LenteraBio
Berkala Ilmiah Biologi

LenteraBio, 2026; Volume 15, Issue 2: 138-151

p-ISSN: 2252-3979 e-ISSN: 2685-7871
https://journal.unesa.ac.id/index.php/lenterabio/index

Fungal Diversity in Senduro Goat Feces from Lumajang

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Article History:
Received:
24-July-2025
Revised:
08-May-2026
Available online:
31-May-2026
Published regularly:
31-May-2026

Abstract
Fungi isolated from Senduro Goat feces can provide information about microbial diversity in the digestive system of livestock. This study aims to identify the diversity of fungi obtained from adult Senduro Goats and young feces by analysing their macroscopic and microscopic characteristics. This type of research is descriptive exploratory, conducted by isolation using the serial dilution method and planting on PDA media, as well as characterisation of colony morphology macroscopically and microscopically for identification. The results showed nine isolates from adult goats identified as *Aspergillus*. Meanwhile, seven isolates from young goats consisted of *Aspergillus*, *Penicillium*, and *Alternaria*, each of which had varied macroscopic and microscopic characteristics. These findings can open up the potential for fungal research as cellulolytic agents, starters, probiotics, sources of enzyme isolation, and prevention of potential pathogenic fungi that can impact human and animal health.

Keywords: Biodiversity; goat feces; *Aspergillus; Penicillium; Alternaria*
How to Cite: Rakhmawati I & Trimulyono G, 2026. Fungal Diversity in Senduro Goat Feces from Lumajang. LenteraBio; 15(2): 138-151.
DOI: https://doi.org/10.26740/lenterabio.v15n2.p138-151

INTRODUCTION

Senduro goats are a leading commodity, so it is essential to preserve them. One approach that can be taken to conserve Senduro goats is through research on goat feces. Goat feces are an ideal medium for the growth of various types of microbiota (Fadhli *et al*., 2021). According to research conducted by Nurakhman *et al*. (2021), the digestibility value of young goats was 41.07%, and that of adult goats was 58.93%. These results indicate that feed absorption in young goats is not optimal because their digestive system is still developing and they cannot efficiently digest coarse fiber, resulting in higher levels of organic matter in their feces than in adult goats. Changes in goat feeding patterns can significantly alter the microbial community, including fungi, in the digestive tract (Teklebrhan *et al*., 2022). Research by Li *et al*. (2023) showed that the microbial composition in the digestive tract of goats is influenced by age and feed type.

Microorganisms such as fungi in ruminant livestock, including goats, play an essential role in digestion and fermentation. Fungi contribute to the balance of rumen microbiota and help improve feed digestion efficiency and digestibility (Agustina *et al*., 2024). Fungi play an essential role in the rumen's ability to degrade cellulose. Each goat has differences in the diversity and composition of rumen microbiota, which are influenced by variations in the feed provided (Langda *et al*., 2020). Fungal diversity in goat feces is influenced by environmental factors and digestive tract conditions, with each intestinal segment harbouring distinct microbial communities and enzymatic activities (Rabapane and Matambo, 2024). Research on fungal diversity from faecal samples of goats in northern Jordan identified 17 fungi, including *Rhizopus nigerces, Mucor* spp., *Chaetomium bostrychodes, Kerina nitida, Ascobolus immersus, Ascobolus furfuraceus, Sacopolus minimus, Lasiobolidium* spp., *Aspergillus niger, Trichurus spiralis, Fusarium oxysporum, Thelivia* spp., *Sordaria fimicola, Scopiularopsis* spp., *Glimanella hamicala, Podospora* spp., *Zopfiella* spp (Altayyar *et al*., 2017).

With advances in isolating and identifying microorganisms, research on fungi in livestock feces has become increasingly relevant. Selective culture methods using specific media can improve the effectiveness of isolating fungi from feces. During the isolation stage, serial dilution techniques aim to

create a supportive environment and reduce the density of microorganisms growing in the sample. The streak plate method is then used to obtain single colonies, followed by the slide culture method to facilitate fungal identification by observing their microscopic characteristics in detail (Armah *et al*., 2022; Doringin *et al*., 2020; Riga *et al*., 2022). Isolates were characterised macroscopically and microscopically to identify fungal diversity (Hikmahwati *et al*., 2020). Research on identifying fungi from goat feces, especially local goats such as Senduro goats, is still limited. Microorganisms in livestock feces have significant potential, such as cellulolytic fungi, which play a role in agricultural, biogeochemical, and nutritional processes (Hess *et al*., 2020; Wunderlich *et al*., 2023). Additionally, fungi can be utilised as fermentation starters (Fitria and Candrasari, 2019) and probiotics (Afriani *et al*., 2022). Meanwhile, identifying potentially pathogenic fungi is crucial for understanding their impact on animal and human health (Simões *et al*., 2023; Janbon *et al*., 2019).

This study aims to identify the diversity of fungi obtained from the isolation of feces from adult and young Senduro goats and to analyse their macroscopic and microscopic characteristics. The information received is expected not only to contribute to knowledge about fungal microbiota in Senduro goats but also to open up potential for research on fungi as cellulolytic agents, starters, probiotics, sources of enzyme isolates, and prevention against potential pathogenic fungi that may affect human and livestock health.

MATERIALS AND METHODS

This exploratory descriptive study was conducted from August 2024 to March 2025. The feces samples were taken directly from the Senduro goat farm in Senduro District, Lumajang Regency, East Java, Indonesia. Isolation and identification of fungal diversity were conducted at the Microbiology Laboratory, Building C10, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. Sampling was conducted from 7:00 AM to 9:00 AM local time, ensuring cleanliness to prevent contamination. Feces samples were collected from female goats of different age categories: 2 adult goats aged 4–5 years fed on forage, concentrate, cassava pulp, and two young goats aged 1–2 months fed on forage, concentrate, cassava pulp, and cow's milk. Samples were collected immediately after the goats defecated, placed in sterile centrifuge tubes labelled with the appropriate information, and stored in a dry ice box. Further fungal isolation was conducted in the microbiology laboratory.

The research procedure began with sterilizing the equipment and materials at 121°C for 15 minutes (Istini, 2020). To prepare the *Potato Dextrose Agar* (PDA) medium, 39 grams were placed in an Erlenmeyer flask and dissolved in 1000 mL of distilled water, then 100 mg/L of chloramphenicol was added. The medium is heated to boiling and stirred thoroughly, then sterilised in an autoclave at 121°C for 15 minutes. Chloramphenicol, an antibiotic, is added to the PDA medium to prevent bacterial growth (Dewi *et al*., 2011). Serial dilution (10^{-1} to 10^{-8}) was performed by adding 1 gram of Senduro goat feces to a test tube containing 9 ml of physiological NaCl (Joni *et al*., 2018). Fungal inoculation was performed by taking 1 ml of suspension from the 10^{-1} to 10^{-8} dilution and transferring it into sterile Petri dishes in duplicate. Subsequently, 15 ml of medium was poured into each Petri dish containing the sample. After the medium hardened, the cultures were incubated with the Petri dishes inverted at 28–30°C for 7 days. The colonies to be purified were collected using a sterile loop heated over a spirit lamp and scraped across the Petri dishes containing sterile PDA medium. Incubation was carried out at a temperature of 28–30°C for 7 days. The results of the quadrant scratch plate technique will show isolated colonies. Single colonies are planted on sterile PDA medium in slanted test tubes. The fungal isolates are transferred using a sterile 5 mm diameter *cork borer* onto sterile PDA medium in Petri dishes, then incubated at a temperature of 28-30°C for 7 days (Miftahussurur *et al*., 2024; Posangi and Bara, 2014; Yastanto, 2020).

Macroscopic characterization involves observing colony shape, surface colour, reverse colour, texture, mycelium, elevation, topography, margin, and colony diameter. (Andriani and Heriansyah, 2021; Dewi *et al*., 2020; Getachew, 2017; Kuribayashi *et al*., 2022; Sajar, 2018; Utama *et al*., 2019). Microscopic characterization of fungi was performed using the slide culture method. A sterile Petri dish

containing cotton was prepared along with a support, then a glass slide was placed on top. A 1x1 cm piece of PDA medium was placed on the slide glass and inoculated with the sample colony on all four sides using a sterile inoculating needle. The medium was covered with a cover glass, and the cotton under the slide glass was moistened with sterile distilled water to create sufficient humidity. The Petri dishes were incubated at 28-30°C. After the fungus has grown, the cover glass is removed, placed on a new slide glass stained with Lactophenol Cotton Blue, and observed under a microscope (Prabandari *et al*., 2024; Tjampakasari *et al*., 2024). Microscopic characteristics include observation of fungal cellular structures, such as hyphae, hyphal colour, conidial shape, conidial colour, conidiophore type, conidiophore colour, conidiophore wall, vesicles, and phialides (Ajmera *et al*., 2019; Gow *et al*., 2017; Julianty *et al*., 2024; Nyongesa *et al*., 2015; Septiana *et al*., 2023). The identification stage was conducted by matching the results of macroscopic and microscopic observations of fungi with the identification book *Illustrated Genera of Imperfect Fungi* (Barnett and Hunter, 1998), and *Pengenalan Kapang Tropik Umum* (Gandjar *et al*., 1999), as well as scientific articles.

RESULTS

The research results include data on fungal isolates from Senduro goat feces taken directly from the Senduro goat farm in Senduro District, Lumajang Regency, East Java, Indonesia. The data were collected from two groups, namely adult goats and young goats, to analyse the diversity of fungi between age groups. The adult Senduro goat feces fungal isolates analysed were isolated from dilutions ranging from 10^{-6} to 10^{-8}. The dilution process used NaCl solution as a solvent, and the diluted suspension was then inoculated in duplicate on PDA medium and incubated for 7 days at 28-30°C. Single colonies growing on PDA medium were transferred using a sterile *corkborer* for macroscopic observation of colony morphology (Figures 1 and 2). Meanwhile, microscopic observation was conducted using the *slide culture* method to facilitate the observation of fungal cellular structures under light microscope (Figure 3). During the isolation process, nine fungal isolates were successfully obtained, designated as FKSD 1, FKSD 2, FKSD 3, FKSD 4, FKSD 5, FKSD 6, FKSD 7, FKSD 8, and FKSD 9. All fungal isolates were further characterised based on macroscopic and microscopic characteristics, as summarised in Table 1 and Table 2.

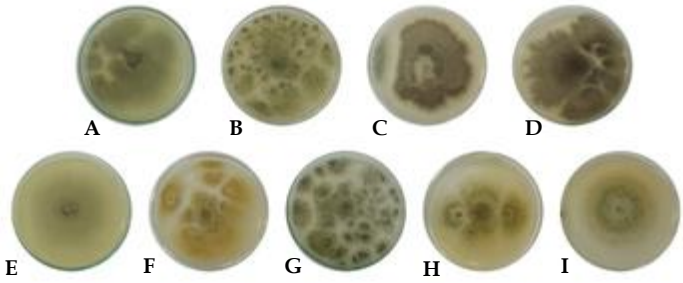


Figure 1. Macroscopic morphology of the upper surface of the isolated adult Senduro goat feces fungal colonies: (A) FKSD 1; (B) FKSD 2; (C) FKSD 3; (D) FKSD 4; (E) FKSD 5; (F) FKSD 6; (G) FKSD 7; (H) FKSD 8; (I) FKSD 9

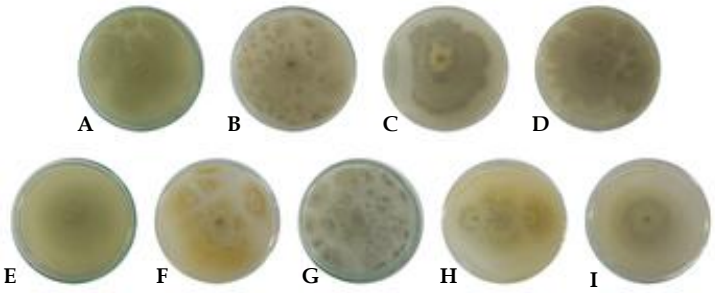


Figure 2. Macroscopic morphology of the lower (inverted) surface of an isolated adult Senduro goat feces fungal colonies: (A) FKSD1; (B) FKSD 2; (C) FKSD 3; (D) FKSD 4; (E) FKSD 5; (F) FKSD 6; (G) FKSD 7; (H) FKSD 8; (I) FKSD 9

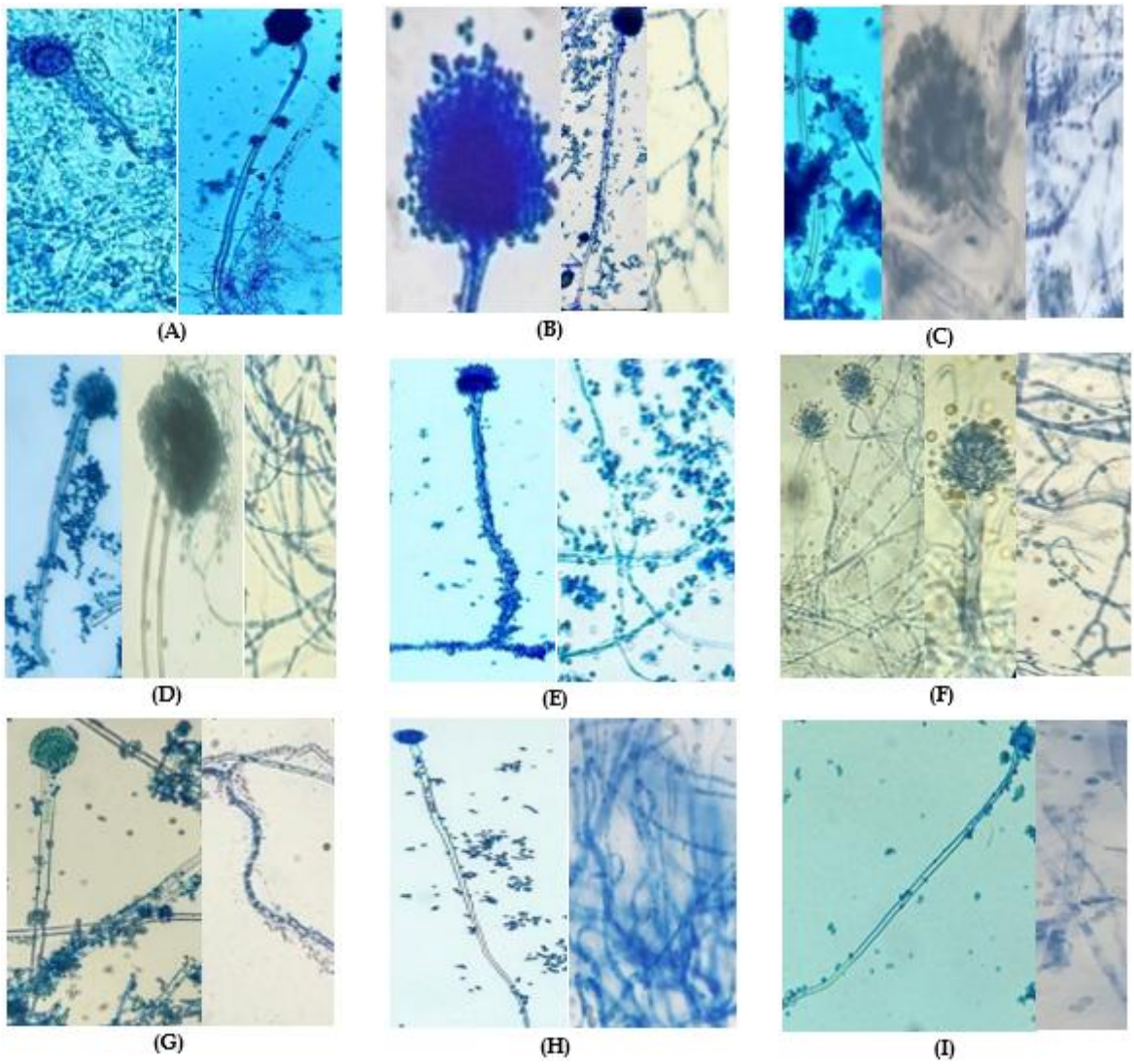


Figure 3. Microscopic morphology of adult Senduro goat feces fungal isolates: (A) FKSD 1; (B) FKSD 2; (C) FKSD 3; (D) FKSD 4; (E) FKSD 5; (F) FKSD 6; (G) FKSD 7; (H) FKSD 8; (I) FKSD 9

Based on the data in Table 1 and Table 2, the morphological characteristics of the fungal isolates from the feces of adult Senduro goats show a variety of colony shapes, including circular, filamentous, and irregular. The color of the surface and back of the colony shows variations such as green, black, white, beige, gray, brown, and yellow. In terms of texture, there are two types: powdery (FKSD 1, FKSD 5, FKSD 8, FKSD 9) and cottony (FKSD 2, FKSD 3, FKSD 4, FKSD 6, FKSD 7). The mycelium type of all isolates is aerial. Colony elevation characters vary; isolates (FKSD 1 and FKSD 5) have flat elevations, while isolates (FKSD 2, FKSD 3, FKSD 4, FKSD 6, FKSD 7, FKSD 8, FKSD 9) show an umbonate shape. The topography of each isolate varies, including flat (FKSD 1 and FKSD 5), wrinkled (FKSD 2, FKSD 6, FKSD 7, FKSD 8, FKSD 9), and undulate (FKSD 3 and FKSD 4). Colony edges in isolates are predominantly filamentous (FKSD 2, FKSD 6, FKSD 7, FKSD 8, FKSD 9), while entire (FKSD 1 and FKSD 5), undulate (FKSD 3 and FKSD 4). Colony diameter varies depending on the isolate during the seven-day incubation period.

Table 1. Characterisation of adult Senduro goat feces fungal isolates with isolate codes FKSD 1-FKSD 5.

Characters	Isolate Code				
	FKSD1	FKSD2	FKSD3	FKSD4	FKSD5
Macroscopic					
Shape	Circular	Filamentous	Irregular	Irregular	Circular
Surface color	Dark green	Greenish-gray	Black	Black	Greenish-gray
Reverse color	Yellowish-green	White-brown	Cream-brown	Cream-brown	White-yellowish
Texture	Powdery	Cottony	Cottony	Cottony	Powdery

Mycelium	Aerial	Aerial	Aerial	Aerial	Aerial
Elevation	Flat	Umbonate	Umbonate	Umbonate	Flat
Topography	Flat	Wrinkled	Undulate	Undulate	Flat
Margin	Entire	Filamentous	Undulate	Undulate	Entire
Colony Diameter	2-3.5 cm	1.5-3 cm	5-7 cm	4-4.5 cm	6-6.5 cm
Microscopic					
Hyphae	Septate	Septate	Septate	Septate	Septate
Hyphae color	Hyaline	Hyaline	Hyaline	Hyaline	Hyaline
Conidia shape	Round	Round to semi-round	Round	Round	Round to semi-round
Color of conidia	Hyaline	Hyaline	Hyaline	Hyaline	Hyaline
Type of conidiophores	Single	Single	Single	Single	Single
Color of conidiophores	Hyaline	Hyaline	Hyaline	Hyaline	Hyaline
Wall of conidiophores	Smooth	Smooth	Smooth	Smooth	Rough
Vesicle	Round to semi-round	Round	Round	Round	Round to semi-round
Phialid	Uniseriate	Biseriate	Biseriate	Biseriate	Biseriate
Genus	*Aspergillus*	*Aspergillus*	*Aspergillus*	*Aspergillus*	*Aspergillus*

Table 2. Characterisation of adult Senduro goat feces fungal isolates with isolate codes FKSD 6-FKSD 9.

Characters	**Isolate Code**			
	FKSD 6	**FKSD 7**	**FKSD 8**	**FKSD 9**
Macroscopic				
Shape	Filamentous	Circular	Filamentous	Circular
Surface color	Yellowish green	Dark green	Dark greenish-yellow	Yellowish green
Reverse color	Cream-yellow	White-green	White-yellowish	White-green
Texture	Cottony	Cottony	Powdery	Powdery
Mycelium	Aerial	Aerial	Aerial	Aerial
Elevation	Umbonate	Umbonate	Umbonate	Umbonate
Topography	Wrinkled	Wrinkled	Wrinkled	Wrinkled
Margin	Filamentous	Filamentous	Filamentous	Filamentous
Colony Diameter	2-4 cm	1.5-2 cm	2.5-4 cm	6-7 cm
Microscopic				
Hyphae	Septate	Septate	Septate	Septate
Hyphae color	Hyaline	Hyaline	Hyaline	Hyaline
Conidia shape	Round	Round	Round	Round
Color of conidia	Green	Hyaline	Hyaline	Hyaline
Type of conidiophores	Single	Single	Single	Single
Color of conidiophores	Hyaline	Hyaline	Hyaline	Hyaline
Wall of conidiophores	Smooth	Rough	Smooth	Rough
Vesicle	Round	Round	Round	Round
Phialid	Biseriate	Biseriate	Uniseriate	Uniseriate
Genus	*Aspergillus*	*Aspergillus*	*Aspergillus*	*Aspergillus*

All isolates have hyaline septate hyphae. The shape of conidia for isolates (FKSD 2 and FKSD 5) is round to semi-round, whereas those of isolates (FKSD 1, FKSD 3, FKSD 4, FKSD 6, FKSD 7, FKSD 8, FKSD 9) are round. The color of conidia in all isolates is hyaline. All isolates have single-type conidiophores that are hyaline. The walls of conidiophores of isolates (FKSD 1, FKSD 2, FKSD 3, FKSD 4, FKSD 6, FKSD 8) are smooth, while isolates (FKSD 5, FKSD 7, FKSD 9) are rough. The vesicles in isolates (FKSD 1 and FKSD 5) are round to semi-round, while those in isolates (FKSD 2, FKSD 3, FKSD 4, FKSD 6, FKSD 8, FKSD 9) are round. There are two types of phialides, namely uniseriate (FKSD 1, FKSD 8, FKSD 9) and biseriate (FKSD 2, FKSD 3, FKSD 4, FKSD 5, FKSD 6, FKSD 7).

Fungal isolates from the feces of young Senduro goats were obtained by dilution at a ratio of 10^{-2} to 10^{-7}. The dilutions were performed using sterile physiological NaCl solution as the solvent, and each suspension was then inoculated in duplicate onto sterile PDA medium as the fungal growth medium. All plates were incubated at 28–30°C for 7 days to provide optimal conditions for fungal colony growth. After incubation, single colonies were transferred using a sterilized *cork borer* to a new medium for macroscopic morphological observation. Microscopic observation was performed using the *slide culture* method to facilitate the observation of fungal cellular structures under a microscope at magnifications of 400× and 1000×. The isolation results yielded seven fungal isolates coded FKSA 1, FKSA 2, FKSA 3, FKSA 4, FKSA 5, FKSA 6, and FKSA 7. The code FKSA stands for "Feces of Young Senduro Goat" and is used to indicate the origin of the isolate samples. All fungal isolates were further

characterized based on macroscopic characteristics observable visually and microscopic characteristics obtained from microscopic observations, with the results presented in Table 3 and Table 4.

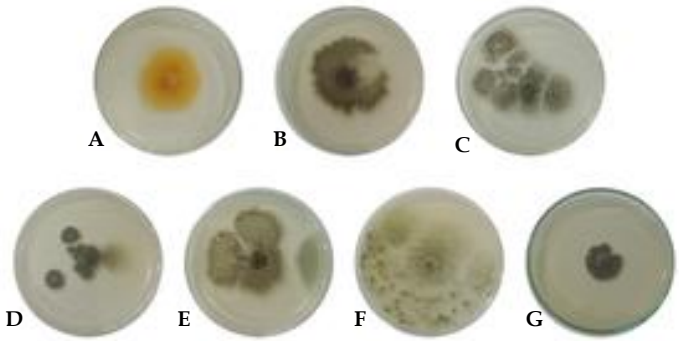


Figure 4. Macroscopic morphology of the upper surface of the isolated young Senduro goat feces fungal colonies: (A) FKSA1; (B) FKSA 2; (C) FKSA 3; (D) FKSA 4; (E) FKSA 5; (F) FKSA 6; (G) FKSA 7

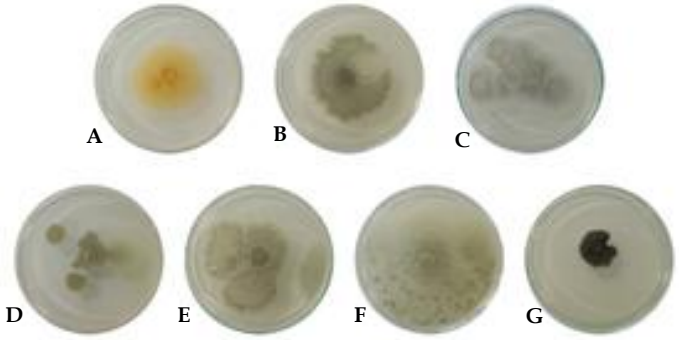
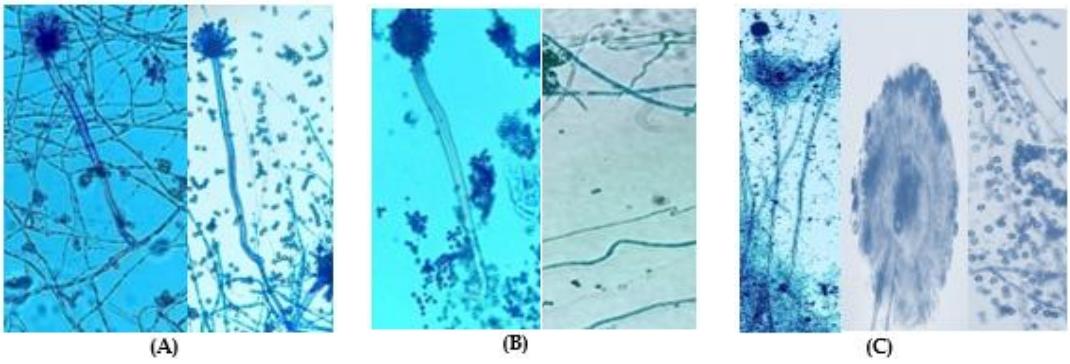


Figure 5. Macroscopic morphology of the lower (inverted) surface of isolated young Senduro goat feces fungal colonies: (A) FKSA 1; (B) FKSA 2; (C) FKSA 3; (D) FKSA 4; (E) FKSA 5; (F) FKSA 6; (G) FKSA 7

Based on the data in Table 3 and Table 4, colony shapes vary, such as circular, irregular, and filamentous. There is variation in color among the colonies, with combinations of yellow, gray, black, green, brown, and white. There are various types of texture in the isolates, namely glabrous with slightly powdery (FKSA 1), cottony (FKSA 2, FKSA 3, FKSA 5, FKSA 6), velvety (FKSA 4 and FKSA 7). All isolates (FKSA 1, FKSA 2, FKSA 3, FKSA 4, FKSA 5, FKSA 6) are aerial, while isolate (FKSA 7) is classified as immerse. The character of the colony elevation varies in each isolate, namely flat (FKSA 1), umbonate (FKSA 2, FKSA 5, FKSA 6, FKSA 7), raised (FKSA 3), and convex (FKSA 4). The colony topography of each isolate varies, including flat (FKSA 1 and FKSA 4), undulate (FKSA 2, FKSA 3, FKSA 5), wrinkled (FKSA 6), and umbonate (FKSA 7). The edges of the colonies on the isolates vary, such as entire (FKSA 1, FKSA 4, FKSA 5, FKSA 7), undulate (FKSA 2 and FKSA 3), and filamentous (FKSA 6). The diameter of the colonies varies in size depending on the isolate during the seven-day incubation period.



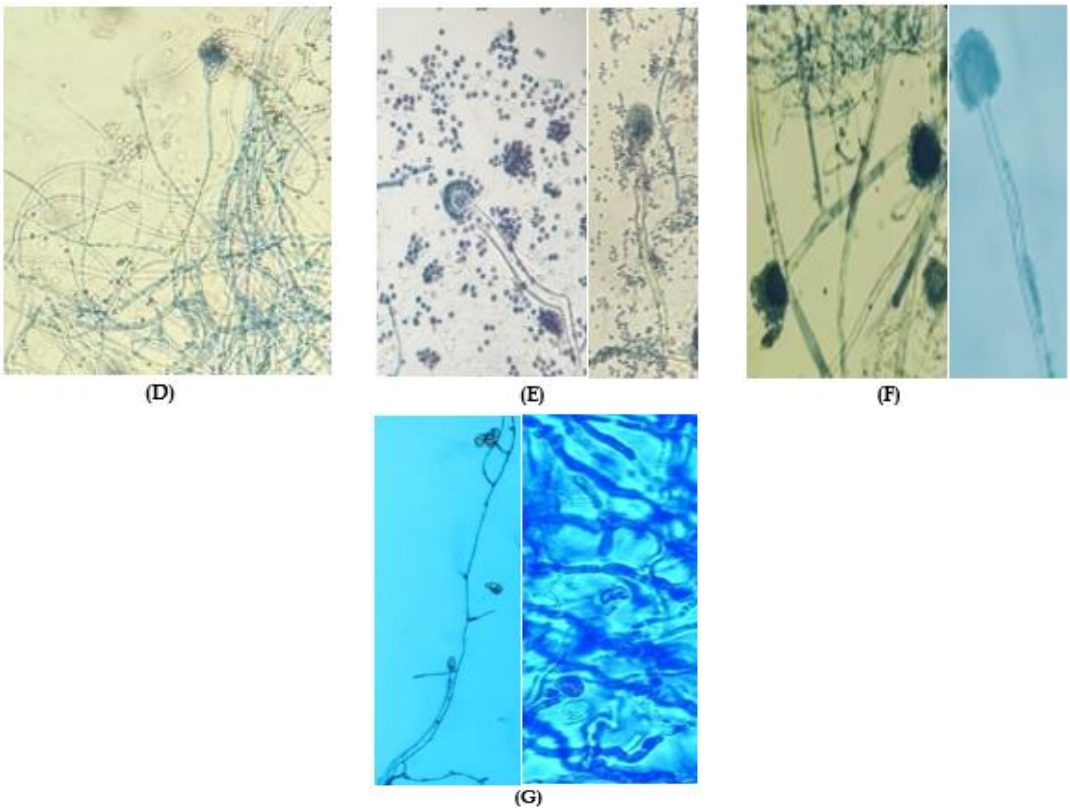


Figure 6. Microscopic morphology of young Senduro goat feces fungal isolates: (A) FKSA 1; (B) FKSA 2; (C) FKSA 3; (D) FKSA 4; (E) FKSA 5; (F) FKSA 6; (G) FKSA 7

Table 3. Characterisation of young Senduro goat feces fungal isolates with isolate codes FKSA 1-FKSA 4.

Characters	Isolate Code			
	FKSA 1	**FKSA 2**	**FKSA 3**	**FKSA 4**
Macroscopic				
Shape	Circular	Irregular	Circular	Circular
Surface color	Yellowish-brown	Grayish-black	Black	Greenish-brown
Reverse color	White-yellowish	White-grayish	White-grayish	White-brown
Texture	Glabrous-powdery	Cottony	Cottony	Velvety
Mycelium	Aerial	Aerial	Aerial	Aerial
Elevation	Flat	Umbonate	Raised	Convex
Topography	Flat	Undulate	Undulate	Flat
Margin	Entire	Undulate	Undulate	Entire
Colony Diameter	4.5-5 cm	5-5.5 cm	3-4 cm	1.5-2 cm
Microscopic				
Hyphae	Septate	Septate	Septate	Septate
Hyphae color	Hyaline	Hyaline	Hyaline	Hyaline
Conidia shape	Round	Round	Round	Elips
Color of conidia	Hyaline	Hyaline	Hyaline	Slightly green hyaline
Type of conidiophores	Single	Single	Single	Branched
Color of conidiophores	Hyaline	Hyaline	Hyaline	Slightly green hyaline
Wall of conidiophores	Smooth	Smooth	Smooth	Smooth
Vesicle	Round	Round	Round	-
Phialid	Biseriate	Uniseriate	Biseriate	Uniseriate
Genus	*Aspergillus*	*Aspergillus*	*Aspergillus*	*Penicillium*

Table 4. Characterisation of young Senduro goat feces fungal isolates with isolate codes FKSA 5-FKSA 7.

Characters	Isolate Code		
	FKSA 5	**FKSA 6**	**FKSA 7**
Macroscopic			
Shape	Irregular	Filamentous	Circular
Surface color	Blackish-green	Green	Grayish-black
Reverse color	White-grayish	White-green	White-grayish
Texture	Cottony	Cottony	Velvety
Mycelium	Aerial	Aerial	Immerse
Elevation	Umbonate	Umbonate	Umbonate
Topography	Undulate	Wrinkled	Umbonate

Margin	Entire	Filamentous	Entire
Colony Diameter	2.5-5 cm	2-3.5 cm	3-3.5 cm
Microscopic			
Hyphae	Septate	Septate	Septate
Hyphae color	Hyaline	Hyaline	Hyaline
Conidia shape	Round	Round	Elips
Color of conidia	Hyaline	Hyaline	Brown
Type of conidiophores	Single	Single	Branched
Color of conidiophores	Hyaline	Hyaline	Brown
Wall of conidiophores	Rough	Smooth	Slightly rough
Vesicle	Round	Round to semi-round	-
Phialid	Uniseriate	Uniseriate	-
Genus	*Aspergillus*	*Aspergillus*	*Alternaria*

Note: (-) = not available

All isolates have hyaline septate hyphae. The shape of conidia varies among isolates: FKSA 1, FKSA 2, FKSA 3, FKSA 5, and FKSA 6 have round conidia, while FKSA 4 and FKSA 7 have elliptical conidia. The color of conidia varies, such as hyaline (FKSA 1, FKSA 2, FKSA 3, FKSA 4, FKSA 5), slightly green hyaline (FKSA 4), and brown (FKSA 7). There are two types of conidiophores, namely single (FKSA 1, FKSA 2, FKSA 3, FKSA 5, FKSA 6) and branched (FKSA 4 and FKSA 7). The color of conidiophores in isolates (FKSA 1, FKSA 2, FKSA 3, FKSA 5, FKSA 6) was predominantly hyaline, while (FKSA 4) was slightly green hyaline, and (FKSA 7) was brown. The walls of conidiophores were predominantly smooth in isolates (FKSA 1, FKSA 2, FKSA 3, FKSA 4, FKSA 6), while (FKSA 5) was rough, and (FKSA 7) was slightly rough. Round vesicles were found in isolates (FKSA 1, FKSA 2, FKSA 3, FKSA 4), round to semi-round vesicles were found in isolate (FKSA 6), while no vesicles were found in isolates (FKSA 4 and FKSA 7). The types of phialids observed were uniseriate (FKSA 2, FKSA 4, FKSA 5, FKSA 6) and biseriate (FKSA 1 and FKSA 3), while (FKSA 7) did not show phialid structures.

DISCUSSION

Fungal isolation from Senduro goat feces showed differences between adult and young goats. Feces isolates from adult Senduro goats yielded nine isolates coded FKSD 1, FKSD 2, FKSD 3, FKSD 4, FKSD 5, FKSD 6, FKSD 7, FKSD 8, and FKSD 9, which consistently produced *Aspergillus* isolates, indicating the dominance of this fungal genus. In contrast, fungal isolates from Senduro goat feces yielded seven fungal isolates with the following details: FKSA 1, FKSA 2, FKSA 3, FKSA 5, FKSA 6 (*Aspergillus*), FKSA 4 (*Penicillium*), and FKSA 7 (*Alternaria*). The book characterized these isolates, *Illustrated Genera of Imperfect Fungi* (Barnett and Hunter, 1998) and *Pengenalan Kapang Tropik Umum* (Gandjar *et al*., 1999).

The fungal isolates from the feces of adult Senduro goats, namely FKSD 1, FKSD 2, FKSD 3, FKSD 4, FKSD 5, FKSD 6, FKSD 7, FKSD 8, and FKSD 9, share similarities in both their macroscopic and microscopic characteristics. Macroscopic observations include various colony shapes, namely round, thread-like, and irregular, as well as various surface and underside colors, such as yellow, gray, black, green, brown, and white. These results are consistent with the study by Atallah *et al.* (2022), which showed that *Aspergillus* sp. fungal colonies have a round shape with varying colors, such as dark brown, white, and yellow, depending on the species and environmental conditions. Based on their texture characteristics, the fungal isolates obtained were grouped into two types: *powdery* for isolates FKSD 1, FKSD 5, FKSD 8, FKSD 9, and *cottony* for isolates FKSD 2, FKSD 3, FKSD 4, FKSD 6, FKSD 7. The powdery texture of *Aspergillus* indicates the production of dry spores, while the cottony texture indicates dense mycelium (Ristiari *et al*., 2018; Handoko *et al*., 2022). All isolates exhibited aerial mycelium, consistent with the findings of Bleichrodt *et al.* (2013) on *Aspergillus niger*, characterized by hyphae growing upward and developing into conidiophores and conidia. The elevation of *Aspergillus* colonies observed was flat and umbonate, with a flat, wrinkled, undulate topography and filamentous, entire, undulate margins, consistent with the study by Géry *et al.* (2021), which reported similar morphological variations, including diverse topography and margins. Additionally, the growth of *Aspergillus* colonies can exhibit significant variations in diameter during the incubation period,

reflecting the fungus's adaptation to the environmental conditions of its growth medium (Sandoval-Contreras *et al*., 2017).

The microscopic characteristics of all fungal isolates from the feces of adult Senduro goats include septate hyphae, hyaline color, conidia shapes ranging from round to semi-round, and conidia color variations, including hyaline and green, consistent with the characteristic features of the genus *Aspergillus*. A study by Sopialena *et al.* (2022) confirmed that *Aspergillus* has septate hyphae with spherical conidia and varying colors depending on the species, ranging from green, yellow, brown, to black. Additionally, round vesicles, hyaline conidiophores with rough and smooth walls are also characteristic of *Aspergillus*, as reported by Hubka *et al.* (2015) and Zakaria (2018) in their taxonomic studies of this genus. Isolates with the fialid type *uniseriate* FKSD 1, FKSD 8, FKSD 9, and *biseriate* FKSD 2, FKSD 3, FKSD 4, FKSD 5, FKSD 6, FKSD 7 support the description by Houbraken *et al.* (2020) that *Aspergillus fumigatus* has uniseriate fialides, while *Aspergillus niger* and *Aspergillus flavus* have biseriate fialides.

The fungal isolates from Senduro goat feces, namely FKSA 1, FKSA 2, FKSA 3, FKSA 4, FKSA 5, FKSA 6, and FKSA 7, exhibit differences in both their macroscopic and microscopic characteristics. The *Aspergillus* isolates FKSA 1, FKSA 2, FKSA 3, FKSA 5, and FKSA 6 exhibit colony morphology characterized by predominantly round shapes and color variations such as yellow, gray, and brown, as well as varying textures including cottony, glabrous, slightly powdery, and velvety. These characteristics align with the findings of Hossain and Ali (2021), who reported *Aspergillus* colonies as round, thick, cottony in texture, and colored white, yellow, brown, gray, or black. The diversity of colony textures and elevations, such as flat, umbonate, raised, and margin variations from entire to filamentous, demonstrates the adaptation and morphological diversity of *Aspergillus,* as found by Oktaviyani *et al.* (2025) in a related study on the isolation of microplastic-degrading fungi, which reported similar macroscopic characteristics in *Aspergillus* isolates. Additionally, the microscopic characteristics of the *Aspergillus* isolates include hyaline septate hyphae, round conidia, hyaline in color, and single conidiophores, also hyaline, with smooth and rough walls, round vesicles, and uniseriate or biseriate phialides. These findings are consistent with the report by Murtafi'ah *et al*. (2022), which described Aspergillus as having hyaline septate hyphae, globose conidia, hyaline in color, and phialides. Additionally, Wangge *et al*. (2012) reported that *Aspergillus* conidia are spherical to semispherical, brown in color, with spherical to semispherical vesicles. *Aspergillus* conidiophores may have rough or smooth walls (Khalil, 2016; Khalil and Hashem, 2018).

FKSA 4 isolate was identified as *Penicillium*, exhibiting macroscopic morphological characteristics such as velvety colonies, greenish-brown color, convex elevation, flat topography, and entire margins. These results are similar to the morphological characteristics reported by Araújo *et al.* (2024), namely a velvety or velvety texture, convex or convex colony elevation, while the topography and edges of the colony appear flat. Microscopic observations such as septate hyphae, elliptical conidia, hyaline or greenish, branched conidiophores, hyaline and smooth-walled, and the presence of phialides support the identification of the genus *Penicillium*, consistent with Munawati's (2021) study, which states that the identification of this genus is highly dependent on the shape and branching of conidiophores, the presence of phialides, and the morphology of conidia.

FKSA 7 isolate was identified as *Alternaria*, showing round colony morphology, grayish black in color, velvety in texture, immersed mycelium, umbonate elevation and topography, and entire margins. The microscopic characteristics of this isolate include septate hyphae, hyaline in color, elliptical conidia with a brown color, branched conidiophores, brown in color, and slightly rough walls. These characteristics are similar to those reported by Ajmal *et al.* (2016) for *Alternaria alternata*, which has branched, septate hyphae, branched conidiophores, golden brown color, and elliptical conidia. Additionally, the characteristics of isolate FKSA 7 are also similar to the description of *Alternaria muriformis* according to Iturrieta-González and Gené (2023), which include round, flat colonies with regular edges, septate hyphae, subhyaline to pale olive, an immersed mycelium, and elliptical conidia forming chains and colored brownish-yellow to brown.`

Female goats, particularly the local Senduro breed, were selected for this study because they are dual-purpose livestock for milk and meat production. According to the survey by Arisani *et al*. (2022), Senduro goats exhibit higher milk performance compared to Peranakan Etawa goats, with an average milk production of approximately 73.9 ml per day and superior milk quality, including higher protein, lactose, and total solids content. This indicates that Senduro goats are capable of demonstrating livestock productivity aspects and are relevant for supporting microbiological research based on feces from livestock actively involved in milk and meat production. Additionally, Trimulyono *et al*. (2025) revealed that Senduro goat milk is a habitat for various microorganisms with diverse characteristics. These findings support the hypothesis that Senduro goats also have the potential to harbor other microbial diversity, including fungi, through fecal analysis. Fungal diversity in adult and young Senduro goats' feces can be influenced by age, feed type, gastrointestinal pH, farming practices, and geographical conditions (Mayulu, 2023). Goat age is vital in gut microbiota development, including fungal communities. In adult goats, the digestive system, particularly the rumen, has matured and functions optimally to ferment high-fiber feed such as grass, leaves, concentrates, and cassava pulp. Research by Abd El-Tawab *et al.* (2021) identified fungi in fecal samples from sheep and goats with different ages and diets, including *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus fischeri, Aspergillus fumigatus*, *Aspergillus terreus, Aspergillus carbonarius, Fusarium chlamydosporum, Penicillium expansum, Penicillium griseofulvum, Penicillium simplicissimum, Rhizopus* spp., *Mucor* spp., *Eurotium chevalieri,* and *Eurotium rubrum*.

Aspergillus isolates were more commonly found in adult goats, with nine isolates identified. This can be attributed to a mature digestive system and a stable rumen pH range of 6–7, ideal for *Aspergillus* enzymatic activity. According to Jemiman *et al*. (2025), rumen pH in goats within this range supports optimal rumen microbial activity. The appropriate pH of rumen fluid is essential for optimal microbial fermentation processes in the rumen. The digestive system, particularly the rumen, is not yet fully developed in young goats. This results in fewer fungal isolates, totaling seven isolates, with a more diverse fungal genus, including *Aspergillus*, *Penicillium*, and *Alternaria*. Research by Wang *et al.* (2020) indicates that the development of gut microbiota in young goats is influenced by the type of feed provided. Feeding with low fiber content limits the colonization of microorganisms capable of degrading fiber. A study by Zhang *et al*. (2019) supports that the rumen of young goats is not yet optimal for the growth of cellulolytic fungi, resulting in a more heterogeneous fungal community.

Gut microbiota diversity in young goats tends to be unstable and more susceptible to environmental and dietary changes, allowing colonization by microorganisms such as *Penicillium* (FKSA 4) and *Alternaria* (FKSA 7), tolerant to pH fluctuations and an immature digestive system. The immune system of ruminant kids, particularly the GALT tissues, does not fully develop until exposure to environmental antigens and gut microbes (Welch *et al*., 2022; Weström *et al*., 2020). These differences are related to microbiota colonization from early life to solid feed intake, which diversifies the microbiota and stabilizes it with age (Chai *et al*., 2021; Du *et al*., 2023). In adult goats, the microbiota is relatively stable due to a consistent diet and the ability to control pathogenic microbes (Argisyamanti *et al*., 2019).

Isolates of *Aspergillus* dominated the feces of adult goats (FKSD 1–9) and some young (FKSA 1, FKSA 2, FKSA 3, FKSA 5, FKSA 6), with the potential to produce various enzymes such as amylase, pectinase, xylanase, cellulase, chitinase, and protease for the hydrolysis of lignocellulosic biomass (Laothanachareon *et al*., 2022; Olanbiwoninu and Odunfa, 2016; Djunaidi *et al*., 2020). Research by Isnawati and Trimulyono (2018) also showed that fungi such as *Aspergillus* have high cellulolytic activity on various fibrous substrates. *Penicillium* was identified in FKSA 4; this genus adapts to simple organic substrates and supports decomposition in the digestive tract of young animals, and can produce α-amylase, lipase, and cellulolytic enzymes (Guevara-Suarez *et al*., 2020; Dar *et al*., 2015). *Alternaria* was found in FKSA 7, commonly growing on moist forage and silage, secreting proteases, cellulases, and xylanases, but also potentially carrying metabolites and mycotoxins (Gallo *et al*., 2015; Singh and Choudhary, 2023; Tramalazza *et al*., 2018; García-Calvo *et al*., 2018; Zaferanloo *et al*., 2014). These three

genera play an essential role in industry and agriculture through the production of cellulolytic enzymes and bioethanol, as well as feed fermentation (Alriksson *et al*., 2009; Ahmed *et al*., 2025), though they carry the risk of producing mycotoxins or pathogenic allergens, necessitating proper management (Sukmawati *et al*., 2018; Christoper *et al*., 2022; Edyansyah, 2016; Faturrachman and Mulyana, 2019).

CONCLUSION

Fungi isolated from the feces of adult Senduro goats consisted of nine isolates (FKSD 1–9), all of which were identified as *Aspergillus*. Meanwhile, isolation from the feces of Senduro young goat yielded seven isolates, namely FKSA 1, FKSA 2, FKSA 3, FKSA 5, and FKSA 6 as *Aspergillus*, FKSA 4 as *Penicillium*, and FKSA 7 as *Alternaria*. Each isolate exhibited distinct macroscopic and microscopic characteristics. The information obtained is expected not only to contribute to knowledge about fungal microbiota in Senduro goats but also to open up potential for research on fungi as cellulolytic agents, starters, probiotics, enzyme sources, and prevention against potential pathogenic fungi that may affect human and livestock health.

ACKNOWLEDGEMENTS

The author would like to express his deepest gratitude to the Senduro goat farm in Senduro District, Lumajang Regency, East Java, Indonesia, for permission to collect samples of Senduro Goat feces for this study.

CONFLICT OF INTEREST

There is no conflict of interest.

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