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Ethnomathematics Exploration on Traditional Herbal Medicine-Making Tools at Sumenep Palace

Fida Dinar Fauziyah[1], Achmad Miftachul Ulum[2], and Marhayati[3]

[1,2,3] UIN Maulana Malik Ibrahim Malang

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Author for correspondence:
Fida Dinar Fauziyah
e-mail: fidin67@gmail.com

Abstract- This study aims to describe the ethnomathematics exploration of traditional herbal concoction tools at the Sumenep Madura Palace. Traditional herbal medicine is a cultural heritage originating from Madura, especially from the nobility in the Sumenep Palace. This study uses a qualitative approach with ethnographic research. Data collection techniques are observation, interviews, field notes, and documentation. The results showed that in the process of making traditional herbal medicine, a mathematical concept was found, namely the concept of value comparison. Meanwhile, the money instruments used to concoct herbal medicine, namely *pipisan*, *gandik*, *botekan* and *cengkelek*, found the concept of geometry, sequence patterns and arithmetic series.

1. Introduction

Sumenep is a regency located at the eastern tip of Madura Island. It has cultural heritages that are still preserved today, including the Sumenep Palace. The Sumenep Palace is a historic building founded by Raden Mohammad Saod or Bindara Saod in 1781 (Abdullah & Liana, 2018; Iskandar, 2003; Zulkarnain et al., 2020). The Sumenep Palace building is a cultural acculturation between Chinese and Madurese buildings by Lauw Pia Ngo (Halim & Royandi, 2022; Indraprasti et al., 2022; Murwandani, 2007). This can be seen from the ornaments of the Sumenep Palace, which are dominated by floral motifs and Hong bird motifs, which are symbols of Chinese peace. The existence of the Sumenep Palace proves that the central government in Sumenep was a kingdom in the past. At that time, the royal consort often carried out a series of palace-style body treatments to maintain beauty using traditional herbs (Ningsih & Lutfiati, 2020; Rizkiyah et al., 2020).

Traditional herbal medicine is a mixture of several types of plants that are synergistic with each other and then mixed or concocted to be used in body care and medicine (Harefa, 2020). The use of traditional herbal Medicine typical of the palace, both in herbal medicine preparations and cosmetics, has become a tradition for the Madurese people (Destryana & Ismawati, 2019). Studies on traditional herbal medicine,

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one of the cultural traditions in Sumenep, have begun to vary and are integrated with several sciences. Among them is research conducted by Hasanah (2019), which discusses ethnobotany in traditional Madurese herbal medicine. The study explains the scientific classification of the various types of ingredients used in making herbal medicine in Madura and the contents contained therein. In addition, Amalia Putri et al. (2022) also researched traditional Sumenep herbal medicine, which was discussed from an ethnoscience perspective and about junior high school learning. However, research that links mathematical concepts to traditional Sumenep herbal medicine has not been found. Integrating mathematical concepts found in local wisdom requires an approach known as Ethnomathematics.

Ethnomathematics has become a hot topic for discussion in recent years. The word ethno exists in several other fields, such as ethnobotany, ethnoscience, ethnomethodology, etc. The word ethno refers to cultural aspects. Therefore, Ethnomathematics itself can be interpreted as the relationship between mathematics, cultural anthropology and mathematical modelling (Orey & Rosa, 2007). D'Ambrosio (in Scott, 1990) stated that Ethnomathematics consists of three parts: Ethno + Mathema + Tics. Each part of the word is related to certain aspects. Ethno relates to culture, Mathema relates to mathematical activities, including explaining and understanding, and Tics means art or technique. Referring to the meaning of each word, Ethnomathematics can be interpreted as a technique in the culture of society that uses mathematical concepts. So, it can be said that Ethnomathematics is a science used to understand how mathematics is adapted from culture and functions to express the relationship between culture and mathematics (Marsigit et al., 2018).

After direct observation at the Sumenep Palace Museum, several mathematical concepts were found that could be studied further in the process of mixing herbal medicine and also in a set of tools used to mix traditional potions or typical palace herbal medicine, which is one type of local wisdom of Sumenep. These mathematical concepts include the concept of comparative value, the concept of geometry, the concept of sequence patterns and arithmetic series. These mathematical concepts have also been found in several ethnomathematics studies in other cultures. Such as the research conducted by Dinar Fauziyah & Faridah (2022), who saw the concept of comparative mathematics in making lontong kupang typical of Sidoarjo. In addition, the concept of arithmetic sequence patterns is also widely found in ethnomathematics research, including in the hadrah dance (Royyani dkk., 2022), gamelan musical instruments (Falah dkk., 2022) and Minangkabau traditional houses (Alghar dkk., 2022). Then the concept of geometry is also found in the conventional Sasak craft culture (Fauzi & Setiawan, 2020).

2. Methods

This research is included in the type of ethnographic research using a qualitative approach. The approach is carried out empirically and theoretically to obtain a description and analysis of culture based on field research. Data collection techniques are observation, interviews, field notes, and documentation. Collection and presentation of qualitative research data in narrative form that reflects the experiences and understanding from the research subject's point of view (Bogdan & Biklen, 1992). Meanwhile, ethnographic research requires direct involvement and in-depth observation to understand a group's culture and social structure (Malinowski, 1992). This study aims to find, collect, process, and conclude data related to mathematical elements in Traditional Herbal Medicine Preparation Tools at the Sumenep Palace. The subjects in this study are traditional herbal medicine mixing tools in the Sumenep Palace, Madura. The sources in this study are tour guides at the Sumenep Palace Museum. The research was conducted on April 27-28, 2023, at the Sumenep Palace at Jalan Dr. Sutomo, Delama Environment, Pajagalan, Sumenep District, Sumenep Regency. This study uses triangulation of data collection methods to obtain valid data, namely direct observation, interviews and literature reviews. In addition, the instrument is also a factor in the success of the research. This research is qualitative, so the main instrument in this research is the researcher himself.

This study uses data analysis techniques: data reduction, presentation, and conclusion. The collected data will be analyzed to draw the findings and make the research results more straightforward. This study uses the Miles and Huberman data analysis techniques consisting of data collection, condensation, data display, and conclusion. (Sugiyono, 2015). The flow of data analysis techniques is presented in Figure 1.

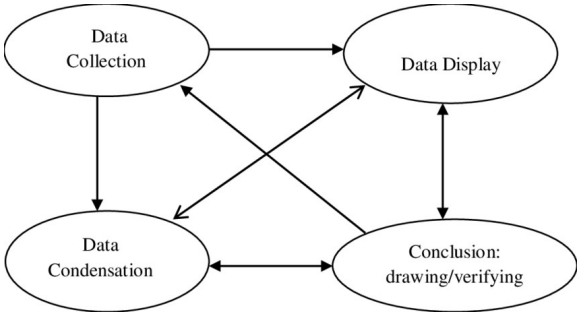


Figure 1. Research Process and Data Analysis on Miles and Huberman

Based on Figure 1, the research flow starts from data collection. In this process, the researcher will collect the data needed. The data used in this study were obtained from the results of observations, interviews, field notes, and documentation received. The next stage is data condensation, which is selecting important data and deleting unnecessary data so that the data will be more focused. The next stage after the data is selected is data display. The data will be presented more simply, such as tables and narratives. A more straightforward data presentation will make it easier for researchers to see data patterns in the research process. The last stage is the conclusion, which is drawing conclusions based on the data that has been presented. In this process, verification is needed to ensure that the conclusions drawn are valid and can be accounted for. This verification is carried out by connecting this research and previous research so that the research is more robust and can be accounted for.

3. Results and Discussion

(a) Traditional Herbal Medicine of Sumenep Palace

Jamu is an herbal concoction made from plants in the form of an extract used as a treatment. The term "*jamu*" comes from the Old Javanese language "*jump*" or "*usodo*", which means healing using herbal medicines or prayers and spells. In the Middle Ages (15-16 AD), the term "*usodo*" was rarely used, while the term jampi became increasingly popular among palace circles. Then, the term "*jamu*" began to be introduced to the public by "dukun" or traditional healers. *Jamu*, originally only known in the palace environment, has already started to leave the palace environment, although it is still used in limited circles.

The traditional *jamu* is mixed and mixed based on a recipe that has been passed down from generation to generation without any changes in composition. The ingredients are measured with the same composition using scales and then ground until smooth. The making of traditional *jamu* used by the palace nobility initially used *pipisan* and *gandik* to smooth the conventional concoction. The *pipisan* has a flat surface shape, as shown in Figure 2, and the *gandik* shape resembles a cylindrical shape, as shown in Figure 3.

Figure 2. *Pipisan*

Figure 3. *Gandik*

Based on the presentation from the resource person, in the past, dry herbal ingredients were stored in a container called a *botekan*. The *botekan* is shaped like a mountain or pyramid, as shown in Figure 4. On the *botekan* some carvings are an acculturation of European and Chinese cultures. Typical European carvings are on the first, third and fifth levels, with flower motifs that symbolize beauty and peace. At the same time, typical Chinese carvings are on the second, fourth and sixth levels. Some of the ingredients in this *botekan* are on the top level, namely gambir. Then, the next level is turmeric and betel. On the next level there are manjakani, kunci pepet, maja kelling, and temu kunci. On the third level there are sambiloto, pace, keji beling, temu lawak, temu ireng and temu koneng. Furthermore, the herbal medicine that has been crushed and in liquid form is served using a coconut shell called *cengkelek,* as shown in Figure 5.

Figure 4. *Botekan*

Figure 5. *Cengkelek*

One example of traditional herbal medicine from Keraton Sumenep is galian rapet herbal medicine which helps tighten the feminine area, facilitate menstruation, and eliminate vaginal discharge. Galian Rapet herbal medicine is made based on information from sources that use dried ingredients, including manjakani, kunci pepet, maja kelling, and temu kunci.

(b) Mathematical Concepts in the Process of Making Traditional Herbal Medicine from the Sumenep Palace

Traditional herbal medicine, *jamu*, is a famous cultural heritage from Madura, especially Sumenep. The culture of consuming *jamu* also began among the nobility in the Sumenep Palace; this is indicated by the collection of tools used to mix traditional *jamu* in the Sumenep Palace Museum. In addition, the museum sells several traditional herbal medicines typical of the Sumenep Palace, whose recipes are also inherited from generation to generation. The form of *jamu* tradition in the Madurese community is also one of the local wisdom. This knowledge is passed down from generation to generation about the selection of herbal ingredients, the making/processing of jamu, and the benefits of drinking *jamu*.

One type of traditional *jamu* from the Sumenep Palace, which is still often consumed by the Madurese people, especially Sumenep and even people outside Madura is *Jamu* Galian Rapet. This *jamu* is consumed by women, slows the stomach, and is suitable for women's reproductive organs. In addition, it is also helpful in tightening the feminine area, facilitating menstruation, and eliminating vaginal discharge. The processing method for this herbal medicine is finely grinding all the ingredients, weighing them, and brewing them with water. The ingredients used in making this herbal medicine include manjakani, kunci pepet, maja kelling, and temu kunci. Based on information from the source, to make Galian rapet herbal medicine, the composition of the ingredients used, namely 1/4 kg each, is used, and the water used to brew is 6 litres. If you only want to make herbal medicine using only the ingredients used, each 1 ounce, then the water used is 2.4 litres. So, the comparison of the composition can be written as in Table 1.

Table 1. Comparison of Galian Rapet Herbal Ingredients Composition

Material	Manjakani	Kunci Pepet	Maja Kelling	Temu Kunci	Water
First size	1/4 kg	1/4 kg	1/4 kg	1/4 kg	6 litre
First size (in ounces)	2,5	2,5	2,5	2,5	60
Second size (in ounces)	1	1	1	1	2,4
Comparison of the first and second sizes	2,5/1=2,5	2,5/1=2,5	2,5/1=2,5	2,5/1=2,5	60/2,4=2,5
Comparison formula of equivalent value	$\frac{a_1}{a_2}=\frac{b_1}{b_2}=\frac{c_1}{c_2}=\frac{d_1}{d_2}=\frac{e_1}{e_2}$				

So based on Table 1, it can be concluded that the comparison of the composition of the ingredients used to make *Jamu* Galian Rapet, namely water, manjakani, kunci pepet, maja kelling and temu kunci in sequence, is 1:1:1:1:2.4. Then it can be shown that the more one of the ingredients used, the more the other ingredients will be. So, it can be said that each amount of ingredients used is directly proportional. This follows the concept of a comparison of value, namely a comparison between two quantities where if one quantity has a more excellent value, the value of the other amount will be more wonderful and vice versa (Ministry of Education and Culture, 2020). The concept of comparing value in culture has also been found in previous research, namely in making Lontong Kupang, a specialty of Sidoarjo (Dinar Fauziyah & Faridah, 2022).

(c) Mathematical Concepts in Traditional Herbal Medicine Preparation Tools of Sumenep Palace

A set of tools for mixing traditional herbal medicine from Keraton Sumenep includes *pipisan, gandik, botekan* and *cengkelek*. Below is a discussion of the mathematical concepts in each tool for mixing herbal medicine. The first tool is *pipisan*, which is made of stone and has a flat surface with a length of 40 cm, a width of 20 cm, and legs with a height of 10 cm. From these dimensions, it can be illustrated as in Figure 6.

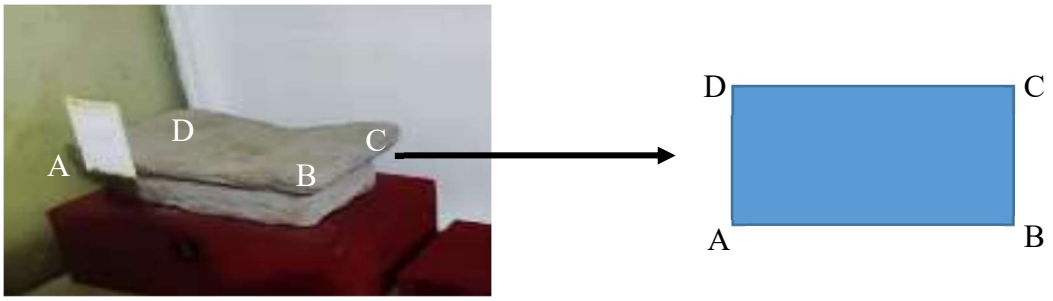


Figure 6. Illustration of the surface shape of a *Pipisan*

So, it can be seen that the ABCD shape has four sides, namely side AB, side BC, side CD, and side DA. Then, it has opposite sides of the same size, namely. $\overline{AB} = \overline{DC} = 40\ cm$ and $\overline{DA} = \overline{CB} = 20\ cm$. Furthermore, it also has two pairs of parallel sides. $\overline{AB}//\overline{DC}$ dan $\overline{DA}//\overline{CB}$, and the exact angle size, namely 90°. Thus, the *pipisan* has the characteristics of a quadrilateral flat shape, namely a rectangle, which has two pairs of sides, each of which is the same length and parallel to its partner and has four angles, all of which are the same size, namely right angles.

The second herbal medicine mixing tool is a pair of *pipisan*, made of stone and used to smooth herbal ingredients. This tool is called a *gandik*, which has a shape that resembles a cylinder, as illustrated in Figure 7.

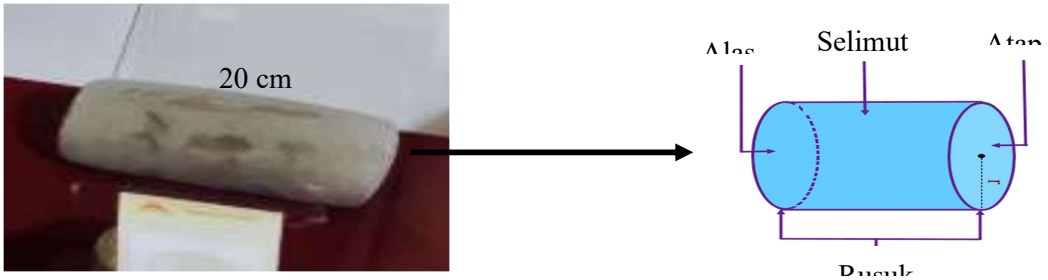


Figure 7. Illustration of *Gandik* Shape

So it is found that the *gandik* is in the form of a tube that has the characteristics of having two bases in the form of circles, having two ribs, having a tube height of 20 cm, having a curved side of the tube cover, having a radius of 6 cm and having no corner points.

According to the source, because this *gandik* is paired with *pipisan*, both always have a balanced or continuous size. Like the *pipisan* and *gandik* in the Sumenep Palace, the *pipisan* has a width of 20 cm, and the *gandik* also has a length of 20 cm and a diameter of 12 cm. Thus, the relationship between the pipisan surface's size and the gandik cover's size can be analyzed in Table 2.

Table 2. Relationship between the Surface Size of the Pipisan and the Size of the Gandik Blanket

Surface Size of the Pipisan	Size of the Gandik Blanket
$L = P \times L$	$L.Selimut = 2 \times \pi \times r \times t$
$= 40\ cm \times 20\ cm$)	$= 2 \times 3{,}14 \times 6 \times 20$
$= 800\ cm^2$	$= 753{,}6\ cm^2$

So it can be obtained that the size of the *pipisan* surface area and the size of the *gandik* blanket have a slight difference, or it can be said to have almost the same size. This is also adjusted to the amount of herbal medicine made.

The mathematical concept of traditional herbal medicine concoction tools in the Sumenep Palace was found in the Botekan, a place to store traditional herbal medicine ingredients. The *Botekan* itself is a seven-level drawer shaped like a pyramid. Regarding shape, the *Botekan* has a mathematical concept, namely geometry and sequence and series number patterns.

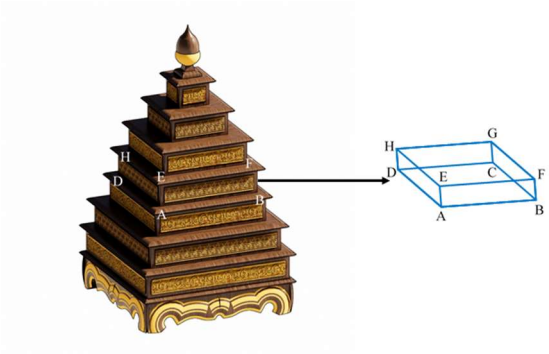


Figure 8. Geometry of Points, Lines and Planes in the Framework of One Level of *Botekan*

The first mathematical concept of geometry discovered was the primitive elements in geometry. The term primitive is intended for simple concepts that are easy to understand but difficult to define. Points, lines, and planes are examples of primitive elements in geometry whose relationships can be observed in the figure. In Figure 8, points A, B and so on are the corner points formed in the figure, which are the intersections of the sides of the figure. Then, from two points, a line can be formed, for example, line AB, which passes through point A and point B; line EF, which passes through point E and point F; line AE, which passes through point A and point E; and so on. This is based on the hypothesis of points and lines, namely that a line can be formed between two points. Furthermore, the plane ABFE can be formed by four lines: line AB, line BF, line EF, and line AE. This is by the theorem of lines and planes: a plane can be formed from at least three arbitrary points (not lying on one line).

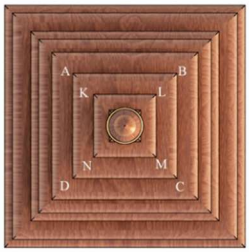


Figure 9. Upper *Botekan* Frame

In addition to the primitive elements, the concept of similarity is also integrated into the dimensions of each level of the *botekan*. From above, as in Figure 9, it can be seen that the KLMN plane is similar to the ABCD plane, which is at the first and second levels of the *botekan*. This is due to ∟K = ∟A, ∟L = ∟B, ∟M = ∟C, ∟N = ∟D and KL: AB = LM: BC = MN: CD = NK: DA = 120mm: 200mm = 3:5. This similarity then has implications for the subsequent levels, so it can be said that at each level of the *botekan* it forms a similar plane.

Furthermore, the concept of sequences and series in the *botekan* has seven levels whose sizes are getting smaller the higher they go. From the observation results illustrated in Figure 8, the width of each level is obtained, which forms a number pattern for the lowest to the highest level, with a difference in the value of each level of 80 mm.

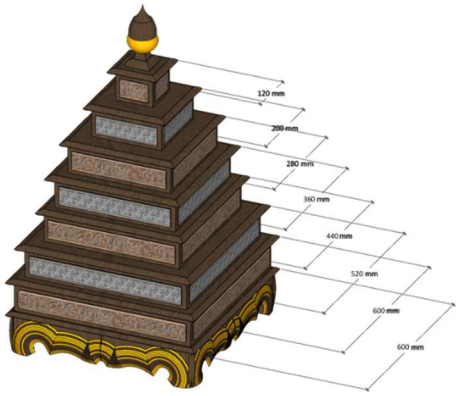
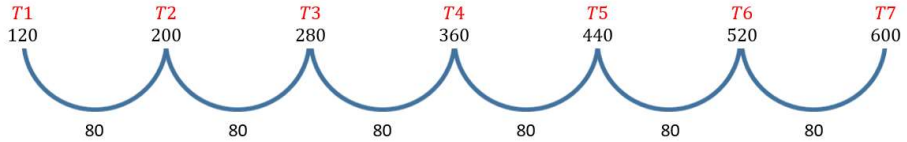


Figure 10. *Botekan* Framework and Its Dimensions

From the illustration of the size of the *botekan* in Figure 10, a row pattern can be found, which can be

written below.



The information in Figure 10 can be further analyzed in Table 3.

Table 3. Relationship between the Surface Size of the Pipisan and the Size of the Gandik Blanket

nth level	Line Pattern	Sequence Pattern Formula
1	120=120	$U_1 = 120$
		$U_1 = 120 + 80(0$
		$U_1 = 120 + 80(1 - 1)$
2	200=120+80	$U_2 = 120 + 80$
		$U_2 = 120 + 80(1$
		$U_2 = 120 + 80(2 - 1)$
3	280=120+80+80	$U_3 = 120 + 80 + 80$
		$U_3 = 120 + 80(2$
		$U_3 = 120 + 80(3 - 1)$
4	360=120+80+80+80	$U_4 = 120 + 80 + 80 + 80$
		$U_4 = 120 + 80(3)$
		$U_4 = 120 + 80(4 - 1)$
5	440=120+80+80+80+80	$U_5 = 120 + 80 + 80 + 80 + 80$
		$U_5 = 120 + 80(4)$
		$U_5 = 120 + 80(5 - 1)$
6	520=120+80+80+80+80+80	$U_6 = 120 + 80 + 80 + 80 + 80 + 80$
		$U_6 = 120 + 80(5)$
		$U_6 = 120 + 80(6 - 1)$
7	600=120+80+80+80+80+80+80	$U_6 = 120 + 80 + 80 + 80 + 80 + 80 + 80$
		$U_6 = 120 + 80(6)$
		$U_6 = 120 + 80(7 - 1)$
⋮	⋮	⋮
n	$U_n = 120 + 80 + 80 + 80 + \cdots + 80$	$U_n = 120 + 80(n - 1)$

So, the first term is worth 120, and the difference value is 80, then the value of the nth term of the sequence can be determined using the formula.

$$U_n = 120 + 80(n - 1)$$

with $n = 1,2,3,4,5,6,7$

This follows the concept of a first-order arithmetic sequence pattern, a sequence of numbers with the difference between two terms having a constant value.

Based on the explanation above, the *pipisan* is a rectangular tool that can clearly represent fundamental geometric principles, particularly the properties of quadrilaterals. The study found that the *pipisan* is an example of a rectangle due to its parallel sides, right angles, and equal opposite sides. This follows other studies in Ethnomathematics that have revealed similar geometric principles in everyday cultural objects. For example, the geometric properties of objects used in traditional architecture, weaving, and pottery from other Indonesian cultures have been explored in studies by Dosinaeng et al. (2020), Fauzi & Setiawan (2020) and Ruamba et al. (2022), who found that local crafts often incorporate symmetrical shapes like rectangles and squares, as well as circles and triangles.

Gandik, which resembles a cylindrical shape, reflects the mathematical concept of a cylinder, with its two circular bases and curved surface. This aligns with other studies conducted by Nugraha et al. (2023) and Nursyahidah & Albab (2021) exploring how cylindrical shapes are used in traditional tools. In addition, the calculation of the surface area of the *gandik*, which closely matches the surface area of the pipisan, illustrates the practical relationship between the dimensions of these tools because both must work together. Gerdes (1999) also found similar applications of geometry in traditional African tools, where mathematical dimensions are integral to the functionality of objects. This study supports the idea that the geometric relationships observed in cultural tools are aesthetic and have functional and practical purposes, similar to how the dimensions of the *pipisan* and *gandik* are balanced for their role in making herbal medicine.

Botekan is a pyramid-like structure used to store herbal medicine ingredients, introducing the concepts of geometry and arithmetic. Its geometric elements involve points, lines, and planes, which align with

fundamental axioms in geometry. The similarity between different levels of the *botekan*, as shown in Figure 9, also reflects the concept of similarity. This is in line with other studies by Gerdes (1999), who explored geometric forms in traditional cultural artefacts, and Sulistyani et al. (2019) and Wati et al. (2021), who also explored the concept of similarity in Batik Gedog and Tulungagung joglo traditional house. Additionally, the arithmetic sequence identified in the *botekan's* dimensions, with each level reducing by 80 mm, showcases the application of number patterns, a common feature in ethnomathematical studies. Researchers like D'Ambrósio (2006) have frequently discussed the appearance of arithmetic and geometric patterns in traditional practices across various cultures, reinforcing the findings of this study. It also aligns with other studies by Alghar dkk (2022) and Falah dkk (2022), who explored the arithmetic sequence in Ethnomathematics.

4. Conclusion

Jamu is a term for traditional herbal medicine mixed and concocted from various plant ingredients. Consuming *jamu* has become a cultural heritage passed down from generation to generation for body care and treatment. This is evidenced by multiple traditional *jamu*-concocting tools in the Sumenep Palace Museum, Madura. These tools include *pipisan*, *gandik*, *botekan* and *cengkelek*. Based on the analysis results, several mathematical concepts were found in making *jamu*, namely the concept of comparative value. In addition, there are also mathematical concepts in traditional *jamu* concocting tools, namely *pipisan*, *gandik*, *botekan* and *cengkelek*. These mathematical concepts include geometry, which consists of the primitive elements of points, lines, and planes, and then the concept of similarity. Other mathematical concepts are sequence patterns and arithmetic series found from the size of each level of botekan.

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