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QUALITY AND NICOTINE CONTENT DIFFERENCES OF MADURA TOBACCO FROM *SAWAHAN* (PADDY FIELD) AND *TEGALAN* (DRYLAND) IN INDONESIA

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ABSTRACT

Tobacco is one of Indonesia's major plantation commodities, with Madura tobacco holding a distinctive position in the national market. Its sensory quality is influenced by various factors, including the type of land where it is cultivated. This study examined differences in quality attributes and nicotine presence between Madura tobacco grown on paddy field (*Sawahan*) and on dryland (*Tegalan*). An experimental approach was applied, combining organoleptic assessment and a simple qualitative nicotine test. The organoleptic evaluation involved 15 purposively selected participants who met three criteria within the past decade: active smokers, tobacco farmers, and native Madurese. Five quality indicators, including texture, taste, color, aroma, and combustibility, were rated on a 1–9 scale. The presence of nicotine was assessed using turmeric extract as an acid–base indicator, enabling a rapid visual detection in field conditions. The results showed that *Tegalan* tobacco scored higher on four sensory attributes (texture 7.67, color 6.07, taste 6.93, aroma 6.87, combustibility 7.30) compared to *Sawahan* tobacco (texture 5.80, color 8.2, taste 2.13, aroma 2.67, combustibility 3.60). The qualitative test confirmed the presence of nicotine in both types, indicated by the development of a reddish-brown coloration. These findings suggest that land type substantially influences the sensory quality of Madura tobacco, while simple field-based methods can be employed for rapid nicotine screening, offering practical value for farmers and local stakeholders.

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INTRODUCTION

Tobacco remains one of the most important crops worldwide, playing a big role in the economies of many countries despite the well-known health and environmental challenges it brings (Yahui et al., 2021). Globally, the tobacco industry keeps growing and becoming more concentrated, affecting how tobacco is produced and traded across regions (Shonhe et al., 2022). Indonesia is a major tobacco producer, ranking sixth globally in 2017. Indonesia is a major player in tobacco farming, where this crop supports millions of farmers and contributes significantly to local and national incomes (Audrine, 2020). Yet, the sector faces challenges like fluctuating yields, soil degradation, and increasing concerns over the health risks linked to tobacco use.

In Indonesia, tobacco grows in quite different environments. Two common land types where tobacco is cultivated are paddy fields, called *Sawahan,* and dry lands, known locally as *Tegalan*. These land types have different physical and chemical characteristics that affect how tobacco plants grow and the quality of their leaves (Kitanov, 2023). Madura tobacco is a special local variety that does well in dry, less fertile soils where many other crops struggle. Its leaves are prized for their unique aroma and flavor, especially as a key ingredient in kretek cigarettes, which are culturally important in Indonesia. Despite how vital Madura tobacco is economically and culturally, there is limited scientific research comparing how the quality and nicotine content vary depending on the region where it is cultivated.

Many factors influence tobacco quality and yield, including soil type, moisture, climate, and farming practices (Putri & Wahyudi, 2023; Santoso et al., 2021). Soil moisture, in particular, is crucial: too little or too much can harm the plants. Some farmers use modern irrigation systems to keep the soil conditions just right, helping to boost their harvests (Hertadi et al., 2024). Understanding how these environmental factors interact with different land types is important for farmers, especially those growing Madura tobacco in very different places.

Nicotine, the main active substance in tobacco, is well-known for its addictive properties and health impacts (Jeong et al., 2024). While nicotine alkaloids are widely regarded as the most characteristic constituents of tobacco, it is notable that nicotine itself is not highly addictive (Rawat & Mali, 2013). Furthermore, an increase in nicotine metabolism was linked to a heightened risk of chronic obstructive pulmonary disease, lung cancer, and impaired lung function in univariable analysis (Khouja et al., 2024). Notably, 77% of tobacco farmers in the study area expressed concerns that tobacco production heightened risks to both the environment and their health. Their responses varied from somewhat positive to very positive, indicating a genuine worry about environmental and health hazards (Mim et al., 2024). While it poses significant health risks, including the stimulation of cancer cell formation (Alegantina et al., 2017), it also holds potential as an antimicrobial agent and bioinsecticide (Alegantina et al., 2017; Paramartha & Lazuardi, 2013). The amount of nicotine in tobacco leaves can vary depending on soil, climate, and how the plants are grown (Henry et al., 2019). While nicotine is a health concern, it also affects how tobacco products are valued and used. Tobacco farmers themselves are often exposed to nicotine and other risks during cultivation, which raises important health and safety issues (Dalberto et al., 2022).

Research shows that tobacco farming presents economic and health challenges. While it offers some financial benefits, these are minimal after labor costs, and farmers often face higher health risks (Van Minh et al., 2009). Factors influencing cultivation include profit, rainfall, credit access, education, and information (Sahadewo et al., 2020). Despite its negative effects, tobacco remains

common in low- and middle-income countries due to perceived profitability (Appau et al., 2019; Rahman et al., 2020). However, in some regions like Tanzania, crops like maize are more efficient (Asmerom et al., 2015). The reasons for cultivating tobacco vary by region, with some areas motivated by accessible markets or industry incentives (Appau et al., 2020). To promote alternatives, efforts should focus on improving perceptions of other crops, credit access, and supply chains (Appau et al., 2020).

The physiological effects experienced by tobacco users are primarily due to the absorption of nicotine through the oral mucosa (Kalashnikov & Shkidyuk, 2021). Tobacco farming offers both economic opportunities and health risks for cultivators. While tobacco is a valuable cash crop (Tassew & Chandravanshi, 2015), its cultivation exposes farmers to elevated levels of nicotine in the air of the lands and drying barns (Yoo et al., 2014). For instance, Ethiopian tobacco leaves exhibit varying nicotine levels, with Virginia tobacco containing the highest concentration at 3.26% (Tassew & Chandravanshi, 2015).

This study examined differences in quality attributes and nicotine presence between Madura tobacco grown on dryland (*Tegalan*) and on paddy fields (*Sawahan*). The results are expected to serve as a basis for decision-making in tobacco cultivation and the development of derivative products. It has been observed that non-smokers among tobacco farmers show a significant increase in urinary cotinine levels, indicating nicotine absorption from tobacco leaves (Onuki et al., 2003). This simple nicotine test can be an alternative visualization for active and passive smokers to see how nicotine accumulates in the lungs. By learning more about these differences, we hope to help farmers improve their cultivation methods and produce better tobacco. This underscores the critical need for education about the dangers of nicotine in tobacco, particularly about smoking within the community. Directly educating smokers and tobacco farmers is vital, as it addresses two groups directly impacted by the effects of tobacco consumption and production.

MATERIALS AND METHODS

Characteristics of the tobacco production process from *Tegalan* and *Sawahan*

Following the rice harvest season, the soil is no longer suitable for planting rice due to irrigation challenges. If farmers decide to grow rice again, they face significant operational costs for irrigation, as they must use water pumps to extract water from the river. As a result of these constraints, farmers tend to favor planting tobacco instead (Barokah et al., 2023). In Meddelan and Sendir, Indonesia, farmers practice alternating harvests of rice and tobacco on their land. This shift in planting necessitates soil improvement, as land consolidation can lead to decreased soil fertility (Zhang et al., 2018). After harvesting rice, the *Sawahan* land in these villages must be drained, and typically, they are left fallow for about two months to decrease the soil moisture levels, making it more suitable for tobacco cultivation. This period

is adequate because the unutilized land gradually loses its agricultural value and becomes overgrown with shrubs and trees (Parahnevioch et al., 2024). The process of tobacco cultivation in *Sawahan* and *Tegalan* land has significant differences in land techniques and management due to different physical conditions and soil properties. The following are the detailed stages of tobacco cultivation on the two types of land:

Table 1. Differences in the characteristics of *Sawahan* and *Tegalan* land in Madura tobacco production

Production Stages	*Sawahan* (Paddy Field)	*Tegalan* (Dryland)
Planting Preparation	• Plowed and cultivated multiple times using tractor machines, ensuring loose and well-structured soil. • Maintains a loose soil structure due to repeated plowing, which benefits crop growth. • *Sawahan* is raised slightly or formed into beds to prevent water puddles that could harm crops. Beds are created with a width of approximately 60–75 cm to allow enough space for roots and water flow. A study conducted by (Mustapha et al., 2021) concluded that the appropriate planting distance influences the yield of chili.	• Only requires one or two loosenings with a hoe or plow to prepare the soil, making it easier and quicker to ready the land. • Naturally has a looser soil structure, needing less intensive cultivation. • *Tegalan* is also raised slightly or formed into beds like in Sawahan.
Planting	Tobacco seedlings are transplanted into *Sawahan* land when they are approximately 1.5 to 2 months old. The recommended planting distance is around 40 to 50 cm between each plant. Since *Sawahan* land tends to be more humid, watering should be done with moderation to prevent the soil from becoming overly saturated.	Transplanting of tobacco seedlings into *Tegalan* land also occurs when they are about 1.5 to 2 months old, with the same spacing of approximately 40 to 50 cm. However, in *Tegalan* land, watering is conducted more frequently during the initial stages to help the seedlings adapt effectively. Watering on *Tegalan* land occurs twice as often as on *Sawahan* land.

Production Stages	*Sawahan* (Paddy Field)	*Tegalan* (Dryland)
Plant Maintenance	• Sawahan land has higher organic matter content because of the regular decomposition of plant residues like rice straw, making the soil more fertile and nutrient-rich. • This land retains moisture better and requires only 1 to 2 irrigations per week, often managed with technology to monitor soil temperature and moisture (Santoso et al., 2021). • The soil is typically more loose due to routine tillage, supporting healthy root development and optimal nutrient absorption. • Tobacco plants in Sawahan land need to be watered 1 to 2 times weekly.	• *Tegalan* land generally has lower nutrient levels because the decomposition of plant residues, such as rice straw, does not occur regularly. As a result, tobacco plants grown in *Tegalan* land require more fertilizer, including nitrogen, phosphorus, and potassium. • *Tegalan* land tends to have lower moisture content, as it is often not irrigated as frequently. This causes water shortages to occur more quickly, leading to suboptimal fertilizer absorption. • *Tegalan* soil is usually denser and less loose than *Sawahan* soil, which benefits from periodic tillage. This compaction can hinder root development and limit nutrient uptake. Supplemental fertilization helps improve soil structure, improve nutrient availability around roots, and promote better growth. • Require watering 4 to 5 times weekly due to the lower moisture levels and denser soil.
Harvesting	• Tobacco in *Sawahan* land typically takes around 25 days after flower picking to reach harvest readiness, roughly 60-90 days after planting. • The leaves are generally larger and thicker compared to Tegalan tobacco. • The harvest is conducted gradually, beginning with the bottom leaves, as ripening occurs unevenly. • Post-harvest, the leaves are dried and processed carefully, with particular attention to moisture management to ensure quality, since *Sawahan* land often maintains better moisture conditions.	• The tobacco plants in *Tegalan* land are ready for harvest approximately 20 days after the flower picking stage, which itself also occurs around 60-90 days after planting. • The leaves tend to be smaller and thinner compared to *Sawahan* tobacco. • Like *Sawahan*, Harvesting is done gradually, starting from the bottom leaves and moving upward, since the leaves do not ripen at the same time. • After harvesting, the leaves are dried and processed accordingly like in Sawahan.

Production Stages	*Sawahan* (Paddy Field)	*Tegalan* (Dryland)
Cigarette Tobacco Manufacturing	• Tobacco leaves from *Sawahan* are stored for 3-4 days in temporary storage, then cut and treated with sugar • The leaves are then arranged on "Saksak" and dried for two days. • However, tobacco from *Sawahan* need to be stored for a longer period of 3-4 years to reach optimal maturity. • There is a price difference: tobacco from *Sawahan* is purchased at approximately 60,000 per kilogram	• After harvesting, the production process for leaves from *Tegalan* is the same as that from *Sawahan*. • Tobacco from *Tegalan* land typically only requires 1-2 years of storage before being processed into cigarettes, since it is considered to have higher quality and shorter maturation time. • Tobacco from *Tegalan* is valued at around 75,000 per kilogram due to its generally better quality.

Materials

The tobacco samples utilized in the organoleptic testing were sourced from two distinct types of land: paddy fields and drylands, situated in the Sendir and Meddelan regions of Madura Island. Local farmers planted this tobacco from June to October 2024, adhering to the traditional planting season of the area. Following the harvest, the tobacco from these two land types was employed not only for organoleptic testing but also for subsequent analyses to assess nicotine levels. The nicotine testing incorporated a variety of simple tools closely associated with the daily lives of the farmers. These tools included nails, cotton, tissue, matches, papyrus sheets, glue, and additional materials such as turmeric, alongside the tobacco from both the rice paddies and dry fields. The choice of these straightforward tools was not only practical, given their accessibility in the field, but also mirrored the customs and practices of local tobacco farmers in Madura.

Methods

Information regarding the Madura tobacco planting process was gathered from farmers who subsequently participated in the next testing phase. This study utilized an experimental method involving both organoleptic and nicotine assessments. As is well known, organoleptic tests depend on sensory evaluation. A group of 15 farmers, selected based on three criteria, conducted the observations for the organoleptic tests. The criteria include being domiciled in Meddelan and Sendir villages, East Java, Indonesia; active smokers; and farmers who grow tobacco on their *Sawahan* and *Tegalan* land. The three criteria must have lasted for at least the last 10 years. During the organoleptic tests, observations focused on the tobacco's texture, color, taste, aroma, and combustibility, which were then rated according to the level of each attribute. The grading scale ranged from 1 to 9, with 1 representing the lowest quality and 9 indicating the highest quality. The tobacco plants were cultivated during the Indonesian dry season, from June to October 2024, a period that is widely recognized as optimal for the development of high-quality tobacco leaves due to lower humidity

and favorable sun exposure. The scale was categorized into three distinct levels, each of which was deemed to adequately capture and represent the inherent differences among the various tobacco types. Organoleptic tests evaluate sensory attributes of food products, including color, aroma, texture, and taste (Suryana et al., 2022):

Table 2. Quality scale of organoleptis test

It	Observation Aspect	Information	Scale
1	Texture	Rough Quite smooth Soft	1-3 4-6 7-9
2	Color	Reddish brown (not bright) Reddish brown (medium) Reddish brown (light)	1-3 4-6 7-9
3	Taste	Not good Quite tasty Delicious	1-3 4-6 7-9
4	Aroma	Not fragrant Slightly fragrant Fragrant	1-3 4-6 7-9
5	Combustibility	Non-flammable Hard to burn Flammable	1-3 4-6 7-9

The nicotine test employs turmeric extraction based on the principle of acid-base indicators. The tobacco samples analyzed were sourced from six *Tegalan* and *Sawahan* lands. These samples underwent a planting process and were dried for approximately five months. Statistical analysis was conducted using descriptive statistical methods to illustrate the organoleptic conditions, employing the averages and graphical representations. Nicotine stands out as the most prevalent alkaloid compound in base tobacco. Therefore, its presence is detected using a natural acid-base indicator derived from turmeric. The tobacco used in this study was cultivated in *Sawahan* and *Tegalan* land, specifically in the rural village area of Meddelan and Sendir, Lenteng, Sumenep, East Java, Indonesia.

RESULTS AND DISCUSSION

Organoleptic Test

a. Texture

The texture of tobacco significantly influences the sensation experienced during smoking. Generally, softer and smoother tobacco offers a more comfortable feeling in the throat than its coarser counterparts. Tobacco cultivated in *Tegalan* land tends to have a slightly finer texture than *Sawahan* land. The differences in texture quality between tobacco from these two soil types can be illustrated in the following graph:

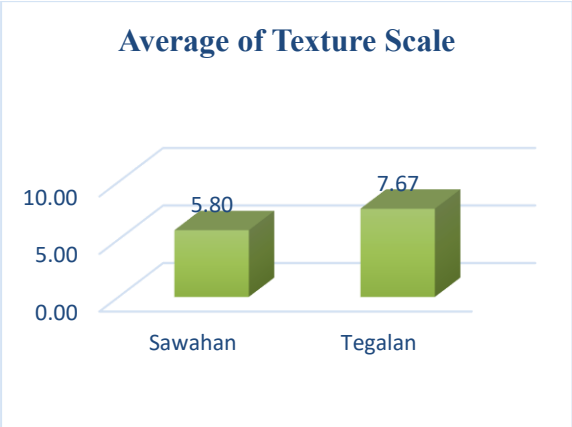


Figure 1. Comparison graph of the texture of tobacco products from *Sawahan* and *Tegalan* land

b. Color

The color variations are influenced by factors such as the type of tobacco, its processing methods, and the environmental conditions of its cultivation, including soil type and climate. Tobacco grown on *Sawahan* land yields a golden yellow hue, whereas tobacco from *Tegalan* land exhibits a brownish-yellow shade. The contrast in color quality between these two soil types is illustrated in the following graph:

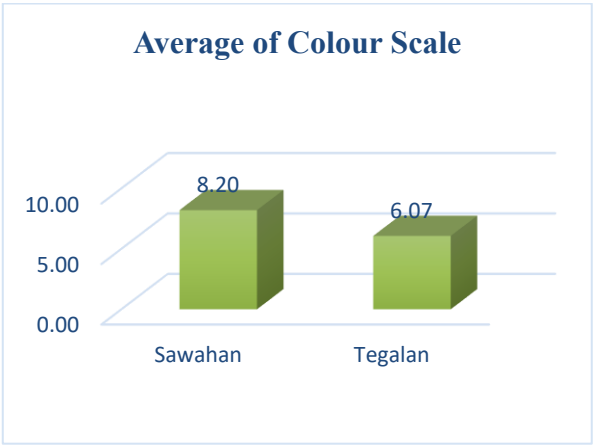


Figure 2. Graph of color comparison of tobacco products from *Sawahan* and *Tegalan* land

c. Taste

Tobacco cultivated in the *Tegalan* and *Sawahan* land exhibits distinct flavor characteristics, attributed to the differing soil conditions, moisture levels, and nutrient profiles in these two locations. When used in cigarettes, tobacco from *Sawahan* tends to produce an immediate bitter taste and an itchy sensation in the esophagus, whereas tobacco from *Tegalan* generally offers a more favorable flavor. The variation in taste

quality between the tobacco from these two soil types can be illustrated in the following graph:

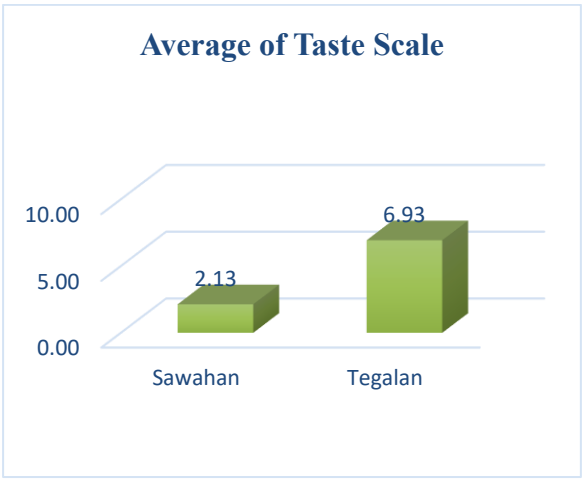


Figure 3. Comparative graph of tobacco product flavors from *Sawahan* and *Tegalan* land

d. Aroma

Tobacco cultivated in *Tegalan* land typically possesses a more intricate and robust aroma. This is attributed to the drier conditions of *Tegalan* Land soils, prompting tobacco plants to adapt by producing more concentrated chemical compounds that enhance the scent. In contrast, *Tegalan* tobacco plants thrive in a less humid environment, resulting in a more uniform aroma due to the soil's limited impact of excess moisture.

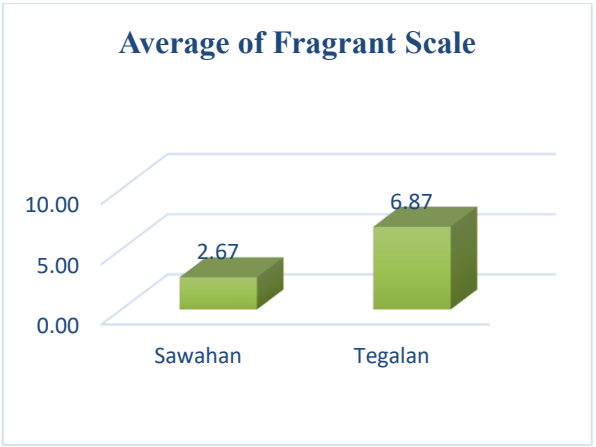


Figure 4. Comparison graph of the aroma of tobacco products from *Sawahan* and *Tegalan* land

e. Combustibility

The soil of *Sawahan* has higher humidity levels due to the irrigation system, resulting in tobacco leaves that tend to retain more moisture. Consequently, the

drying process for these leaves is more challenging. It takes longer to reach the desired level of dryness, in contrast to tobacco grown in the drier soil of *Tegalan*, which is more inherently arid.

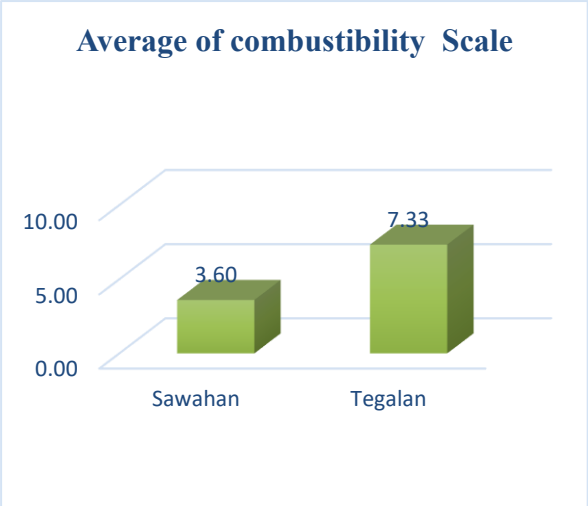


Figure 5. Comparison graph of combustible tobacco products from *Sawahan* and *Tegalan* land

The Informant was also asked about the weight of tobacco grown in different soil types. It was noted that those cultivated in *Sawahan* land tend to weigh more than those from *Tegalan* soil for the same amount of tobacco. *Sawahan* soil is generally wetter and retains more moisture than the drier *Tegalan* soil. This higher humidity allows tobacco from *Sawahan* to absorb more water, resulting in a greater overall weight than tobacco grown in *Tegalan* land. Additionally, *Sawahan* Land soils are typically denser and clayier, while *Tegalan* soils are often looser. The clay content in *Sawahan* soil helps retain moisture, whereas the loose structure of *Tegalan* soil facilitates quicker drainage, contributing to the differences in the weight of the produced tobacco.

Nicotine Test

Turmeric is a practical and user-friendly indicator in basic acid-base experiments, making it particularly useful in educational settings or science demonstrations. As a natural indicator, turmeric helps identify the acidic or base nature of a solution due to the presence of curcumin, a pigment that responds to changes in pH. Here's how turmeric functions as an acid-base indicator:

- Under acidic conditions (low pH): Turmeric maintains its distinctive yellow hue.
- In base conditions (high pH): Turmeric shifts to a reddish-brown or dark orange.

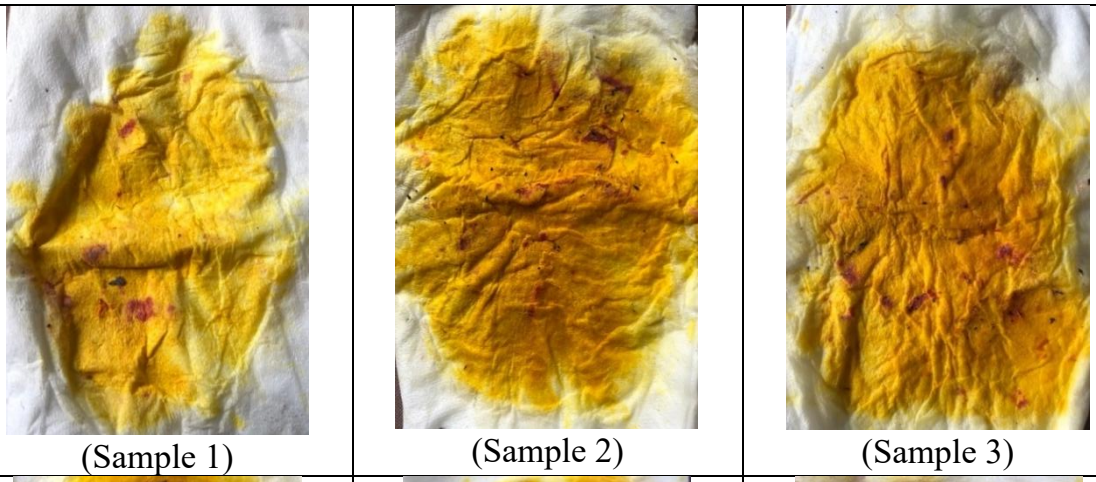
This property makes turmeric a practical and straightforward indicator for detecting base substances in a solution. It’s reaction is commonly employed in simple science experiments or at home to assess the acid-base properties of various liquids.

Figure 6. Turmeric as an indicator of acid-base

This experimental process is designed with a more contextual approach, enabling smokers to observe the color changes occurring in the turmeric indicator directly. The experiment begins by creating a hole in a bottle to accommodate cigarette smoke. Cotton is then placed inside the bottle. The tobacco is wrapped in papyrus to resemble commercially available cigarettes. Next, turmeric is prepared by grinding it to extract the juice, which is dripped onto a tissue and subsequently placed inside the bottle. The experiment is conducted by blowing cigarette smoke into the bottle, as depicted in the accompanying image.

Figure 7. Smoking demonstrator with a test bottle

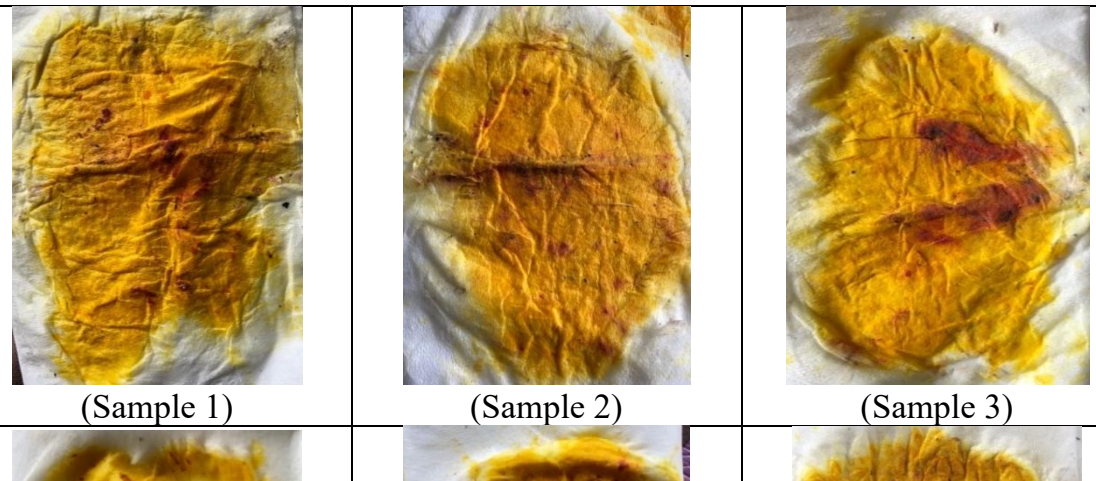
If there is a change in color to red or orange, this indicates the presence of a base reaction from nicotine, as the curcumin in turmeric will react to the base by changing color. Nicotine is the most abundant alkaloid found in tobacco compared to other alkaloids. Nicotine itself is a base. The color changes in these two types of tobacco from different lands can be seen in the following figures:



(Sample 1) (Sample 2) (Sample 3)

(Sample 4) (Sample 5) (Sample 6)

Figure 8. Nicotine appearance in the indicator of *Sawahan* tobacco turmeric



(Sample 1) (Sample 2) (Sample 3)

(Sample 4) (Sample 5) (Sample 6)

Figure 9. Nicotine appearance in the *Tegalan* tobacco turmeric indicator

Nicotine, found in tobacco, exhibits base properties. As a nitrogen-containing alkaloid, nicotine has a pH of approximately 8 in its pure form. Tobacco itself is generally base, primarily due to its nicotine content, which contributes to this characteristic. The nitrogen atoms in nicotine can engage with protons, imparting its base nature. The interaction between curcumin, the active compound in turmeric, and nicotine, an alkaloid from tobacco, is unlikely to produce significant direct chemical reactions under typical conditions, as both are relatively stable organic compounds.

Color changes observed result from alterations in the chemical structure of curcumin when it reacts with hydroxide ions (OH^-) in base solutions. This interaction leads curcumin to adopt a more ionized form, altering how it absorbs light and resulting in a noticeable color change. However, there is no significant chemical reaction between curcumin and nicotine under normal conditions. While they may physically interact or induce color changes when dissolved in base environments, they do not chemically react to form new compounds without the influence of catalysts, extreme reaction conditions, such as high temperatures, or oxidizers.

A simple experiment conducted by tobacco farmers involved using tissue coated with turmeric liquid as a medium to capture tobacco smoke. After being exposed to the smoke from burning tobacco, the tissue changed color to reddish brown. This color change visually indicates the presence of nicotine residue carried along with the smoke. This phenomenon can be compared to what happens in the respiratory tracts of smokers. Each time cigarette smoke is inhaled, fine particulates and chemical compounds such as nicotine and tar enter the lungs and adhere to the walls of the bronchi and alveoli, which over time can lead to blackened lungs. This finding not only enhances our understanding of the characteristics of Madura tobacco, including differences in land and nicotine content, but also highlights important public health considerations. It particularly affects the farming community, which is directly exposed to the products they cultivate. Their involvement in tobacco farming is not just an economic activity; it also carries the potential for significant health impacts.

CONCLUSION

Understanding the process of cultivating tobacco on *Sawahan* and *Tegalan* land in Indonesia enables farmers to implement targeted cultivation techniques tailored to the specific soil characteristics and moisture levels. The products yielded from both types of land also provide valuable insights into the distinct qualities associated with each, which can significantly benefit farmers. This study explains that tobacco from *Tegalan* land has several advantages over tobacco from Sawahan land. However, it is essential to acknowledge the health risks associated with tobacco, mainly due to the presence of nicotine in both *Tegalan* and *Sawahan* varieties.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

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