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The Effectiveness of Honey Purity Testing from Several Regions in Central Sulawesi Province

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Abstract

Honey is a valuable natural product with nutritional, medicinal, and economic importance, but its high commercial value makes it prone to adulteration, which threatens consumer trust and product quality. This study aimed to evaluate the effectiveness of simple purity tests in identifying adulteration in honey samples collected from several regions in Central Sulawesi Province. A total of 12 honey samples from different bee species and floral sources were analyzed using seven tests, namely solubility, cloudiness and foam, heating, hexagonal pattern, seepage, raw fish, and onion tests. The results showed that most tests successfully distinguished pure honey from adulterated samples. Specifically, the solubility, cloudiness and foam tests, as well as heating, and raw fish tests indicated that 66.67% of the samples were pure, while the hexagonal pattern, seepage, and onion tests confirmed purity in all samples (100%). These findings demonstrate that simple, low-cost methods can provide reliable initial screening of honey purity and are suitable for routine use in local communities where advanced laboratory facilities are limited. The application of these tests is expected to support honey quality assurance, protect consumer trust, and promote the sustainable development of the beekeeping industry in Central Sulawesi.

Keywords: Adulteration detection; Honey purity; Regional quality; Simple tests; Sulawesi honey.

INTRODUCTION

Honey is a natural sweet substance produced by honey bees from the nectar of flowers or from secretions of living parts of plants (Abeshu & Geleta, 2016; Tafere, 2021). It has been widely recognized for its nutritional, medicinal, and economic value. Honey contains carbohydrates, amino acids, vitamins, minerals, organic acids, and various bioactive compounds with antioxidant, antimicrobial, and anti-inflammatory properties (Manyi-Loh et al., 2011; Ranneh et al., 2021; Afroz et al., 2023). Due to these benefits, honey is highly sought after in both local and international markets, making it a valuable commodity for beekeepers and traders (García, 2018). However, its high commercial value has also led to an increased risk of adulteration, which negatively impacts consumer trust, market stability, and public health (Anagaw et al., 2024).

Adulteration in honey often involves the addition of sugar syrups, molasses, or other sweeteners to increase volume and reduce production costs (Fakhlaei et al., 2020). Such practices can compromise the nutritional quality and bioactive properties of honey, as well as mislead consumers (Bose & Padmavati, 2024). Globally, honey adulteration has been identified as one of the most common forms of food fraud (Siddiqui et al., 2022; Morariu et al., 2024). In Indonesia, including the province of Central Sulawesi, this issue remains a concern due to the diversity of honey production areas and the varying levels of quality control across regions. Although honey from Central Sulawesi is known for its distinctive flavor and potential health benefits, systematic assessments of its purity are limited.

Central Sulawesi is geographically diverse, with ecosystems ranging from lowland forests to mountainous regions, each offering different floral sources for nectar production (Kahono et al., 2023). This environmental variation contributes to differences in honey characteristics, including color, aroma, viscosity, and chemical composition (Oroian et al., 2016; Mohammed, 2022). Consequently, honey from different districts or regions may vary significantly in quality. Identifying the purity of honey from these areas is not only important for consumer protection but also for maintaining the reputation and market value of local honey products (Bose & Padmavati, 2024).

Various methods have been developed to assess honey purity, including physicochemical tests (e.g., moisture content, ash content, acidity, electrical conductivity) (Dobrinas et al., 2022), microscopic analysis of pollen content (melissopalynology) (Nunes et al., 2024), and advanced instrumental techniques such as

Fourier-transform infrared spectroscopy (FTIR) or high-performance liquid chromatography (HPLC) (Halko et al., 2024). In Indonesia, basic physicochemical analyses remain the most accessible and cost-effective approach for routine quality monitoring, particularly in rural beekeeping communities where advanced laboratory equipment may not be available (Wakjira et al., 2021). These tests can detect abnormal values that may indicate adulteration or poor handling practices, such as excessive water content leading to fermentation or unusually high ash content, which suggests contamination (Choudhary et al., 2020).

Previous studies have emphasized the importance of establishing regional honey quality profiles to support quality assurance and product certification (Mădaş et al., 2020). For instance, moisture content is a critical parameter that affects honey stability and shelf life; the Codex Alimentarius standard sets a maximum of 20% moisture to prevent fermentation (Correa-Mosquera et al., 2022). Similarly, the ash content reflects the mineral composition of honey, which is influenced by botanical and geographical origins but can also indicate adulteration if levels are abnormally high. Additionally, parameters such as pH, electrical conductivity, and reducing sugar content provide valuable information for distinguishing pure honey from adulterated products (Gela et al., 2023; Inaudi et al., 2025).

This research aims to evaluate the effectiveness of honey purity testing by applying standard physicochemical analyses to samples collected from several regions in Central Sulawesi Province. The findings are expected to provide scientific evidence regarding the quality of honey in the region, identify potential cases of adulteration, and highlight differences attributable to geographic and floral variations. Ultimately, this study will contribute to efforts in improving honey quality assurance, protecting consumer rights, and promoting the sustainable development of the local beekeeping industry.

MATERIALS AND METHODS

Time and Location

This research was conducted from July to August 2025. The experimental work took place at the Biology Laboratory, Faculty of Teacher Training and Education, Tadulako University.

Tools and Materials

The tools used in this study included a stainless steel tablespoon, stainless steel teaspoon, glass beakers, thermometer, white ceramic plates (15 cm in diameter), matches, candles, jam jars, a camera for observation, and a stopwatch for recording observation time. The materials used consisted of honey samples, plain water, and warm water at 50 °C. The warm water was prepared at a constant temperature of 50 °C. The honey samples were obtained from four different bee species originating from various sources, totalling 12 samples. Each honey sample was transferred into a 50 ml test tube. The sources of honey samples used in this research are presented in Table 1 and Figure 1.

Table 1. The sources of honey samples used in this research.

Sample Code	Species	Types of Feed
ADDAR	*Apis dorsata*	Multiflora
ACPMR	*Apis cerana*	Mango (*Mangifera indica*)
ACBIR	*Apis cerana*	Multiflora
ADBKR	*Apis dorsata*	Multiflora
ACBLR	*Apis cerana*	Water apple (*Syzygium aqueum*)
TSMIR	*Tetragonula sapiens*	Multiflora
TSMUR	*Tetragonula sapiens*	Multiflora
WIPOR	*Wallacetrigona incisa*	Multiflora
ADSIR	*Apis dorsata*	Rambutan (*Nephelium lappaceum*)
ACTUR	*Apis cerana*	Multiflora
ACTIR	*Apis cerana*	Rambutan (*Nephelium lappaceum*)
ACPUR	*Apis cerana*	Multiflora

Note: Information on bee species and forage type was obtained from the sellers.

Figure 1. The sources of honey samples used in this research.

The honey samples were obtained from different sources because the foraging sources of each bee species vary. The use of different samples was intentional, as this study aimed to evaluate the effectiveness of the tests. Each test was expected to be effective in determining honey purity regardless of its origin (bee species and honey source).

Procedure
Each honey sample was stored in a 50 ml test tube and labelled according to its type. For each purity test, five replications were performed for every honey sample. The purity tests included the solubility test, turbidity and foam test, heating test, hexagonal pattern test, leakage test, raw fish test, and onion test. Data were collected using the One-Zero Sampling method.

Solubility Test
A glass with a diameter of 10 cm was filled with 200 mL of warm water (50 °C) and placed on a white cardboard base to clearly observe the movement of the honey when poured. One tablespoon of honey was poured slowly into the glass from a vertical distance of 10 cm above the water surface at a 30° inclination. If the honey and water were mixed immediately, a score of 0 was assigned (indicating adulterated honey). Conversely, if no immediate mixing occurred, a score of 1 was assigned (indicating pure honey).

Cloudiness and Foam Test
A glass with a diameter of 10 cm was filled with 200 mL of warm water (50 °C) and placed on a white cardboard base to observe the color and foam of the honey when it was poured. One tablespoon of honey sample was added to the glass and stirred with a teaspoon approximately 100 times over 30 seconds until well mixed. If small bubbles formed, disappeared quickly, and the mixture appeared clear, a score of 0 was assigned (adulterated honey). Conversely, if small bubbles formed, persisted, and the mixture became cloudy, a score of 1 was assigned (pure honey).

Heating Test
A 5 mL of a honey sample was placed in a tablespoon and heated over a candle flame with a 1 cm wick length, positioned 2 cm above the flame surface for 2 minutes. If the honey did not overflow (spill from the spoon) after 2 minutes, a score of 0 was assigned (adulterated honey). Conversely, if foam formed and overflowed (spilt from the spoon) before 2 minutes, a score of 1 was assigned (pure honey).

Hexagonal Pattern Test
A volume of 10 mL of a honey sample was poured onto a white ceramic plate with a diameter of 15 cm, and 100 mL of water was added along the plate's edge until the honey was submerged. The plate was gently moved in a figure-eight motion three times. If the resulting hexagonal patterns were unclear, irregular, and disappeared within 10 seconds, a score of 0 was assigned (adulterated honey). Conversely, if the hexagonal patterns were regular, distinct, and persisted for at least 10 seconds, a score of 1 was assigned (pure honey).

Seepage Test
A volume of 5 mL honey sample was dropped onto blotting paper placed on a flat surface and allowed to seep for 30 minutes. If the seepage reached 1–3 mm from the original drop, a score of 1 was assigned (pure honey). Conversely, if the seepage extended more than 3 mm from the original drop, a score of 0 was assigned (adulterated honey).

Raw Fish Test
A fresh, whole baby fish (bawal), 5 cm in length, was placed in a plastic cup with a diameter of 10 cm. A volume of 50 mL honey sample was poured into the cup to fully immerse the fish, which was secured with a bamboo skewer to keep it submerged. The cup was sealed tightly with plastic and stored in a cool, dark place for two weeks. After two weeks, the fish was examined. If the fish remained moist, did not shrink, and the honey did not liquefy (absorb water), a score of 0 was assigned (adulterated honey). Conversely, if the fish became dry, odorless, and the honey liquefied (absorbed water), a score of 1 was assigned (pure honey).

Onion Test
A fresh, whole shallot without skin, 3 cm in length, was placed in a plastic cup with a diameter of 10 cm. A volume of 50 mL honey sample was poured into the cup, and the shallot was secured with a bamboo skewer to keep it submerged. The cup was sealed tightly with plastic and stored in a cool, dark place for two weeks. If the shallot remained intact and unspoiled, a score of 0 was assigned (adulterated honey). Conversely, if the shallot shrank and changed color to dark purple, a score of 1 was assigned (pure honey).

Data Analysis
Experimental Design
The experimental design employed was a Completely Randomized Design (CRD), with bee species as the treatment factor. The mathematical model used, as described by Mattjik and Sumertajaya (2002), is as follows:

$$Y_{ij} = \mu + P_i + \varepsilon_{ij}$$

Where:
Yij : Observed value of the iii-th bee species in the jjj-th replication
μ : Overall mean
Pi : Effect of the iii-th bee species on honey purity test effectiveness
εij : Experimental error

The collected data were first tested for assumptions, followed by an analysis of variance (ANOVA) to determine the effect of treatments on the observed variables, using SAS software version 9.1.3.

Variables

The observed variable in this study was the percentage effectiveness of honey purity tests. A honey sample was considered to have passed the test if it is effectiveness percentage reached 85%. The test effectiveness was calculated using the following formula:

$$\text{Effectiveness } (\%) = \frac{\alpha}{s} \times 100$$

Where:

α : Number of successful results in each test

s : Number of replications in each test

RESULTS AND DISCUSSION

Solubility Test

The solubility test was conducted on 12 honey samples to evaluate their authenticity. The results show that 8 out of 12 samples (66.67%) did not immediately mix with water, indicating purity, whereas 4 samples (33.33%) showed immediate mixing, suggesting adulteration (Table 2 & Figure 2).

Table 2. Effectiveness of the solubility test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	0	0	0	0	0	0
ACBLR	1	1	1	1	1	100
TSMIR	0	0	0	0	0	0
TSMUR	0	0	0	0	0	0
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	0	0	0	0	0	0

Note: The sources of honey vary

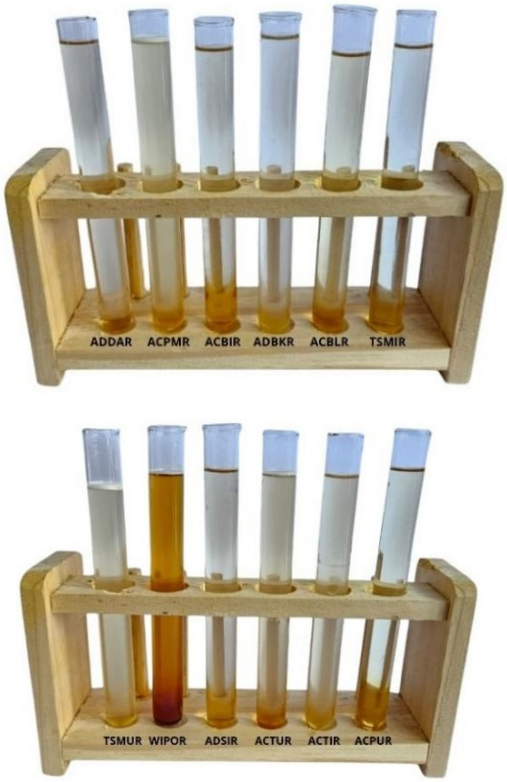

Figure 2. Effectiveness of the solubility test on 12 honey samples.

Cloudiness and Foam Test

The cloudiness and foam tests were performed on 12 honey samples to evaluate their authenticity. The results showed that 8 out of 12 samples (66.67%) produced small bubbles that persisted and formed a turbid mixture, indicating purity, whereas 4 samples (33.33%) produced small bubbles that quickly disappeared and resulted in a precise mixture, suggesting adulteration (Table 3 and Figure 3).

Table 3. Effectiveness of the cloudiness and foam test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	0	0	0	0	0	0
ACBLR	1	1	1	1	1	100
TSMIR	0	0	0	0	0	0
TSMUR	0	0	0	0	0	0
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	0	0	0	0	0	0

Note: The sources of honey vary

Figure 3. Effectiveness of the cloudiness and foam test on 12 honey samples.

Heating Test

The heating test was conducted on 12 honey samples to evaluate their authenticity. The results showed that 8 out of 12 samples (66.67%) produced foam that overflowed from the spoon within 2 minutes, indicating purity, whereas 4 samples (33.33%) did not overflow within 2 minutes, suggesting adulteration (Table 4 and Figure 4).

Table 4. Effectiveness of the heating test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	0	0	0	0	0	0
ACBLR	1	1	1	1	1	100
TSMIR	0	0	0	0	0	0
TSMUR	0	0	0	0	0	0
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	0	0	0	0	0	0

Note: The sources of honey vary

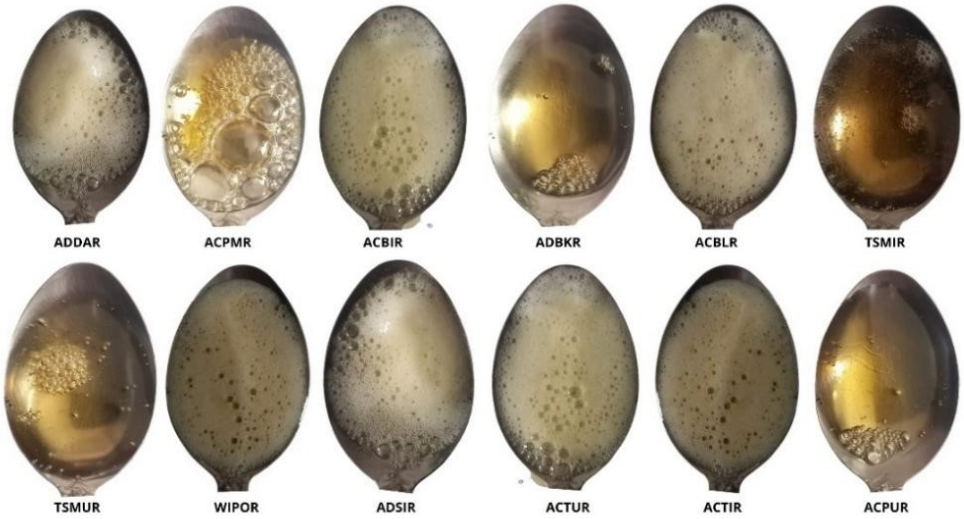

Figure 4. Effectiveness of the heating test on 12 honey samples.

Table 5. Time overflowed on 12 honey samples.

Code*)	Repetition					Average
	1	2	3	4	5	
ADDAR	53.46	59.91	58.91	52.35	54.55	55.84
ACPMR	58.86	55.66	58.74	57.75	59.05	58.01
ACBIR	57.26	58.16	57.65	56.15	57.20	57.28
ADBKR	-	-	-	-	-	-
ACBLR	56.61	58.31	52.74	55.50	57.80	56.19
TSMIR	-	-	-	-	-	-
TSMUR	-	-	-	-	-	-
WIPOR	57.66	56.91	54.57	56.55	57.79	56.70
ADSIR	54.86	56.76	57.75	53.95	56.64	55.99
ACTUR	51.81	58.91	57.52	50.70	56.25	55.04
ACTIR	58.82	55.16	54.55	57.90	56.63	56.61
ACPUR	-	-	-	-	-	-

Note: Number in seconds.

Hexagonal Pattern Test

The hexagonal pattern test was conducted on 12 honey samples to evaluate their authenticity. The results showed that all samples (100%) formed regular and distinct hexagonal shapes that remained visible for more than 10 seconds, indicating purity (Table 6 and Figure 5).

Table 6. Effectiveness of the hexagonal pattern test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	1	1	1	1	1	100
ACBLR	1	1	1	1	1	100
TSMIR	1	1	1	1	1	100
TSMUR	1	1	1	1	1	100
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	1	1	1	1	1	100

Note: The sources of honey vary

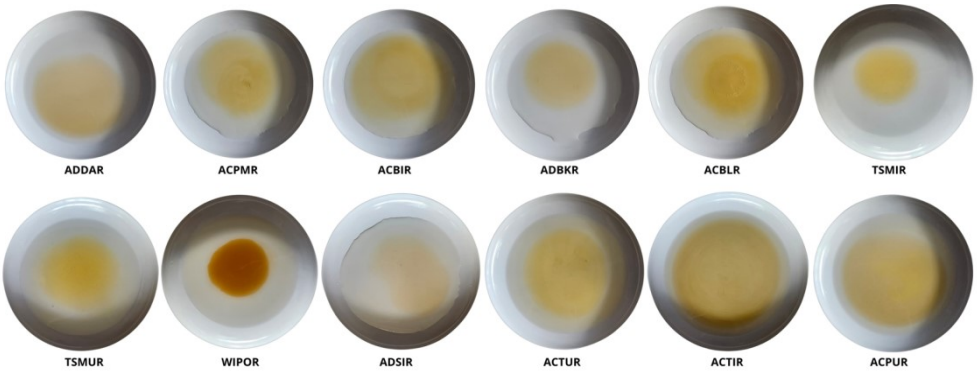

Figure 5. Effectiveness of the hexagonal pattern test on 12 honey samples.

Seepage Test

The seepage test was conducted on 12 honey samples to evaluate their authenticity. The results showed that all samples (100%) exhibited leakage ranging from 1–3 mm from the initial drop, indicating purity (Table 7 and Figure 6).

Table 7. Effectiveness of the seepage test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	1	1	1	1	1	100
ACBLR	1	1	1	1	1	100
TSMIR	1	1	1	1	1	100
TSMUR	1	1	1	1	1	100
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	1	1	1	1	1	100

Note: The sources of honey vary

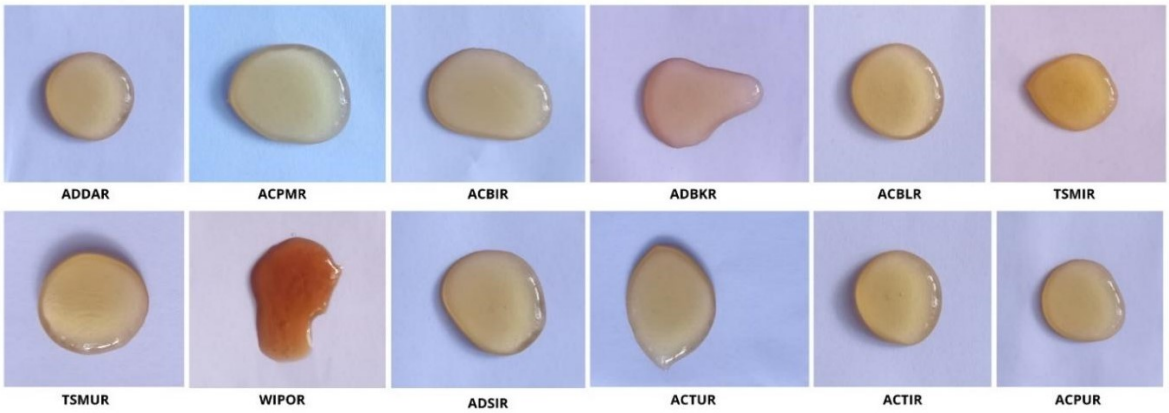

Figure 6. Effectiveness of the seepage test on 12 honey samples.

Raw Fish Test

The raw fish test was conducted on 12 honey samples to evaluate their authenticity. The results showed that 8 out of 12 samples (66.67%) exhibited dry fish texture, absence of odor, and liquefied honey (absorbing water), indicating purity, whereas 4 samples (33.33%) exhibited wet fish texture, no shrinkage, and non-liquefied honey (not absorbing water), suggesting adulteration (Table 8 and Figure 7).

Table 8. Effectiveness of the raw fish test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	0	0	0	0	0	0
ACBLR	1	1	1	1	1	100
TSMIR	0	0	0	0	0	0
TSMUR	0	0	0	0	0	0
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	0	0	0	0	0	0

Note: The sources of honey vary

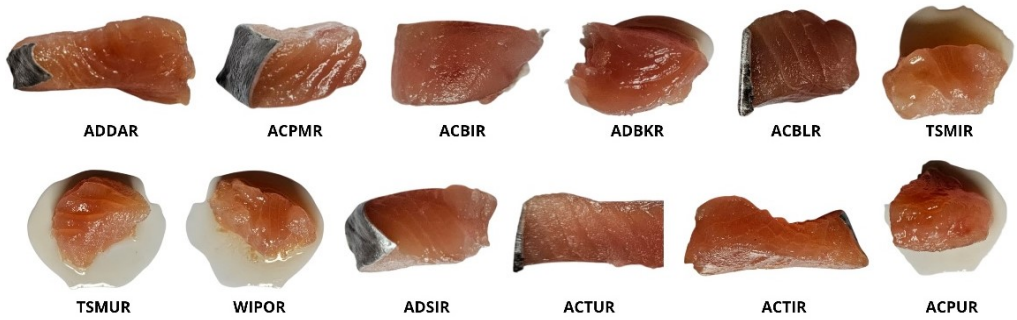

Figure 7. Effectiveness of the raw fish test on 12 honey samples.

Onion Test

The onion test was conducted on 12 honey samples to evaluate their authenticity. The results showed that all samples (100%) caused the onion to shrink and change color to dark purplish (Table 9 and Figure 8).

Table 9. Effectiveness of the onion test on 12 honey samples.

Code*)	Repetition					Percentage
	1	2	3	4	5	
ADDAR	1	1	1	1	1	100
ACPMR	1	1	1	1	1	100
ACBIR	1	1	1	1	1	100
ADBKR	1	1	1	1	1	100
ACBLR	1	1	1	1	1	100
TSMIR	1	1	1	1	1	100
TSMUR	1	1	1	1	1	100
WIPOR	1	1	1	1	1	100
ADSIR	1	1	1	1	1	100
ACTUR	1	1	1	1	1	100
ACTIR	1	1	1	1	1	100
ACPUR	1	1	1	1	1	100

Note: The sources of honey vary

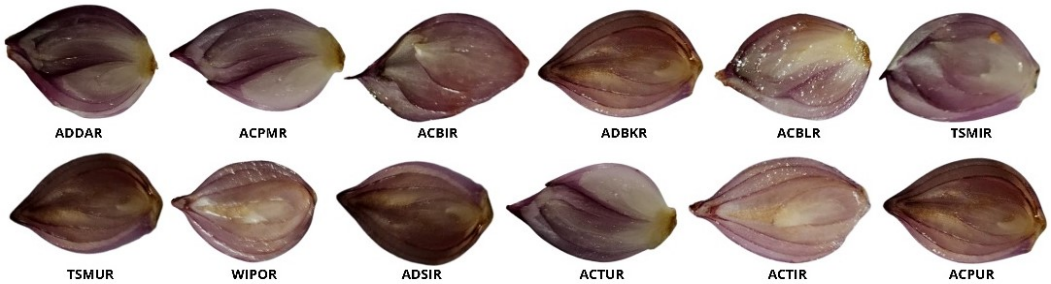

Figure 8. Effectiveness of the onion test on 12 honey samples.

Discussion

4 types of tests including The Solubility, Cloudiness and Foam, Heating, and Raw Fish Tests obtained the same results, namely 66.67% of samples indicated pure honey and the remaining 33.3% were indicated as false while different results were shown by 3 types of tests, namely Hexagonal Pattern, Seepage, and Onion Tests which indicated that 100% of honey samples were genuine. Pure honey generally has a high viscosity, a greater density than water, and contains various natural components such as reducing sugars (fructose and glucose), enzymes, and phenolic compounds that make it not immediately dissolve when dripped into water (Al-Kafaween et al., 2023; Mello dos Santos et al., 2025). Pure honey also generally contains complex organic compounds that contribute to the formation of stable foams when homogenized with water (Saxena et al., 2010; Tyowua et al., 2023). Stable foaming accompanied by solution turbidity occurs due to the interaction between complex sugars and natural protein and colloidal compounds in honey (Brudzynski & Sjaarda, 2021). In addition, turbidity can also be affected by the presence of

pollen (pollen) and minerals that are natural characteristics of pure honey (Raweh et al., 2023).

Based on this data, 4 samples with the code ADBKR, TSMIR. TSMUR and ACPUR are strongly indicated to include adulterated honey which is supported by the majority of test results. Honey that has been adulterated dissolves more easily when dripped into water (Damto, 2021; Tomczyk et al., 2023). Furthermore, adulterated honey is generally derived from sugar cane and sugar beet such as corn syrup, sucrose syrup, HFCS, inverted syrup, glucose syrup and high fructose inulin syrup which changes its physicochemical properties so that it can be known through honey authenticity detection tests (Fakhlaei et al., 2020). Although the 4 samples have been strongly indicated including fake honey, these results are not completely valid because they are limited to initial qualitative tests. To obtain valid results in proving the authenticity of honey, it is necessary to carry out physicochemical analysis and instrumental techniques that are more accurate and more measurable such as chromatographic and hyphenated techniques, spectroscopy, elemental techniques, bioanalytical techniques and electrochemical methods (Mohamat et al., 2023; Zhang et al., 2023).

CONCLUSIONS

This study demonstrated that simple and low-cost methods are effective in detecting honey purity. Among the seven tests applied, the solubility, cloudiness and foam, heating, and raw fish tests identified 66.67% of samples as pure, while the hexagonal pattern, seepage, and onion tests confirmed purity in all samples (100%). These results indicate that the combination of these traditional methods provides reliable preliminary screening to distinguish pure honey from adulterated products. The use of such techniques is highly beneficial for local communities in Central Sulawesi, where advanced laboratory facilities may be limited. Overall, the application of these tests can strengthen honey quality assurance, safeguard consumer trust, and support the sustainable development of the regional beekeeping industry.

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Competing Interests: The authors declare that there are no competing interests.

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