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Characterization of Pig, Cow and Goat Raw Skin Using E-Nose for Visual Data Comparison of Characteristics of Halal Skin-Processed Products

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ABSTRACT

The presence of questionable halal claims for various products in the market presents concerns among consumers, particularly Muslims. As a result, the need to accurately identify halal skin products has become crucial. This study focuses on differentiating pig skin from other commonly used raw materials such as cow skin and goat skin by utilizing visual characteristic data. The data was obtained through the analysis of samples using a chemometric-based electronic nose instrument, which detected volatile organic compounds (VOCs) through metal oxide semiconductor sensors (TGS 26xx and TGS8xx). The samples consisted of pig skin, cow skin, and goat skin, and their specific odors were measured and represented in line graphs, revealing distinct odor patterns detected by the sensors. The analysis revealed that pig skin exhibited the highest and increasing trend line, indicating a higher concentration of VOCs and an intense odor. Cow skin displayed a moderate trend line with lower concentrations of VOCs, while goat skin showed a lower trend line compared to cow skin but possessed strong odor properties. The analysis employed the linear discriminant analysis (LDA) method, which further confirmed these characteristics by generating line graphs that demonstrated significant differences, particularly in pig skin. The LDA plot graphs presented clear groupings of the original pig skin, cow skin, and goat skin data. Discriminant function 1 accounted for 89.13% of the grouping, while discriminant function 2 accounted for 10.87%, resulting in a total value of 100% for the discriminant function. In conclusion, this research establishes a clear distinction between pig skin and cow/goat skin based on their odor characteristics and sensor data. The LDA plot graphs serve as a valuable visual tool for identifying the characteristics of halal products. By utilizing this approach, consumers, especially those seeking halal-certified skin products, can make informed choices and have greater confidence in their purchasing decisions.

KEYWORDS : Halal, electronic nose, chemometrics, linear discriminant analysis, characteristic visual data.

INTRODUCTION

Halal is a term in Islam that states the permissibility of something [1]. The concept of halal is defined as something that is allowed by sharia (religious) law, such as licensing of objects or activities that are used and carried out in Islam [2]. The opposite of halal is haram, that is, everything that is prohibited. As we know in many litearcy, in Islam the concept of haram states about the prohibition of things that

have been determined, one of which is related to pigs. The non-halal or haram of pig skins is something that is firm and clear in the guidance of Islam; Al-Qur'an and Hadith.

Furthermore, regarding the non-halalness of pig skins, some of the products currently circulating and marketed have doubts about their halal quality [1]. These products, which include food and drink as well as clothing, are found to contain elements that are known to be pig skin-based. This is also confirmed by digital media; republica.co.id and sciencemag.org, that of several food and clothing products on the market, the main raw material is leather derived from pig skin. These products include processed food products, pharmaceuticals as well as disposable products and accessories. Associated with doubts about this, eventually led to concerns over the absence of a guarantee of halal products for consumers, especially Muslims. As a result, many Muslims feel reluctant and choose not to become consumers of these products [3]. To overcome this concern, especially for Muslims, it is necessary to identify based on reference data/characteristics of the products that will be circulating in the market. The reference data used is characteristic visual data. Characteristic visual data is a representation of data that has been abstracted in the form of schemas such as tables and graphs containing characteristic information [4]. The purpose of using characteristic visual data is so that the characteristic information contained in the data can be easily understood properly. Characteristic visual data used as a basis for identification, namely characteristic analysis data on livestock pig skins.

The use of pig skin as an object for characteristic analysis data is the cause of the use of pig skin itself. The reason is because of the large number of mass productions of pig skins as raw material for skin-processed products instead of the majority of livestock skins in general. The amount of production is also supported by several factors such as availability, convenience and economic value [5]. Related to cattle skin of pigskin as an object for characteristic analysis data, this data is also compared with data on characteristic analysis of cow skin and goat skin as raw materials that are commonly used in skin-processed products; leather, rambak crackers, etc.

Electronic nose or e-nose uses a chemical compound base in its measurements and works like a human nose. E-nose can identify an object through the features provided in the form of a smell or scent pattern. This instrument basically consists of odor delivery system, detection system, data acquisition system and data analysis unit [6]–[10]. In practice, the e-nose detection system utilizes the content of chemical compounds released (smell or aroma) by skin samples in the form of gas which is the detection-measurement target [11]. The chemical compounds released are basically volatile organic compounds (VOC) or organic volatile compounds which are a collection of simple or complex organic chemical compounds that evaporate easily at RTP conditions [12]. Fig 1. Electronic nose or e-nose instruments

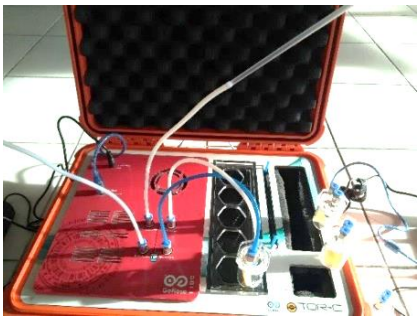

Figure 1. Electronic nose or e-nose instruments

The skin of animals, especially livestock, is an organic material composed of macro (chemical) components; including 60-65% water, 30-33% protein, 2-3% fat and micro components; minerals around 0.5-1% [13], [14]. In addition, organic materials such as skin, fat and meat naturally also produce

volatile compounds that are physically volatile under RTP environmental conditions[8], [15], [16]. Each composition and content of volatile compounds from pig, cow and goat skin is different from each other, thus creating a distinctive odor [6]. The use of e-nose in the identification of samples by utilizing volatile organic compounds has been widely applied before. These include identification of lard based on volatile organic compounds using e-nose [6], detection and discrimination of lard from mixed samples of other livestock fats for halal authentication [15], and analysis of pork and olive oil based on odor pattern classification (features) [17]. Several studies have also emphasized the advantages of using e-nose. Such as analysis that is fast, simple, low cost (low-cost material testing), broad selectivity, and good reliability as well as non-destructive testing [6], [8], [9], [17]–[19].

The volatile compounds released by each pig, cow and goat skin will be detected by the e-nose and measured in the form of a change in electrical voltage pattern in milli-volt (mV) units. This voltage change pattern will be recorded over a certain time interval (V-t) and then converted into a digital numeric value by a data logger [17]. Furthermore, this numerical data is extracted, and analyzed using a data analyzer by applying the chemometric method.

The chemometric method is a combination of statistical and mathematical methods to design optimal procedures to provide information contained in the data [17]. The most common application of this method is in the evaluation of data (analytics) in analytical instruments. The chemometric-based electronic nose applies the chemometric combination method to the analysis process based on the data from the extraction of data feature characteristics [20]. In this study, the combination chemometric method used the linear discriminant analysis (LDA) method to obtain information on the characteristics of each skin sample. The LDA method is a method for finding linear combinations of features that characterize or characterize a sample (object) [21]. The discovery of combinations is done by grouping or classifying classes/groups/clusters into groups [22].

The results of the analysis of cow and goat skin samples using the LDA method are characteristic visual data in the form of LDA plot graphs. Based on this visual data, the identification of each skin can be easily identified by observing the data groups on the graph. Each data group will be separated and classified in the LDA plot graph. Separation of data groups represents the classification of each skin sample based on the characteristics of the skin, namely the released organic volatile compounds. Identification of the pattern of separation of data groups can be determined by looking for the value of the discriminant function (discriminant function value). Numerically the value of this discriminant function can classify and classify data. Data interpretation can be done directly by looking at the visual separation of data groups.

Based on the concept of this study, it can be seen how the characteristics and comparisons of each skin differ through characterization using a chemometric-based electronic nose instrument and it can also be seen how the characteristics of each skin are as characteristic visual data for halal quality assurance. To find out and obtain reference data on these characteristics, it is necessary to test each skin type using a chemometric-based electronic nose characterization instrument. Furthermore, this characteristic visual data can be used as reference data in identifying products for halal quality assurance.

METHODS

Place, Date and Time

The type of research conducted is experimental-laboratory research. The research started from July 2020 and was completed in December 2020. The research was carried out at the Materials and Biophysics Laboratory, Department of Physics, Faculty of Mathematics and Natural Sciences, Padang State University.

E-Nose Instrument

This study uses an electronic nose instrument type GeNose 118C as a characterization instrument for skin samples. This electronic nose works by detecting volatile organic compounds in the sample by a detection system consisting of eight metal oxide semiconductor sensors TGS 26xx and TGS8xx, as well as two temperature and humidity sensors which as a whole form a sensor array system. For more details, the following table lists sensors and their detection targets;

Table 1. List of sensors and detection targets.

No	Sensor	Detection Targets (Gas)
1	TGS 813	CO, methane, ethanol, propane, isobutane, hydrogen
2	TGS 822	methane, CO, isobutane, n-hexane, benzene, ethanol, acetone
3	TGS 826	iso-butane, hydrogen, ammonia, ethanol, trimethyla-mine
4	TGS 832	R-134a[a], R-12[b], R-22[c], ethanol
5	TGS 2600	methane, CO, iso-butane, ethanol, hydrogen
6	TGS 2603	amine chain, sulfur; trimethylamine methyl mercap-tan
7	TGS 2612	ethanol, methane, iso-butane, propane
8	TGS 2620	methane, CO, iso-butane, hydrogen, ethanol
9	STS3x	Detect temperature
10	SHT3x	Detect humidity

Source: References [23], [24]

[a]R-134a: 1,1,1,2 tetrafluoetana

[b]R-12: diklorodifluorometana

[c]R-22: difluoromonoklorometana (refrigerant)

This instrument is equipped with two software applications or software installed separately on a computer system or personal computer. Each software, namely GeNose Datalogger and TOR-C Analytical Tool works as a data logger and data analyzer program.

Materials

The main materials of this research are; raw cow, goat and pig skins. These skins were collected from the abattoir of Bukittinggi City and local slaughterhouses in the area of Padang City. While other materials are complementary materials needed for sample preparation.

Sample Preparation

There are three sample preparation methods applied. Sample preparation aims to obtain conditions in which similar to raw materials used in skin-processed product.

The sample preparation steps as original skins are based on the initial sample preparation method for various skin-processed products such as leather, rambak crackers and chemical products derived from skin-processed; collagen and gelatin [13], [25]–[29];

1) Provide skin; pigs, cows and goats.
2) Clean each skin using plain/tap water from factors that affect the skin chemically.

3) Make sure each skin is clean from the remaining dirt. Then cut each skin to size; the sample area is 2×2 cm2 with a thickness of ± 0.5-1 cm.
4) Code the original skin sample with KBO (original pigskin), KSO (original cow skin), and KKO (original goat skin). Furthermore, the original skin sample is ready to be tested

Sample Testing and Data Logging

E-nose configured with software on the computer system is ready to characterize the target samples, namely pig skin, cow skin and goat skin. Sample testing and data logging are supported by the GeNose Data Logger software. The configuration of per-sample testing with the help of software is carried out in one test cycle. Data recording for each sample by e-nose (sampling) is carried out in an interval of 36 seconds with a sampling period of 0.1 seconds. Tests for each skin type were carried out as many as 10 samples.

Repeated testing is carried out so that the sample data becomes accurate and precise and can be analyzed so that it can be used as reference data. The duration of the test time per sample based on the deployment of the tool and its configuration is 15 minutes per sample. Test results are recorded and stored in .csv numeric data format.

Data Analysis

Data analysis or processing is supported by the TOR-C Analytical Tool software as a data analyzer. Data analysis was carried out in two processes; feature extraction and chemometric-based analysis. Data feature extraction plays a role in determining the results of data grouping through extracting essential information from data features [23]. Data feature extraction is carried out using the maximum value feature extraction method. The maximum value method extracts data with characteristic results in the form of the maximum value of the sensor signal response obtained from the test results for each skin sample. Furthermore, the extracted data is used as data for the analysis of the LDA method. Data analysis was carried out based on sample test results containing data features (smell). Chemometric-based data analysis was carried out by applying the LDA method and producing data in the form of an LDA plot graph. The LDA plot graph is displayed with graphic elements in the form of discriminant function values 1 and 2.

RESULTS AND DISCUSSION

Results

The GeNose 118c type e-nose instrument is an electronic nose type that uses a metal-oxide semiconductor sensor in its measurement. This instrument utilizes the concept of semiconductivity and electrochemical sensing in detecting targets in the form of odors or volatile compounds released by each skin type.

Mathematical equations must be numbered consecutively and starting with (1) to the end of the paper including the appendix (attachment). This numbering must begin and end with opening and closing brackets and right aligned. Add one blank line above and below the equation.

Discussion

Description of Test Result Data for Original Skins Samples

According to the sample preparation for original skin in the research procedure, the original skin sample was not affected at all by any particular variation. Tests on original samples take advantage of the pure

characteristics of each skin; pigskin, cow skin and goat skin. This characteristic is just a distinctive smell that is smelled when an organoleptic test is carried out per each skin sample. Like the smell of pig skin which has a distinctive smell that is very different from other types of skin, it smells very fishy and is more pungent. Meanwhile, cow skin generally smells like beef, that is, it doesn't smell fishy and doesn't have a pungent smell. Meanwhile, goat skin itself has a quite pungent odor but does not smell fishy [30]. Testing of original skin samples by the e-nose instrument was followed by data recording, which turned out to be in accordance with a brief description of the smell of each skin. The test results in the form of graphs also show significant differences, especially in pig skin. The graph of the test results for each original skin sample can be seen in the following graphs;

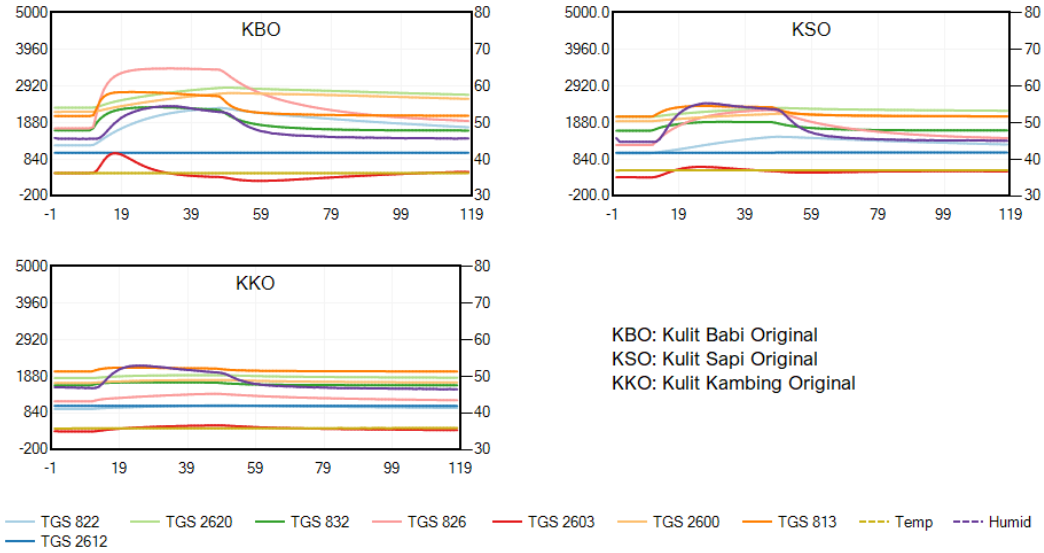

Figure 2. Test results of original skin samples; (a) pig skin, (b) cow skin, and (c) goat skin. KBO, KSO and KKO was written in indonesian, which refer to (in sequence) original pig skins, original cow skins and original goat skin.

The picture above shows a graph for each representative of the original skin sample. You can clearly see the difference in odor patterns detected by each sensor. For the KBO sample, it is clear that the trend line on the chart is higher and rising compared to KSO and KKO. The trend line on the KBO is dominated by signal responses from the TGS 826, TGS 813, TGS 2620 and TGS 2600 sensors. Meanwhile, the TGS 2603 sensor response, although not classified as a dominant response, compared to the sensor response to cow and goat skin, has a trend line which still shows the existence even though it is only detected in the initial interval of the sampling time. (Overall) the trend line is higher and increasing, indicating a high concentration of organic volatile compounds in pig skin. This also contributes to the intense odor produced by the pig skin. For KSO, cow skin shows a moderate upward trend line. When compared with the sensor response that dominates pig skin, the trend line of cow skin shows a lower concentration of organic volatile compounds, especially in the TGS 822 sensor signal response. Meanwhile, the response on the TGS 2603 sensor shows very low levels of volatile compounds. When compared with the characteristic smell of cow skin this seems very fitting. While KKO, goat skin shows a trend line beyond expectations, where based on organoleptic test samples, goat skin has a quite pungent odor. However, based on the test, the trend line on the chart appears to be low, even lower than KSO, cow skin. This proves that goat skin contains organic volatile compounds with very low concentrations but with strong properties (odor).

Based on the three charts above, it appears that the trend line pattern on the chart is different for each original skin sample. It is also clear from the three graphs that the response signals for the TGS 826, TGS 822 and TGS 2603 sensors in each skin sample are very different. In addition, the sensor response to temperature and humidity (temp, humid) of each original skin sample does not appear to be different, this proves that the testing of each sample was carried out in a controlled environment (room temperature pressure) with the control variable maintained, according to with research-experimental laboratory methods.

Data Interpretation from Analysis of Original Skins Sample

Interpretation is carried out based on the results of the analysis of the data from the sample test results above. Each sample that has been tested is in graphic form, saved in .csv format. The data in this format is portable and consists of feature data and data from features. Data feature extraction plays a role in determining the results of data grouping. Data extraction is carried out with the help of a data analyzer and produces data extraction.

The use of the LDA plot graph as the basis for identification is much more effective because it immediately groups and classifies the target sample well, especially on skin samples determined by skin type, so that the data from the analysis using the LDA method is an identity and visual characteristics data can be used through comparison tests. The following are the results of the analysis for original skin samples.

Testing on genuine/original samples utilizes the pure characteristics of each skin; pigskin, cow skin and goat skin. This characteristic is just a distinctive smell that is smelled when an organoleptic test is carried out per each skin sample. This is in line with the characteristic odor or aroma produced by the skin which comes from volatile compounds in the organic material itself.

The results of the analysis of the test data show a pattern that matches the description of the characteristics of each skin, which is unique and different from one another. In the following plot graph, it appears that the skin of pigs, cows and goats are separated and grouped into certain groups. The LDA plot graph for the analysis of original skin samples can be seen in the following figure;

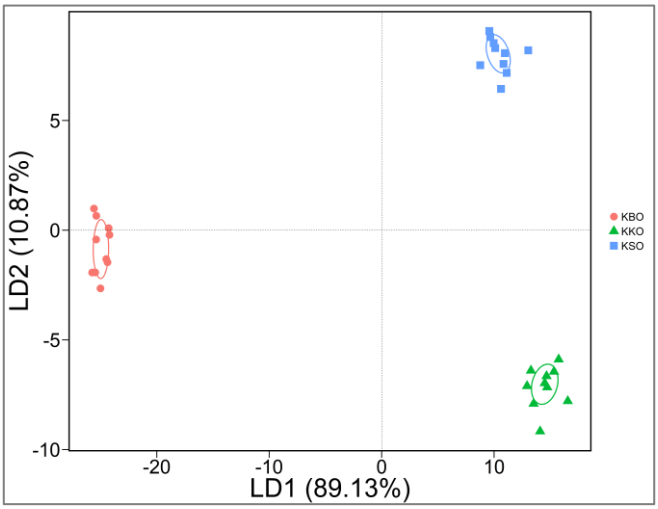

Figure 3. LDA plot graph for original skin samples with discriminant function value 1; 89.13% and the value of the discriminant function 2; 10.87%

In the LDA plot graph above, it is clear that the KBO, KSO and KKO original skin samples are grouped very well. Where the distribution of the groups is divided into three with KBO pig skins marked with red circle plots, KSO cow skins with blue circles and KKO goat skins with green circles.

The center of the KBO group, pig skin is at coordinates (-27, (-1)). It can be observed carefully that based on the organoleptic test and test results with the KBO pig skin e-nose instrument, it has characteristics that really distinguish it from others, as well as the results of the analysis. If using the Cartesian coordinate plane division, it appears that the center of the KBO pig skin grouping group is in the area between quadrants II and III, which is far from the center of data distribution for KSO and KKO. As for the KSO group, cow skin is in quadrant I with the center of the group coordinates (10,8), and KKO, goat skin is in quadrant IV, coordinates (15, (-8)). The data distribution center for KSO and KKO is located in an area that tends to be closer than KSO and KKO with KBO.

Referring to previous research, the analysis of samples from pigs has unique characteristics so that sample analysis using modern instruments such as an electronic nose can easily identify samples of organic matter from pigs, and even classify and classify them [6], [15], [17]. Based on this fact, samples from pigs will stand out from other samples, just like the analysis that has been done in this study.

Each group can be said to be very well identified with a fairly high level of precision due to the low level of data distribution. The discriminant function that characterizes the grouping/classification has the value of the first discriminant function; LD1=89.13% and the value of the second discriminant function; LD2=10,87%. The total value of the discriminant function of this LDA plot graph is 100%, which indicates a very good grouping of the original skin samples.

Based on the observations of the three graph plots above, it can be observed that the grouping area of each skin maintains its position where in this case it is possible to identify skin samples and skin samples that have been prepared like skin-processed products using an electronic nose. Based on this analysis it can also be concluded that the LDA plot graph of skin-processed samples can be used as visual data on the characteristics of halal products.

CONCLUSION

Based on the experiment and discussion of the data analysis results, it can be concluded that the difference between pig skin and cow and goat skin is very clear on the graph of the test results, this is in accordance with the original characteristics of each skin which has a distinctive odor. Meanwhile, the differences in characteristics of pig skin with cow and goat skin as visual characteristics data based on the LDA plot graph are also very well presented, especially in terms of grouping/classification with the total value of the discriminant function is 100%. Based on this analysis, it can also be concluded that the LDA plot graph of skin-processed samples can be used as visual data on the characteristics of halal products.

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