of fat, 22.6 grams of carbohydrates and various micronutrients contained in 100 grams of red oncom makes it a healthy food that helps people live more prosperously without going hungry (Zamakhsyari et al., 2018). Red oncom has a shelf life of 2 days at room temperature, making it easy for people to meet their daily nutritional needs (Ridawati, 2018). Initially red oncom was produced using simple technology, but with current technological developments the process of making red oncom has experienced innovation in both raw materials, manufacturing technology and the manufacturing process by each manufacturer.

Education is an important foundation in the formation of a competitive and sustainable society. Applied science learning has a crucial role in equipping students with practical skills that can be applied in everyday life (Amar & Haning, 2022). In this context, applied science learning offers opportunities for students to understand scientific concepts and apply them in real situations. In facing the digital era and information technology, innovative learning approaches are becoming increasingly necessary. To face the challenge of innovation in meeting food needs, an appropriate learning model was developed to encourage the production and development of red oncom by students. The model that supports a contextual approach in guiding students to innovate red oncom food products is sustainable problem based learning with ai-driven design thinking (SUS-PADT). In the context of applied natural sciences (IPA) learning, the SUS-PADT model offers students the opportunity to learn through direct experience, which is considered more effective than conventional learning based solely on theory.

Applied science learning is becoming increasingly relevant in the context of improving the quality of education and preparing students to face global challenges. By integrating scientific concepts into everyday life, this learning provides students with the opportunity to develop practical skills that can be applied in various fields, including the food industry (Asmorowati et al., 2021). In relation to food innovation, applied science learning can be an effective means of introducing concepts such as food safety, nutrition and sustainability to students. One example of food innovation that is interesting to study in the context of applied science learning is the production of red oncom. Red oncom, which is a fermented product of certain grains, has high nutritional value and a distinctive umami taste. This innovation offers the potential as an environmentally friendly alternative to healthy food,
which can be a solution in overcoming nutritional problems and food sustainability in Indonesia (Surya & Romulo, 2023).

The aim of implementing SUS-PDAT in applied science learning is to provide practical experience to students in the process of making red oncom. In this way, students not only learn scientific concepts related to making fermented food theoretically, but can also experience the process directly in the school environment. Apart from that, this learning also aims to increase students' understanding of the importance of food innovation in supporting sustainable living. As well as a stimulus for students to always participate in national development.

Through applied science learning using the SUS-PDAT method, students are expected to develop critical, collaborative and creative thinking skills. By being directly involved in the process of making red oncom, students can learn actively and gain a deeper understanding of the scientific concepts involved. This can also help students develop a responsive attitude to global problems such as hunger, malnutrition and environmental damage. The implementation of applied science learning using the SUS-PDAT method not only provides benefits for individual students, but also has wider implications in the context of sustainable development. By introducing food innovations such as red oncom to students, it is hoped that it can encourage awareness of the importance of healthy and sustainable food consumption in society. Apart from that, this learning can also be a source of inspiration for the younger generation to be involved in the innovative and environmentally friendly food industry in the future.

**Methods**

This research uses a qualitative approach with a descriptive type. A qualitative approach was chosen to gain an in-depth understanding of the problem of hunger and efforts to solve it through making red oncom as a healthy and nutritious food innovation. This type of descriptive research is used to provide an overview, detail and analyze data related to current problems and focus on problem solving.

Data collection was carried out through literature studies from various sources, including national and international journals relevant to the research topic. This literature study aims to collect the latest information regarding the problem of hunger, the application of Applied Science learning, as well as food innovations such as making red oncom as a solution for a healthy and prosperous life without hunger. Data analysis in this research uses the Miles and Huberman model, which consists of three stages:

1. **Data reduction**
   At this stage, the data that has been collected from the literature study will be selected, simplified, and focused on things that are relevant to the research objectives.

2. **Data Presentation (data display)**
   The reduced data is then presented in the form of narrative text, tables, graphs, or other forms that make it easier to understand and draw conclusions.

3. **Drawing Conclusions**
   The final stage is drawing conclusions from the data that has been presented. This conclusion will answer research problems and provide recommendations related to making red oncom as a food innovation for a healthy and prosperous life without hunger in applied science learning.

Through this research method, it is hoped that comprehensive and in-depth information can be obtained regarding the problem of hunger, the potential of red oncom as a food...
innovation, and its implementation in applied science learning to achieve a healthy and prosperous life without hunger.

**Results and Discussion**

Red oncom is a processed food product typical of West Java which is usually processed into various dishes. Oncom is usually processed into stir-fry, tutug rice, chili sauce and even fried oncom. Making red oncom utilizes the fermentation process of the *Neurospora sitophila* fungus using peanuts as the base ingredient. *Neurospora* is a common fungus, has been used in many experiments, and extensive genetic information has been obtained through DNA sequencing. In 1843 *neurospora* fungi had become the focus of research in the field of traditional fermentation and enzyme production (Kanti & Sudiana, 2016). *Neurospora sitophila* is an important fungus for traditional fermented foods. Increasing protein consumption is also good for improving the quality of people’s nutrition. Apart from its nutritional content which can support health, the affordable price is the key to making red oncom popular with the public.

**Making Red Oncom**

Making red oncom generally uses raw materials such as tofu dregs, peanut meal and tapioca production waste. The process of making red oncom requires paying attention to the optimal temperature for fungal growth and the time required for fermentation. The optimal growth temperature for *Neurospora sitophila* is temperature 35°C (Kanti & Sudiana, 2016). The length of the fermentation process affects the results of the enzymes produced. Maximum production of the phytase enzyme by *Neurospora cytophila* achieved after going through a fermentation process for 4 days. Research into making red oncom products consists of this product process consisting of several stages starting with the steaming process, adding yeast, molding and fermentation. The stages of the red oncom manufacturing process are as follows.

![Figure 1. Stages of making red oncom](Source: Mulyani & Wisma, 2016)
The process of making red oncom involves a series of steps which include raw material preparation, fermentation and drying. The following is a detailed explanation of the process of making red oncom:

1. Raw Material Preparation
   - The main raw material used in making red oncom is soybean seeds.
   - Soybean seeds are soaked in water for several hours to speed up the fermentation process and make it easier to peel the skin.
   - After soaking, the soybean seeds are peeled and washed thoroughly to remove dirt and unwanted microorganisms.

2. Fermentation Process
   - Peeled soybean seeds are then boiled until cooked.
   - After boiling, the soybean seeds are crushed or mashed into mush.
   - The soy bean pulp is then mixed with Neurospora sitophila mold or red oncom yeast.
   - This mixture is then incubated for several days in a closed container to allow the fermentation process to take place.
   - During fermentation, the Neurospora sitophila mold will produce enzymes that break down the components of the raw material into compounds that give red oncom its distinctive taste and aroma.

3. Drying
   - After the fermentation process is complete, the red oncom that has been formed is then cut into pieces or shaped according to your wishes.
   - The red oncom pieces are then dried in the sun or using a dryer to reduce the water content.
   - The drying process aims to increase the durability of red oncom and produce the desired texture (Sarwono, 2010).

During the process of fermentation, mold Neurospora cytophiila will produce various enzymes including proteolytic, lipolytic and amylolytic enzymes (Liu et al., 2019). Proteotillic enzymes function to hydrolyze peanut flour into peptides and free amino acids (Andayani et al., 2020). The umami taste in oncom arises due to the fermentation process in red beans. The fermentation process produces many active compounds such as glutamic acid and aspartic acid which produce the umami taste (Warmke et al., 1996). The addition of nucleotides to foods containing glutamate can increase the umami intensity severalfold (Mouritsen & Khandelia, 2012). In addition, the presence of organic acids, such as succinic acid, propionic acid, and lactic acid can also strengthen the umami taste in oncom (Istiqamah et al., 2019). Amino acids and peptides can have a dominant influence on the taste of oncom, because of the raw materials used (Andayani et al., 2020). The fat content of red oncom decreases during fermentation due to mold utilize fat as an energy source for growth. Carbohydrates in red oncom are influenced by the percentage of water, ash, protein and fat content (Kurnia et al., 2023).

Texture is one of the indicators used to assess the quality, taste, nutrition and appearance of food products. The texture of red oncom is influenced by fermentation time and raw materials (Qiu et al., 2022). Oncom has gone through a fermentation period of 48 hours at room temperature and has a compact, soft, moldy texture, pH 4-6, and contains reducing sugars. The duration of red oncom fermentation influences the increase in hardness and elasticity. This is due to the filamentous fungal content and degradation of supporting structures such as fibers (Sastraatmadja et al., 2002).
IPA Concept in Making Red Oncom

In making red oncom, there are physics, chemistry and biology concepts involved. The following are these concepts:

Physics Concept

a. Heat Transfer

The fermentation process in making red oncom involves the transfer of heat from the environment into the fermentation substrate. This heat transfer is important to create optimal temperatures for mold growth (Lavine, et al., 2011). Red oncom is a fermentation product produced using mold (usually Neurospora sitophila or Rhizopus oligosporus) which grows on a substrate of tofu dregs or peanut meal. This fermentation process includes several important stages, including substrate preparation, mold inoculation, and incubation under certain conditions. Heat transfer is the process of transferring heat energy from one place to another, and in the context of fermentation, it is the transfer of heat from the environment into the fermentation substrate. Heat transfer can occur through three main mechanisms: conduction, convection, and radiation. Conduction in the process of making oncom is the process of heat transfer through direct contact between molecules without macroscopic movement of material. In making red oncom, conduction occurs between the surface of the substrate and the surface of the container or fermentation tool which is in direct contact.

Convection in the process of making oncom describe about heat transfer through fluid movement, which in this case is the air around the fermentation substrate. Convection can be natural (caused by temperature differences that produce convective currents) or forced (driven by devices such as fans). Radiation in the process of making oncom describe about heat transfer via electromagnetic waves. Although its contribution is usually smaller than conduction and convection, heat radiation from the surrounding environment still influences the substrate temperature (Shanahan & Chalim, 2023). Optimal temperature is very important for mold growth during red oncom fermentation. Temperatures that are too low can slow down the activity of microorganisms, while temperatures that are too high can kill mold or inhibit its growth. The optimal temperature for fermenting red oncom is usually in the range of 30-37°C (Ainursyiam, 2023).

Controlling heat transfer during fermentation can be done in several ways. Maintain a constant temperature of the fermentation room within the optimal range. This can be done using a heater or cooler if necessary. Uses a vessel that has good thermal insulation properties to maintain a consistent internal temperature. Materials such as styrofoam or special fermentation containers can be used. Ensure there is good air circulation to distribute heat evenly. This can be done by installing fans or an efficient ventilation system. Using temperature sensors to monitor and control substrate temperature during the fermentation process. This sensor can be connected to an automatic control system to adjust temperature in real-time (Ainursyiam, 2023). Heat transfer is a critical aspect in the red oncom fermentation process. Understanding heat transfer mechanisms and how to control them is essential to create optimal temperature conditions for mold growth. By ensuring the right temperature, the fermentation process can run efficiently, producing red oncom products with the desired quality.

b. Gas Diffusion

During the fermentation process, gas diffusion occurs, such as oxygen and carbon dioxide, between the fermentation substrate and the surrounding environment. This
gas diffusion is important to ensure the availability of oxygen for mold growth and the release of carbon dioxide as a byproduct.

![Diffusion Process Diagram](image)

**Figure 2.** Diffusion process
Source: (Cussler, EL 2009)

c. Fluid Mechanics
The process of mixing and stirring fermentation substrates involves fluid mechanics concepts, such as viscosity and fluid flow which influence the efficiency and final results of fermentation. Viscosity is an important property of fluids that determines the internal resistance to flow, while fluid flow refers to the movement of fluids in a system. The following is a detailed explanation of the concept of fluid mechanics in the process of mixing and stirring fermentation substrates is viscosity, fluid flow and effect of changes in viscosity and fluid flow. The viscosity of the fermentation substrate liquid affects the liquid's ability to flow and mix evenly during the fermentation process (Rohman & Maharani, 2020). An increase in liquid viscosity can hinder the movement of particles in the liquid and reduce mixing efficiency (Rohman & Maharani, 2020). Understanding the viscosity of the substrate liquid is important to determine optimal mixing parameters so that mixing can be carried out efficiently.

The fluid flow concept considers how the fluid substrate moves during the fermentation process, which can be influenced by the stirring speed and the geometry of the fermentation vessel (Meutia et al., 2021). Good fluid flow ensures even distribution of nutrients and microorganisms in the substrate, so that the fermentation process can take place optimally (Meutia et al., 2021). Setting the fluid flow speed and stirring pattern appropriately can increase the efficiency of the fermentation process and the quality of the final product.
Changes in the viscosity of the substrate fluid during fermentation can affect the ability of microorganisms to move and interact with the substrate, which in turn influences the rate of fermentation reactions. (Nurdyansyah & Hasbullah, 2018). Good fluid flow can ensure even distribution of nutrients, sufficient oxygenation, and removal of heat generated during fermentation, so that microorganisms can develop optimally (Meutia et al., 2021). Monitoring viscosity and fluid flow during the fermentation process is important to optimize fermentation conditions and ensure the quality of the final product.

By understanding fluid mechanics concepts, such as viscosity and fluid flow, in the process of mixing and stirring fermentation substrates, producers can optimize fermentation conditions to achieve desired results efficiently and consistently.

1. Chemistry Concept
a. Enzymatic Reactions

In the fermentation process, mold produces enzymes that break down complex compounds such as proteins, carbohydrates and fats into simpler compounds. This enzymatic reaction produces organoleptic changes and nutritional value in red oncom (Nelson, & Cox, 2017). The stages of the enzymatic reaction are as follows:

- **Decomposition of Starch by Amylase:**
  In the initial stage, amylase produced by microorganisms will break down the starch contained in the substrate (peanut meal) into simple sugars such as glucose and maltose. This reaction is important because this simple sugar will be used by microorganisms as an energy source and for growth (Afifah et al., 2015).

  \[
  \text{Starch} \xrightarrow{\text{Amylase}} \text{Glucose} + \text{Maltose}
  \]

- **Protein Decomposition by Protease:**
  The proteins in the substrate are also broken down by protease enzymes into smaller peptides and amino acids. This amino acid is not only important for the growth of microorganisms but also gives oncom its distinctive taste (Matsuo, 2006).

  \[
  \text{Protein} \xrightarrow{\text{Protease}} \text{Peptide} + \text{Amino Acid}
  \]

- **Fat Breakdown by Lipase:**
  The fat in the substrate is hydrolyzed by lipase into fatty acids and glycerol. These fatty acids can contribute to the aroma and taste of oncom (Kumbhare & Ijrbat, 2015).

  \[
  \text{Fat} \xrightarrow{\text{Lipase}} \text{Fatty Acid} + \text{Glycerol}
  \]

During fermentation, microorganisms grow and produce these enzymes, which gradually change the chemical composition of the substrate. The texture of the substrate becomes softer, the characteristic aroma of oncom begins to develop, and the nutritional value of the product increases due to increased availability of essential amino acids and fatty acids (Lallo et al., 2018).

The fermentation process for making oncom is the result of complex interactions between microorganisms and substrates through enzymatic reactions. Microorganisms such as Neurospora cytophila and Rhizopus oligosporus produce amylase, protease and lipase enzymes which break down starch, protein and fat in the substrate. The result is a fermented product with a distinctive taste, altered texture, and increased nutritional value (Lestari & Asri, 2021).

b. pH changes

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During fermentation, pH changes occur due to the metabolic activity of the mold. This change in pH is important for creating an optimal environment for mold growth and inhibiting the growth of other undesirable microorganisms (Stahl, DA 2015). The following is a detailed explanation of pH changes and their impacts:

1) Mold Metabolic Activity
   - Organic Acid Production: Molds such as Neurospora intermedia produce a variety of organic acids during metabolism, including lactic acid, acetic acid, and citric acid. The production of these acids lowers the pH of the fermentation environment.
   - Substrate Breakdown: Molds also break down substrates such as proteins and carbohydrates, which can produce other metabolic products that affect pH. For example, protein breakdown can produce ammonia, which is alkaline, but overall organic acids are more dominant in lowering pH (Widowati et al., 2020).

2) pH Changes During Fermentation
   - Beginning of Fermentation: At the beginning of fermentation, the pH of the substrate is usually close to neutral. As the mold begins to grow and metabolize the substrate, the pH begins to decrease due to the production of organic acids.
   - Middle Phase: In this phase, the pH decreases more significantly, creating a more acidic environment. This low pH helps in inhibiting the growth of unwanted microorganisms, such as pathogenic bacteria and other molds that may compete with the main mold.
   - End of Fermentation: In the final stages of fermentation, the pH usually reaches a stable point that is optimal for the mold. This pH stability is important to ensure that the fermentation process runs well and the mold can continue to produce bioactive compounds (Sucipto & Handoko, 2023).

3) Impact of pH Changes
   - Inhibition of Other Microorganisms: Low pH creates a hostile environment for many pathogenic and spoilage microorganisms, thereby reducing the risk of contamination and extending product shelf life.
   - Optimizing Mold Growth: The mold used for fermenting red oncom grows optimally at a lower pH. This change in pH helps the mold dominate the fermentation process, ensuring consistent fermentation and desired product quality.
   - Flavor and Aroma Development: Changes in pH also contribute to the development of the characteristic taste and aroma of red oncom. The resulting acids provide a distinctive sour taste, while the aroma compounds produced during fermentation provide a complex and interesting flavor profile (Sampebarra, 2018).

   Overall, pH changes during red oncom fermentation are crucial factors that favor the growth of beneficial molds and inhibit undesirable microorganisms. This ensures that the fermentation process produces a product that is safe, of good quality and has the desired sensory characteristics.

c. Oxidation

In the fermentation process, an oxidation reaction occurs which changes the color of the fermentation substrate to red. This oxidation reaction involves enzymes produced by mold, such as tyrosinase and lactase.
The following is an explanation of the oxidation reactions that occur during oncom fermentation:

- **Protein Degradation**
  
The fungus *Neurospora sitophila* produces protease enzymes that break down complex proteins in tofu dregs or peanut meal into simpler peptides and amino acids. During this process, some amino acids can undergo oxidation to form simpler products such as keto acids and ammonia (Starzyńska-Janiszewska et al., 2017).

- **Carbohydrate metabolism**
  
  Carbohydrates in fermentation substrates, such as starch or fiber, are also broken down by enzymes produced by mold. The amylase enzyme breaks down starch into simple sugars such as glucose. Glucose is then oxidized via the glycolysis pathway to pyruvic acid, which can then enter the citric acid cycle (Krebs cycle) if oxygen is present, producing energy in the form of ATP and releasing CO$_2$ as a byproduct (Pantaya et al., 2023).

- **Formation of Red Pigment**
  
The fungus *Neurospora sitophila* produces red pigment which is characteristic of red oncom. The formation of these pigments involves complex oxidation reactions, in which pigment precursors are oxidized and modified into stable pigment forms (Matsuo, 2006).

- **pH control**
  
  During fermentation, the production of organic acids through the oxidation of carbohydrates and proteins causes a decrease in the pH of the substrate. This lower pH inhibits the growth of pathogenic microorganisms and supports an environment more conducive to fermentative molds (Cika et al., 2022).

d. **Structure Molecule**

Changes in the molecular structure of substrate components, such as proteins, carbohydrates and fats, during fermentation can influence the final characteristics of red oncom. The following is a detailed explanation of the structural changes:

1) **Proteins**: Proteins in oncom substrates undergo significant structural changes during fermentation. Enzymes produced by fermenting microorganisms, such as proteases, play a role in breaking down proteins into peptides and amino acids. This process is called proteolysis. Protein breakdown changes the amino acid profile of the substrate, which can affect the taste, aroma, and texture of the final product. In addition, byproducts of proteolysis, such as free amino acids and peptides, may also contribute to the taste and aroma of ripe oncom (Masrukan, 2020).

2) **Carbohydrate**: Carbohydrates in the oncom substrate also change during fermentation. Fermenting microorganisms produce the enzyme amylase which is
responsible for converting complex carbohydrates into simple sugars, such as glucose and fructose. This process is called amylolysis. Increasing simple sugar levels can increase the sweet taste and reduce the astringent taste of oncom. Additionally, fermentation can also change the type of carbohydrates present in the substrate, which can also influence the final flavor profile of the product (Faizah et al., 2020).

3) Fat: The fat in the oncom substrate undergoes more complex changes during fermentation. The lipase enzyme produced by fermentation microorganisms can convert fat into free fatty acids and glycerol. This process is called lipolysis. These changes can produce various aroma compounds, such as esters and aldehydes, which can contribute to the final aroma of oncom. In addition, these changes can also affect the texture and elasticity of the final product (Khamidah et al., 2019). These molecular structural changes are critical in producing the desired organoleptic characteristics in mature red oncom. The right fermentation process can produce a final product that has optimal taste, aroma, texture and nutritional value.

e. Compound Bioactive
Red oncom-producing mold can produce bioactive compounds such as antioxidants, pigments and antimicrobial compounds that provide health benefits. The following is a detailed explanation of these bioactive compounds:

1) Antioxidant
   • Type of Compound: Red oncom-producing mold can produce various antioxidant compounds, such as polyphenols, flavonoids and carotenoids.
   • Mechanism of Action: Antioxidants function by neutralizing free radicals in the body, which can cause cell damage and contribute to aging and various degenerative diseases (Wardhani & Sulistyani, 2012).
   • Health Benefits: Consuming red oncom which contains antioxidants can help reduce the risk of cardiovascular disease, cancer and other chronic diseases. Antioxidants also play a role in improving the immune system and reducing inflammation.

2) Pigment
   • Pigment Type: One of the pigments produced by Neurospora intermedia is astaxanthin, which gives oncom its red color.
   • Mechanism of Action: This pigment also has strong antioxidant properties. Additionally, natural pigments such as astaxanthin have been found to have anti-inflammatory and immunomodulatory activities (Puspitasari & Desrita, 2019).
   • Health Benefits: Pigments such as astaxanthin may help protect body cells from oxidative damage, support healthy skin, increase endurance, and protect the eyes from age-related macular degeneration.

3) Antimicrobial Compound
   • Type of Compound: The mold in red oncom produces antimicrobial compounds such as organic acids (for example, lactic acid), antimicrobial peptides, and phenolic compounds.
   • Mechanism of Action: These compounds work by inhibiting the growth of pathogenic bacteria and other dangerous microorganisms. Organic acids can lower the pH of the microbial environment, while antimicrobial peptides can damage microbial cell membranes (Istiqamah et al., 2019).
   • Health Benefits: The presence of antimicrobial compounds in red oncom can help maintain a healthy digestive tract by suppressing the growth of pathogenic bacteria, increasing healthy gut microbiota, and reducing the risk of digestive tract infections. Overall, consumption of red oncom produced through fermentation by Neurospora intermedia mold not only provides nutritional benefits but also offers various additional health benefits through the bioactive compounds it produces.
2. Biology Concept

a. Mold Growth
   In making red oncom, mold growth is the main factor that determines the success of fermentation. The mold used, such as Neurospora sp. or Monascus purpureus, has specific growth characteristics and enzyme production.

b. Mold Metabolism
   Molds carry out metabolic activities to produce enzymes, organic acids, pigments and other compounds that contribute to organoleptic changes and nutritional value of red oncom (Han, 2004).

c. Microorganism Interaction
   Apart from mold, there are other microorganisms that can interact during the fermentation process, such as bacteria and yeast. This interaction can influence the final characteristics of red oncom (Nout & Aidoo, 2010).

d. Ecology Microbes
   The interaction between mold and other microbes in the fermentation substrate can influence the success of fermentation and the final quality of red oncom (Marui et al., 2014).

e. Biotechnology
   Biotechnology applications, such as genetic engineering or enzyme immobilization, can be used to increase the efficiency of red oncom production or produce new product variations.

   By understanding the physical, chemical and biological concepts involved in making red oncom, this research can provide more in-depth information about the fermentation process and efforts to optimize the quality and nutritional value of red oncom as a healthy and nutritious food innovation.
Characteristics and Nutritional Value of Oncom

Oncom characteristics can be seen in Figure 5.

![Figure 5. Red oncom character](Source: Kurnia et al., 2023)

In Figure 5, it can be seen that oncom has characteristics that can be seen and felt. Physical characteristics that can be observed include texture, wateriness, and color. The characteristics that can be smelled are fermented, sour, and nutty aromas. Characteristics that can be tasted include umami, sour, tart, bitter to bland. The taste that appears in red oncom is influenced by the raw materials and duration of fermentation (Fahmi & Nurrahman, 2011). Fermentation can cause an increase in acidity levels. Therefore, a long fermentation period can produce a stronger sour taste. Generally, when total acidity increases, red oncom will tend to taste sour.

![Figure 6. Red oncom consumption patterns](Source: (Kurnia et al., 2023)

During the fermentation process, oncom will produce the enzyme alpha-galactosidase which can break down soybean raffinose and stachyose to a very low level, as a result it does not cause gas formation (Mulyani & Wisma, 2016). Therefore, oncom does not have a flatulence effect (stomach bloating) so it is liked by all groups, both men and women.

![Figure 7. Oncom protein levels](image)

Source : (Mulyani & Wisma, 2016)

When viewed in terms of nutritional value, red oncom has higher protein levels than black oncom. However, the protein content is still influenced by the raw materials for making oncom.

<table>
<thead>
<tr>
<th>Bahan oncom</th>
<th>Kadar Protein</th>
<th>Kadar Lemak</th>
</tr>
</thead>
<tbody>
<tr>
<td>onggok</td>
<td>1,6-2,4 %</td>
<td>0,54 %</td>
</tr>
<tr>
<td>Ampas tahu</td>
<td>5,0 %</td>
<td>2,1 %</td>
</tr>
<tr>
<td>Kacang kedelai</td>
<td>37,4 %</td>
<td>20,8 %</td>
</tr>
<tr>
<td>Bungkil</td>
<td>13,0 %</td>
<td>6,0 %</td>
</tr>
</tbody>
</table>

![Figure 8. Protein and fat content in oncom based on the raw materials for which it is made](image)

(Source: Mulyani & Wisma, 2016)

Based on figure 8. The highest oncom protein content is made from peanut meal as raw material. Meanwhile, oncom with the lowest protein content is made from onggok. Oncom, which has the highest fat content, is made from peanut meal. Meanwhile, oncom which has the lowest fat content is made from onggok. Oncom consumption by sufferers of certain diseases needs to pay attention to the raw materials for making it. So that the nutritional value consumed through oncom is sufficient and
not excessive. To strengthen red oncom production as a food security innovation, a SWOT analysis was carried out in Table 1.

**Table 1. SWOT analysis**

<table>
<thead>
<tr>
<th>Internal factors</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Renewable raw materials and utilizing local potential</td>
<td>1. Product durability</td>
</tr>
<tr>
<td></td>
<td>2. Low sugar and fat content</td>
<td>2. Lack of awareness of healthy food by the community</td>
</tr>
<tr>
<td></td>
<td>3. Does not require preservatives or artificial sweeteners</td>
<td>3. Errors in processing/selecting raw materials</td>
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<td></td>
<td>4. Prices can be reached by all groups</td>
<td>4. Considered an outdated product</td>
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<thead>
<tr>
<th>External factors</th>
<th>Opportunities</th>
<th>Product packaging innovation</th>
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<tbody>
<tr>
<td></td>
<td>MSME opportunities supported by the government</td>
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<td></td>
<td>Improved marketing strategies through online and offline (if online, deeper product processing is carried out to increase product durability)</td>
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<table>
<thead>
<tr>
<th>Threats</th>
<th>Opportunities</th>
<th>Product packaging innovation</th>
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<tbody>
<tr>
<td></td>
<td>Increased research intensity for product development</td>
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<tr>
<td>1. Often innovates flavor variants/raw ingredients</td>
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<td>2. Commercial industrial competition that already exists in the market</td>
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<td>Analyze consumer tastes and make adjustments</td>
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**Conclusion**

Based on the description above, it can be concluded that red oncom is an innovation for solving health problems, especially in meeting nutritional needs. So that people can be free from hunger by accessing affordable products. Red oncom has a high protein content but is low in sugar and fat. Red oncom can be produced using various raw materials. So the nutritional content can be adjusted to suit your wishes. Therefore, red oncom is included in healthy food with affordable economic value. It is hoped that the red oncom innovation which has an umami taste can help the government in sustainable development for a healthy and healthy life without hunger.
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