

The potential of Lai fruit seeds (*Durio kutejensis*) as a prebiotic source for poultry

Potensi biji buah Lai (*Durio kutejensis*) sebagai sumber prebiotik untuk unggas

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ABSTRACT

Lai (*Durio kutejensis*) is an endemic fruit of Kalimantan whose seeds have potential as a prebiotic source. This study aimed to identify the types of prebiotics in Lai fruit seeds and evaluate their potential for the growth of lactic acid bacteria. The study was conducted using a Completely randomized design (CRD) with four treatments and six replications. The parameters observed included proximate composition, resistant starch content, and total bacteria. Proximate analysis was carried out with three treatments: Lai seed flour (LSF), boiled Lai seeds (BLS), and roasted Lai seeds (RLS). In vitro tests used cultures of *Lactobacillus plantarum* and *Lactobacillus casei* treated with LSF at three levels (T1: 1%, T2: 2%, T3: 3%, and T0: without LSF). In conclusion, LSF has strong potential as a novel prebiotic source due to its resistant starch content and its ability to promote lactic acid bacterial growth. These preliminary results may serve as a basis for developing alternatives to antibiotic growth promoters (AGP) in poultry.

ABSTRAK

Lai merupakan buah endemik khas Kalimantan yang bagian bijinya berpotensi sebagai sumber prebiotik. Penelitian bertujuan untuk mengkaji jenis prebiotik yang terkandung dalam biji buah Lai dan mengevaluasi potensinya terhadap bakteri asam laktat. Penelitian ini menggunakan Rancangan acak lengkap (RAL) dengan empat perlakuan dan enam ulangan, parameter yang diamati meliputi komposisi proksimat dan kandungan pati resisten. Analisis proksimat biji buah Lai dengan 3 jenis perlakuan yaitu LSF (tepung biji Lai), BLS (Biji Lai rebus) dan RLS (Biji Lai Sangrai). Kultur bakteri yang digunakan untuk uji in vitro adalah bakteri *L. plantarum* dan *L. casei* yang diberi perlakuan LSF dengan 3 taraf pemberian yaitu: T1: 1%, T2: 2%, dan T3: 3% dan T0 : kontrol tanpa LSF. Kesimpulannya yaitu LSF berpotensi sebagai sumber prebiotik karena mengandung pati resisten sebesar 14,35% dan mampu dimanfaatkan oleh bakteri *L. plantarum* dan *L. casei* selama masa inkubasi. Hasil ini merupakan data awal yang dapat digunakan dalam pengembangan sumber prebiotik terbaru khususnya sebagai alternatif pengganti AGP pada unggas.

Kata kunci:

Durio kutejensis

Prebiotik

Pati resisten

INTRODUCTION

Lai (*Durio kutejensis*) is an endemic plant that grows very well in Kalimantan, including East Kalimantan. Lai fruit has similar properties to durian fruit because both are still in the same family (Manurung et al., 2022). Lai is a durian native to Kalimantan that has unique characteristics, including no smell or fragrant

aroma like durian, blunt spines, and attractive fruit flesh color, which is yellow to reddish orange (Antarlina, 2016); (Handayani et al., 2017). Local people use Lai fruit as a food source, either eaten directly or processed into processed foods such as lempok or durian dodol, while its waste has not been widely utilized. Each *Durio kutejensis* tree can produce around 30-50 fruits per season, with an optimal productivity of 1-2 tons per hectare.



Its population spread across various districts in Kalimantan ensures its sustainable availability (Sunaryo et al., 2019).

About 10-15% of the weight of Lai fruit is seeds, and only one-third of the consumable parts of Lai fruit (Rizal et al., 2015). So far, Lai fruit seeds have not been utilized and are only thrown away as waste, even though, if explored further and in depth, it turns out that Lai fruit seeds have a high carbohydrate content equivalent to other durio species, which is up to 47.6% and starch of 25.07% (Aditya et al., 2016; Fiqtinovri et al., 2020).

The high content of carbohydrates, fiber, and starch in Lai fruit seeds makes it a potential source of prebiotics, including oligosaccharide and polysaccharide compounds. Carbohydrates that cannot be digested and are known to have a prebiotic effect because they can selectively increase the growth of beneficial bacteria in the intestine (Rusdi et al., 2021). In addition, it can be fermented by digestive tract bacteria into short-chain fatty acids, especially acetate, propionate, and butyrate, thus lowering the intestinal pH, which in turn can inhibit the growth of pathogenic bacteria, including *Salmonella* and *E. coli* (Lam et al., 2013; Ricke et al., 2020).

Prebiotics commonly given to poultry include oligosaccharides such as fructooligosaccharides (FOS), manooligosaccharides (MOS), galactooligosaccharides (GOS), xylooligosaccharides (XOS), raffinose, and stachyose. Nowadays, prebiotic studies are not only derived from oligosaccharide components but have also been widely studied and developed other candidates that function as prebiotics, including polysaccharides such as inulin, cellulose, hemicellulose, pectin, glucomannan, and resistant starch (Fajrih et al., 2023).

Research related to the characterization and evaluation of Lai fruit seeds as prebiotic candidates has never been reported, so this study aims to assess the types of prebiotics contained in Lai fruit seeds and evaluate their potential in vitro as a source of nutrients for the growth of lactic acid bacteria. The ban on the use of antibiotic growth promoters (AGPs) in poultry due to concerns about antimicrobial resistance has further highlighted the urgent need for natural alternatives, such as prebiotics, to maintain animal health and productivity. Furthermore, it can be used as preliminary data

in the development of new prebiotic sources, especially as an alternative to AGP in poultry. In addition, to increase the economic value of Lai fruit seed waste and increase the availability of prebiotic sources from natural materials.

MATERIALS AND METHODS

Equipment and Materials

The research used Lai fruit seeds, the main material obtained from the Samarinda city market in East Kalimantan. The bacterial cultures used for the in vitro tests were lactic acid bacteria in the form of *Lactobacillus plantarum* and *Lactobacillus casei*, which are commonly found in the digestive tract of chickens. The tools used were analytical scales, a sieve, an autoclave, Petri dishes, test tubes, a beaker, a measuring flask, an incubator, an oven, a micropipette, LABtips, and a laminar air flow.

Procedures for Making Lai Seed Flour

The Lai fruits used in this study were mature. The fruits were cut open and separated into their components, namely the pulp, seeds, and peel, after which the seeds were collected. The cleaned seeds were then subjected to three treatments: T1 (dry heating/oven), T2 (wet heating/boiling), and T3 (dry heating/roasting). For the T1 treatment (Lai seed flour/LSF), the seeds were thinly sliced and dried in an oven at 65°C for 24 hours. After drying, they were ground using a blender, sieved, and stored in tightly closed containers. For the T2 treatment (boiled Lai seeds/BLS), the seeds were boiled for 10 minutes, while for the T3 treatment (roasted Lai seeds/RLS), the seeds were roasted for 7 minutes. Seeds that had undergone the heating process, boiled, roasted, or oven-dried, were then thinly sliced and subjected to proximate analysis. The experiment was designed using a Completely randomized design (CRD) consisting of three treatments with six replications. The data obtained were analyzed using Analysis of variance (ANOVA), followed by Duncan's multiple range test (DMRT) at a significance level of 0.05 to determine differences among treatments.

Nutrient Content Analysis of Lai Seeds

Each treatment, namely BLS, RLS, and LSF, was analyzed for proximate contents, including moisture, ash, carbohydrate, crude protein, and crude fat ([AOAC] Association of Official Analytical Chemists., 2012). Carbohydrate

content was obtained by different methods. Resistant starch (RS) analysis was conducted using an enzymatic method with α -amylase (37°C, 30 min) and amyloglucosidase (60°C, 30–60 min) to hydrolyze the digestible starch fraction, followed by glucose quantification. The remaining fraction was calculated as RS, and its characteristics were further confirmed using near-infrared spectroscopy (NIR) (Andriani et al., 2024). The crude fiber content was analyzed using the Van Soest method. The proximate results were processed and statistically analyzed using Analysis of variance (ANOVA), followed by Duncan's multiple range test (DMRT) at a 5% significance level when significant differences were observed. The experiment was arranged in a Completely randomized design (CRD) consisting of three treatments with six replications.

Testing Lai Seed Flour (LSF) on Total Lactic Acid Bacteria

Testing of LSF containing prebiotics was carried out using *L. plantarum* bacteria, which were assumed to be present in the digestive tract of chickens. Total LAB count was determined using the Total plate count (TPC) method based on the method (Halimatunnisroh et al., 2017). The TPC analysis was conducted to determine the number of bacterial colonies contained in a sample by counting the colonies that grew on agar media. The TPC test was performed using three levels of Lai seed flour, namely T1: 1%, T2: 2%, T3: 3%, and T0: without LSF, each tested on *L. plantarum* and *L. casei*. These two bacterial strains were selected as they were considered representative for evaluating the prebiotic potential of Lai seed compounds, given their role as key beneficial gut bacteria commonly employed in prebiotic assessments. The TPC analysis was conducted using plate count agar (PCA) medium by inoculating 0.1 ml of sample dilutions into petri

dishes, which were then incubated for 48 hours at 35°C. The colony count results were expressed as colony-forming units (CFU) per ml/g. Colony counts were performed at dilution series of 10^{-6} , 10^{-7} , and 10^{-8} CFU/ml. Bacterial colonies were placed on a petri dish in the counting chamber, and the counting device was adjusted to the zero position. Colony counting was carried out using a pointer needle while observing the numbers on the counting screen. The total number of colonies was calculated within the range of 30–300 colonies using the formula described by Sutton (2011). This study was designed as an in vitro laboratory experiment.

RESULTS AND DISCUSSION

Characteristics and Composition of Lai Fruit Parts

Based on the results of the study, it was found that Lai fruit (*Durio kutejensis*) weighs about 500–600 g per fruit, consisting of skin, flesh, and seeds. The percentage of fruit parts from highest to lowest is skin (52.6%), pulp (36.5%), and seeds (10.8%). In line with Aditya (2016) that Lai has a portion of fruit meat around 20–40%. While research Simanjuntak et al. (2024) reported that the whole Lai fruit produces 75% waste (50% skin and 25% seeds) in 1 seed. These results indicate that Lai fruit seeds are in quite a quantity and can be used to develop food products and animal feed. The Lai fruit parts are shown in Figure 1.

Nutrient Composition of Lai Fruit Seeds

Table 1 shows the results of the proximate analysis of Lai fruit seeds with different treatments. The nutrient composition of Lai seeds is strongly influenced by various processing methods. LSF treatment was significantly ($P < 0.05$) lower than BLS and RLS treatments (Table 1). According to Li et al. (2023) when the seeds are boiled, there



Figure 1. *Durio kutejensis* fruit parts (a) whole fruit, (b) pulp, and (c) seeds

Table 1. Nutrient composition of Lai fruit seeds oven-dried treatment (LSF), boiling treatment (BLS) and roasted treatment (RLS)

Nutrient composition	LSF	BLS	RLS
Moisture (%)	49.12±0.03 ^b	51.47±0.42 ^b	28.52±0.37 ^a
Ash (%)	1.23±0.01 ^a	3.46±0.08 ^c	1.79±0.04 ^b
Crude fat (%)	6.38±0.05 ^c	2.68±0.12 ^a	3.95±0.06 ^b
Crude protein (%)	20.83±0.06 ^a	23.97±0.05 ^b	28.65±0.07 ^c
Carbohydrate (%)	64.08±0.02 ^b	56.83±0.17 ^a	63.96±0.05 ^b
Crude fiber (%)	7.56±0.16 ^c	3.05±0.07 ^b	1.70±0.02 ^a
Resistant starch (%)	14.35	NA	NA

Notes: Different superscripts in the same row indicate significantly different (P<0.05). NA: Not analyzed.

is a process of protein denaturation followed by the dissolution of water-soluble proteins into the boiling medium. This dissolved protein is then wasted with the cooking water, which causes a reduction in the total protein content in the seeds. Meanwhile, the RLS roasting treatment tends to increase the protein content Sun et al. (2014) explained that this happens because roasting causes a significant decrease in water content without losing protein through decay, thus proportionally increasing the percentage of protein. In line with Supriana et al. (2020) during roasting, there is a reduction in moisture content in the seeds in the absence of a liquid medium that can dissolve proteins. As a result, proteins remain trapped in the seed matrix and do not decay during the boiling process (Lamid et al., 2015).

The carbohydrate content was significantly (P<0.05) highest in the LSF and RLS treatments compared to the BLS treatments (Table 1). The high carbohydrate content in the LSF or oven drying treatment is closely related to the characteristics of the drying process. According to Paga et al. (2022) during oven drying, there is a slow and controlled evaporation of water, increasing the concentration of solids, including carbohydrates. In addition, the relatively low drying temperature is effective in reducing the moisture content so that this process minimizes carbohydrate degradation. As a result, the percentage of carbohydrates obtained increased. Meanwhile, the RLS treatment resulted in smaller carbohydrate content. According to Fitriani et al. (2023) during boiling, starch gelatinization occurs, followed by the dissolution of some simple carbohydrates and oligosaccharides into the cooking water. Water as a heating medium

facilitates the hydrolysis of starch into smaller units, which can then dissolve and disappear with the cooking water. Furthermore, Paga et al. (2022) stated that boiling can also cause cell walls to break, which allows carbohydrates to escape from the material matrix. This mechanism resulted in a smaller carbohydrate content in the BRL treatment.

The content of crude fiber in the LSF treatment was also higher than in the BLS and RLS treatments (Table 1). This occurred because the temperature used in oven drying does not cause degradation of fiber components such as cellulose, hemicellulose, and lignin, which are the main components of crude fiber. While boiling treatment causes the cell structure to become softer and causes chemical bonds to be broken in the cell wall, containing fiber components. In this process, parts of the fiber can be partially broken, especially hemicellulose, which is more easily hydrolyzed under wet and hot conditions (Yu et al., 2016). Similar to RLS treatment, high temperatures in roasting can cause depolymerization and thermal degradation of fiber components, especially on the surface of the material (Li et al., 2023). The result of this process is a more significant reduction in crude fiber content compared to oven drying.

Based on the proximate analysis, Lai seed flour (LSF) showed the highest carbohydrate and crude fiber content among treatments, indicating the presence of components that may function as prebiotics. Subsequent analysis confirmed the presence of resistant starch (RS) at 14.35% in LSF. Resistant starch is a starch fraction that is not hydrolyzed by digestive enzymes but can be fermented by lactic acid bacteria such

as *Lactobacillus* and *Bifidobacterium*, thereby potentially supporting gut health (Zhou et al., 2017; Zeng et al., 2018). Because of its physiological properties like oligosaccharides, which are not digested in the small intestine and can be fermented in the large intestine, resistant starch is included as a prebiotic candidate (Lockyer et al., 2017; Khayrah et al., 2022). While these findings suggest that LSF has promising prebiotic potential, further in vivo evaluation is needed to confirm its functional effects. Notably, the RS content of LSF (14.35%) is comparable to, or higher than, some commonly studied sources of resistant starch, such as raw potato starch (6.30 %), maize starch (1.16%), and banana starch (15.87%) (Setiarto et al., 2015). This quantitative comparison highlights the potential of LSF as a novel local source of resistant starch for livestock feed.

Effect of Lai Fruit Flour on *L. plantarum* Bacteria

Figure 2 shows that total *L. plantarum* bacteria can grow on media given substrates from LSF (T1, T2, T3) containing resistant starch, although higher results were obtained in the T0 treatment. This is because in the control treatment (T0), *L. plantarum* bacteria may be more efficient in utilizing the simple carbon sources available in the base medium, without the need to expend additional energy to synthesize the enzymes needed to degrade resistant starch. On the other hand, the total *L. plantarum* in treatment T3 was higher than in T1 and T2. This indicates that the higher the concentration of LSF, the more substrate is available to be utilized by *L.*

plantarum, although it cannot surpass the growth efficiency in the control. Furthermore, Wang et al. (2022) suggested that *L. plantarum* requires a longer adaptation period to develop the enzyme system required in resistant starch metabolism, which is seen in the lower growth in T1 and T2.

The total bacteria of *L. plantarum* in this study was lower than the results of the study Wang et al. (2022) which reached 9.5 log CFU/mL in 24 hours when given a substrate of resistant starch nanoparticles. The results showed that 0.5% resistant starch nanoparticles contained 45% resistant starch content that could continue to be fermented by *L. plantarum* until the 70th hour of the incubation period. In contrast, the total *L. plantarum* was only 6.75 log CFU/mL when the carbon source used was glucose. This phenomenon indicates that the resistant starch level in LSF is not enough to increase the total bacteria of *L. plantarum*, so the concentration needs to be increased.

Effect of Lai Fruit Flour on *L. casei* Bacteria

Based on the results of the study, it was found that the treatment of Lai seed flour (LSF) can be utilized by *L. casei* bacteria for its growth (Figure 3.). The highest results were obtained in the T3 treatment with 3% LSF concentration, which showed the most optimal growth of *L. casei* bacteria compared to other treatments. This was followed by the T2 treatment with a concentration of 2% which also showed quite good growth results, although not as high as T3.

The T1 treatment with a concentration of 1% showed slightly higher growth than the control, while the lowest results were shown in

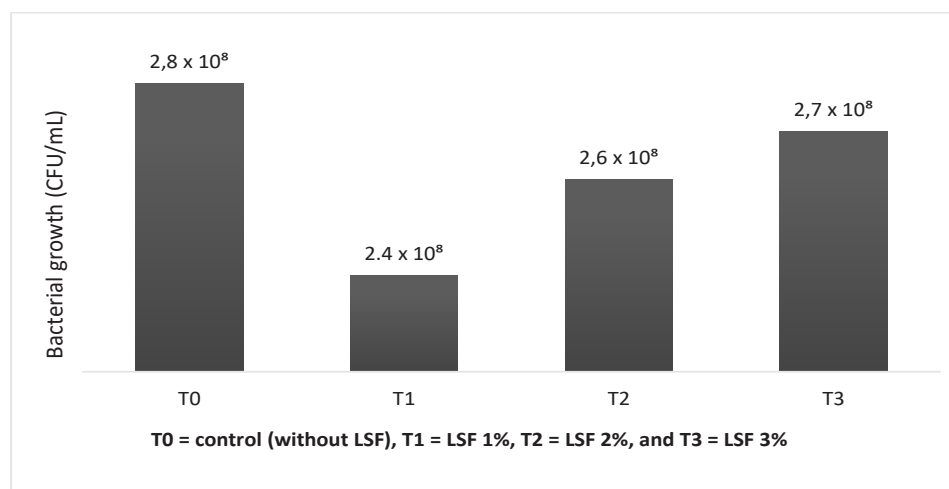


Figure 2. Effect of LSF on total *L. plantarum* bacteria

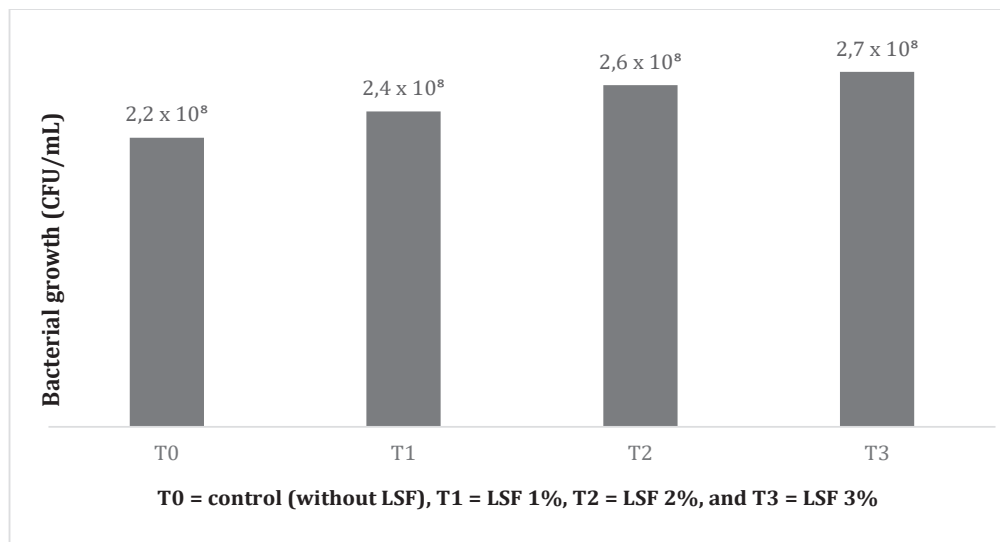


Figure 3. The effect of LSF on total *L. casei* bacteria

the control treatment (T0) without the addition of resistant starch (Figure 3). This condition occurs because LSF contains resistant starch, which acts as a prebiotic so that it can be utilized by *L. casei* bacteria as a source of nutrients for growth. The higher the concentration of resistant starch is available, the more substrate that can be utilized by bacteria to grow and develop. This result indicates that resistant starch with a concentration of 3% is the optimal concentration to support the growth of *L. casei* bacteria in the research conducted.

L. casei utilizes LSF containing resistant starch through the hydrolysis of resistant starch into smaller sugar units. This is done with the enzyme amylase made by the bacteria, and then these simple sugars can be used as a source of carbon and energy to support the growth and metabolism of *L. casei* (Homayouni et al., 2014). Furthermore, during the fermentation process, *L. casei* produces various metabolites that can reduce the pH of the environment, which helps its growth and can prevent the growth of pathogenic bacteria (Supriana et al., 2020). The growth of *L. casei* is influenced by several factors, including the availability of fermentable carbohydrates, optimal pH, temperature, and anaerobic conditions that support its metabolic activity.

CONCLUSIONS

Lai seed flour (LSF) has the potential as a source of prebiotics because it contains resistant starch of 14.35% and able to be utilized by *L. plantarum* and *L. casei* bacteria during

the incubation period in vitro. These results are preliminary data that can be used in the development of new prebiotic sources, especially as an alternative to AGP in poultry. The resistant starch in Lai fruit seeds is hypothesized to improve poultry growth performance, improve gut health, and reduce the colonization of pathogenic bacteria. Therefore, further research should be conducted to examine the effect of Lai fruit seeds containing prebiotics in the form of resistant starch on poultry growth performance in vivo.

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REFERENCES

- [AOAC] Association of Official Analytical Chemists. (2012). *Official Methods of Analysis*. Washington (DC): Benjamin Franklin Station.
- Aditya, R., & Kartika, R. (2016). Pembuatan bioethanol dari biji buah Lai (*Durio Kutejensis*). *Jurnal Atomik*, 1 (1), 47-49. <https://www.e-jurnal.com/2016/06/pembuatan-bioetanol-dari-biji-lai-durio.html>
- Andriani, M., Putra, R. Y., & Rosyta, D. G. (2024). Uji efektivitas daun Sirih Merah (*Piper crocatum*) terhadap penurunan kadar gula darah Mencit Putih Jantan (*Mus musculus*) yang diinduksi aloksan. *Bioeduscience*,

- 8(2), 197–197. <https://doi.org/10.22236/jbes/13320>
- Antarlina, S. S. (2016). Identifikasi sifat fisik dan kimia buah-buahan lokal Kalimantan. *Buletin Plasma Nutfah*, 15(2), 80. <https://doi.org/10.21082/blpn.v15n2.2009.p80-90>
- Fajrih, N., Wiryawan, K. G., Sumiati, & Syahpura, S. K. (2023). Glucomannan potential of Banana Corms (*Musa paradisiaca*) as prebiotics. *Advances in Animal and Veterinary Sciences*, 11(11), 1887–1896. <https://dx.doi.org/10.17582/journal.aavs/2023/11.11.1887.1896>
- Fitqinovri, S. M., Benita, A. M., Marseno, D. W., & Pranoto, Y. (2020). Sifat fisik, amilograf, dan morfologi pati biji Lai (*Durio kutejensis*) asetilasi menggunakan asetat anhidrat. *AgriTECH*, 40(1), 74. <https://doi.org/10.22146/agritech.33809>
- Fitriani, S., Yusmarini, Y., Riftyan, E., Saputra, E., & Rohmah, M. C. (2023). Karakteristik dan profil pasta pati sagu modifikasi pragelatinisasi pada suhu yang berbeda. *Jurnal Teknologi Hasil Pertanian*, 16(2), 104. <https://doi.org/10.20961/jthp.v16i2.56057>
- Halimatunnisroh, R., Yudiarti, T., & Sugiarto, S. (2017). Jumlah coliform, BAL dan total bakteri usus halus ayam broiler yang diberi kunyit (*Curcuma domestica*). *Jurnal Peternakan Indonesia*, 9(2), 79–84. <https://doi.org/10.25077/jpi.19.2.79-84.2017>
- Handayani, F., & Rahayu, S. P. (2017). Short communication: Assessment of genetic diversity in Lai (*Durio kutejensis*) local cultivars of Batuah (Indonesia) using ISSR marker. *Biodiversitas*, 18(2), 525–528. <https://doi.org/10.13057/biodiv/d180212>
- Homayouni, A., Amini, A., Keshtiban, A. K., Mortazavian, A. M., Esazadeh, K., & Pourmoradian, S. (2014). Resistant starch in food industry: A changing outlook for consumer and producer. *Starch/Staerke*, 66(1–2), 102–114. <https://doi.org/10.1002/star.201300110>
- Khayrah, U., Prangdimurti, E., & Nuraida, L. (2022). Karakteristik dan evaluasi prebiotik tepung biji Cempedak (*Artocarpus champeden*). *Jurnal Ilmu Pertanian Indonesia*, 27(2), 248–254. <https://doi.org/10.18343/jipi.27.2.248>
- Lam, K. L., & Cheung, P. C. K. (2013). Non-digestible long chain beta-glucans as novel prebiotics. *Bioactive Carbohydrates and Dietary Fibre*, 2(1), 45–64. <https://doi.org/10.1016/j.bcdf.2013.09.001>
- Lamid, A., Almasyhuri, A., & Sundari, D. (2015). Pengaruh proses pemasakan terhadap komposisi zat gizi bahan pangan sumber protein. *Media Penelitian Dan Pengembangan Kesehatan*, 25(4), 235–242. <https://doi.org/10.22435/mpk.v25i4.4590.235-242>
- Li, L., Wang, Q., Liu, C., Hong, J., & Zheng, X. (2023). Effect of oven roasting on major chemical components in cereals and its modulation on flour-based products quality. *Journal of Food Science*, 88(7), 2740–2757. <https://doi.org/10.1111/1750-3841.16625>
- Lockyer, S., & Nugent, A. P. (2017). Health effects of resistant starch. *Nutrition Bulletin*, 42(1), 10–41. <https://doi.org/10.1111/nbu.12244>
- Manurung, H., Susanto, D. W. I., Kusumawati, E. K. O., Aryani, R., Nugroho, R. A., Kusuma, R., & Sari, R. D. (2022). Phytochemical, GC-MS analysis and antioxidant activities of leaf methanolic extract of Lai (*Durio kutejensis*), the endemic plant of Kalimantan, Indonesia. *Biodiversitas*, 23(11), 5566–5573. <https://doi.org/10.13057/biodiv/d231104>
- Paga, A., & Suek, F. S. (2022). Efek metode pengeringan berbeda rumput laut *Sargassum Sp.* terhadap kandungan bahan kering dan karbohidrat. *Prosiding Seminar Nasional Hasil-Hasil Penelitian*. (Vol.5, No. 1). 209–213.
- Ricke, S. C., Lee, S. I., Kim, S. A., Park, S. H., & Shi, Z. (2020). Prebiotics and the poultry gastrointestinal tract microbiome. *Poultry Science*, 99(2), 670–677. <https://doi.org/10.1016/j.psj.2019.12.018>
- Rizal, M., Rahayu, S. P., & Supriyono, A. (2015). Prospek pengembangan buah Lai (*Durio kutejensis*) sebagai varietas unggul lokal di Kabupaten Kutai Kartanegara, Kalimantan Timur. in *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia* 1(6), pp. 1497–1501. <https://doi.org/10.13057/psnmbi/m010641>
- Rusdi, B., Yuliawati, K. M., & Khairinisa, M. A. (2021). Comparison on the prebiotic polysaccharides and oligosaccharides from plant studies in Indonesia and outside of Indonesia. *Journal of Engineering Science and Technology*, 16(3), 2260–2272.
- Setiarto, R. H., B., Jenie, B. S., L., Faridah, D. N., & Saskiawan, I. (2015). Study of development resistant starch contained in food ingredients as prebiotic source. *Jurnal Ilmu Pertanian Indonesia*, 20(3), 191–200. <https://doi.org/10.18343/jipi.20.3.191>
- Simanjuntak, S., Fanani, A. F., Ardiansyah, A., & Sholihah, M. A. (2024). Kandungan

- nutrisi limbah buah Lai (*Durio kutejensis*) yang difermentasi dengan beberapa jenis mikroba yang berbeda. *Jurnal Pertanian Terpadu*, 12(1), 97–106. <https://doi.org/10.36084/jpt.v12i1.535>
- Sun, Q., Gong, M., Li, Y., & Xiong, L. (2014). Effect of dry heat treatment on the physicochemical properties and structure of proso millet flour and starch. *Carbohydrate Polymers*, 110, 128–134. <https://doi.org/10.1016/j.carbpol.2014.03.090>
- Sunaryo, W., & Pranoto, H. (2019). Interspecific grafting to solve the rootstock shortage in vegetative propagation of Lai-durian (*Durio zibethinus* × *kutejensis*) originated from East Kalimantan. *Australian Journal of Crop Science*, 13(4), 642–648. <https://doi.org/10.21475/ajcs.19.13.04.p1845>
- Supriana, N., Ahmad, U., Samsudin, S., & Purwanto, E. H. (2020). Pengaruh metode pengolahan dan suhu penyangraian terhadap karakter fisiko-kimia kopi robusta. *Jurnal Tanaman Industri Dan Penyegar*, 7(2), 61. <https://doi.org/10.21082/jtidp.v7n2.2020.p61-72>
- Sutton S. (2011). Accuracy of plate counts. *Journal of Validation Technology*, 17(3), 42–46.
- Wang, M., Chen, X., Zhou, L., Li, Y., Yang, J., Ji, N., & Sun, Q. (2022). Prebiotic effects of resistant starch nanoparticles on growth and proliferation of the probiotic *Lactiplantibacillus plantarum* subsp. *plantarum*. *Lwt*, 154, 11275. 1–7. <https://doi.org/10.1016/j.lwt.2021.112572>
- Yu, Q., Zhuang, X., Yuan, Z., Kong, X., Qi, W., Wang, W., & Tan, X. (2016). Influence of lignin level on release of hemicellulose-derived sugars in liquid hot water. *International Journal of Biological Macromolecules*, 82, 967–972. <https://doi.org/10.1016/j.ijbiomac.2015.10.045>
- Zeng, H., Chen, P., Chen, C., Huang, C., Lin, S., Zheng, B., & Zhang, Y. I. (2018). Structural properties and prebiotic activities of fractionated lotus seed resistant starches. *Food Chemistry*, 251, 33–40. <https://doi.org/10.1016/j.foodchem.2018.01.057>
- Zhou, L., Fang, L., Sun, Y., Su, Y., & Zhu, W. (2017). Effects of a diet high in resistant starch on fermentation end-products of protein and mucin secretion in the colons of pigs. *Starch/Staerke*, 69(7–8), 1–7. <https://doi.org/10.1002/star.201600032>