Ethnomathematics: Concept of Proportion in the Process of Making Special Blitar *Pecel* Sauce

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Abstract. This study aimed to explore and describe the concept of comparative mathematics in making *pecel* sauce Blitar. The research method used is an ethnographic method with a qualitative approach. The research subjects are Tlogo Village, Blitar Regency residents, who produce and distribute Blitar's signature *pecel* sauce. Data collection techniques were carried out by observation, interviews, and documentation with parties related to the manufacture of *pecel* sauce. The data analysis technique uses the Miles and Huberman flow: data collection, data reduction, data presentation, and decision-making/verification. The validity check in this study used triangulation of data sources. The results showed that there was a concept of proportion in the process of making *pecel* sauce, including direct proportion (measurement activities of ingredients, time with the number of ingredients, weight of peanuts with the final result of chili pecel, and weight of chili with selling price), and indirect proportion (the number of workers to the duration of manufacture).

Keywords: Direct proportion · ethnomathematics · indirect proportion · *pecel* sauce

1 Introduction

Mathematics is an activity in real life that has previously been embedded in the mind and processed by the human mind through a logical thinking process [1]. It is not surprising that people carry out various daily activities by applying mathematical concepts but are oblivious to them [2]. Mathematical concepts that are applied to various cultural products can be integrated into the activities of human life, and it can be constructed as ethnomathematics. The culture here means a legacy of symbolic behavior carried out by the community. According to Ubiratan D'ambrosio, ethnomathematics is defined as mathematics practiced in specific cultural groups and community groups whose application can differ from one group to another [3]. The application of ethnomathematics can be seen in people's daily activities, such as counting, measuring, and designing.

Ethnomathematical studies still focus on the cultural products of the Indonesian people, but not many have studied the activities or processes of these cultural products [1]. As Bishop argues, ethnomathematical objects can be in the form of traditional

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games, traditional crafts, artefacts, and activities (actions) in the form of culture [4]. Ethnomathematics comes from the assimilation between habits and tradition, resulting in habits and heredity being carried out by the people in the area [5]. Ethnomathematics is mathematics that is practiced by society. Mathematics formed together with culture, will produce various forms according to the development of the user group. In other words, ethnomathematics is mathematics that is applied and grows in a culture where the culture is still valid and followed in a particular society/ethnicity. Due to the nature of ethnomathematics that grows in a culture, it is not surprising that people do not realize that the cultural activities they have carried out are the application of mathematics. Conducting an ethnomathematics study provides an overview of how mathematics is expressed in terms of local wisdom. Besides, by conducting exploration or cultural exploration, the ethnomathematics of a particular ethnicity will be revealed, which will be beneficial for the development of science.

An example of the study of ethnomathematics was done by Mulyadi [3], which revealed mathematical concepts in the coconut sugar production process by the Pacitan (East Java) residents, including plane geometry, solid geometry, proportion, speed, distance and time, measurement, probability, social arithmetic, similarity, and mathematics related to economics. From this study, it was also found that people unconsciously apply mathematical concepts in life.

The application of mathematical concepts in life also appears in various cultures and activities of the Blitar (East Java) residents. Besides being found in architectural buildings, daily activities, and artefacts, ethnomathematics can also be found in traditional dishes. Furthermore, some traditional food such as *geti* snacks, *wajik kletik*, and *pecel* rice is a food in great demand by the Blitar residents and tourists. From a variety of typical foods, one of the famous foods used as a souvenir object for travelers is *pecel*, a traditional Javanese peanut sauce for steamed salad regularly produced in Blitar. The production of *pecel* sauce is often produced by the people of Blitar for sale/business and consumption.

It is critical to understand mathematical concepts in daily activities because it involves the mathematical concepts of ratio and proportion, including direct and inverse proportion, as well as mathematical concepts in making *pecel* sauce. Proportion is comparing two or more values/variables. The concept of a proportion of both direct and indirect is one of the contents for students in grade which is regulated in the Indonesian national curriculum, the 2013 curriculum.

The learning objectives related to proportion is described in several basic competences of the 2013 curriculum, namely basic competence 3.8 which says *distinguishing direct and inverse proportions represented as data tables, graphs, and equations*; and basic competence 4.8 that stated *solving problems related to direct and inverse proportion* [6]. With the 2013 curriculum, education is designed to benefit students in the surrounding environment by exploring various applications of mathematics that can be found [7].

From this description, the researcher wants to reveal the contextual relationship between mathematical concepts and the production process of Blitar *pecel* sauce, which has never been discussed before. By conducting this ethnomathematics study, it is expected that it will be useful in understanding mathematical concepts in making Blitar *pecel* sauce.

2 Methods

This research employs an ethnographic type with a qualitative approach. This research focuses on identifying mathematical concepts in the production of typical Blitar *pecel* sauce. The research location was in Tlogo Village, Blitar Regency, East Java, Indonesia. The subjects were three residents who produce and distribute *pecel* sauce. Data collection techniques were carried out using observation, interviews, and documentation. In the observation, the researcher examined the process of making *pecel* sauce once to three different people. The researcher also noted what ingredients were needed in making *pecel* sauce and the quantities. Researchers conducted interviews to support the observation data. In the interview, researchers obtained data on the purchase price of ingredients and the selling price of *pecel* sauce products. Documentation is used as complementary data. Meanwhile, data analysis uses the flow of Miles and Hubberman namely data collection, data reduction, data presentation, and decision-making/verification [8].

3 Results and Discussion

Direct observations were carried out by researchers in Tlogo Village, Kanigoro District, Blitar Regency. Researchers also conducted interviews and documentation to support the completeness of the data obtained during the production. According to the informant, this business was initiated in 2010 using recipes passed down from generation to generation.

In the production activity, the informant made *pecel* sauce with the following ingredients: 4 kg of peanuts, 28 oz of brown sugar, 4 oz of garlic, 2 oz of aromatic ginger, 6 oz of cayenne pepper, and 4 oz of large chili. Roasting is carried out for a specific time interval, followed by grinding for further packaging. In detail, the process of making *pecel* sauce is as follows: (Fig. 1).

1. Gathering the basic and supporting ingredients for the *pecel* sauce. The main ingredients are peanuts, cayenne pepper, large chilies, palm sugar, as well as supporting spices including garlic, salt, aromatic ginger, and tamarind.
2. Peeling garlic and aromatic ginger. Next, cutting the garlic and chilies into several pieces.
3. Roasting the ingredients using *kreweng*, a skillet made from clay. According to the informant, *kreweng* was selected to maintain the hot temperature so that the ingredients cooked perfectly. Roasting does not use cooking oil because it will produce savory cooking ingredients and will not produce much oil when it becomes *pecel* sauce. The first roasting consists of roasting garlic, chili, and aromatic ginger until wilted and fragrant. The second roasting is peanuts that have been prepared. The peanut roasting is finished when the shells can be easily peeled off.
4. Separating the peanuts that have been roasted from the shells. After completion, all the ingredients are milled using a machine and will be packaged according to the price that has been decided based on the large number of production costs.

The mathematical concept of the *pecel* sauce production process was based on the identification of raw materials and production methods. In identifying the activity of making *pecel* sauce, the researchers found a mathematical concept, proportion. The

Fig. 1. The ingredients of *pecel* sauce (left), roasted ingredients (middle), the packaged product of *pecel* sauce (right)

proportion between two or more variable values is also known as a ratio. The proportion is identical to the concept of a fractional number and the variable of the proportion will not change when it is multiplied or divided by another number.

Direct and inverse proportion are different types of proportion. Direct proportion shows if one value increases, the other values also increase. This proportion is known as the price proportion. Direct proportions are related to equivalent fractions. Meanwhile, inverse proportion shows that if one value increases, the other value will decrease. The proportion is said to be reversed if the two proportions are always constant even though the proportion is inverse. Nevertheless, the units and magnitudes of values are still considered [9].

The proportion concept found in the processing of making *pecel* sauce which can be categorized as direct proportion are (a) the activity of measuring the ingredients needed in making *pecel* sauce, (b) the relationship between the time required and the number of ingredients processed, (c) the relationship between peanuts as the main ingredient with the results of processing *pecel* sauce, and (d) the relationship between the weight of the chili per package and the price given. The concept of indirect proportion appears in the relationship between the number of workers and the time needed.

3.1 The Concept of Direct Proportion

The activity of measuring the ingredients for making *pecel* sauce. The mathematical concept of measuring the raw material for *pecel* sauce focuses on the ingredients: 4 kg of peanuts, 28 oz of Javanese sugar, 4 oz of garlic, 2 oz of aromatic ginger, 6 oz of cayenne pepper, and 4 oz of red chili. According to the ingredients, a formula a specific proportion obtained from the weight of each raw material and the weight of peanuts. To start finding modelling, first, equate all materials into the same unit of weight, then divide it equally by the weight of the peanuts.

The list of abbreviations in Table 1 defines the weight of each ingredients.

So that the proportion is obtained as follows:

$$bKt : bGj : bBp : bK : bCr : bCb$$

$$= 4\,kg : 28\,ounce : 4\,ounce : 2\,ounce : 6\,ounce : 4\,ounce$$

$$= (4000g : 2800g : 400g : 200g : 600g : 400g)$$

Table 1. The abbreviations representing the weight of each ingredients of the *pecel* sauce

Abbreviations	Explanation
bKt	Peanuts
bGj	Palm sugar
bBp	Garlic
bK	Aromatic ginger
bCr	Cayenne pepper
bCb	Red chilli

$$= 1g : 0.7g : 0.1g : 0.05g : 0.15g : 0.1g$$

$$= 1 : 0.7 : 0.1 : 0.05 : 0.15 : 0.1 \quad (1)$$

The mathematical model of the concept of proportion will be determined by adding the variable n as the weight of peanuts:

$$= n : 0.7n : 0.1n : 0.05n : 0.15n : 0.1n \quad (2)$$

From the mathematical model found, to make *pecel* sauce with a weight of peanuts as much as n units of weight, it takes $0.7n$ brown sugar, $0.1n$ garlic, $0.05n$ aromatic ginger, $0.15n$ cayenne pepper and $0.1n$ red chili.

By determining the mathematics model (1) and (2), it can be concluded that the ingredients of the *pecel* sauce material have the concept of direct proportion where every single ingredient that changes in quantity will affect the measurement of other ingredients according to the mathematical model found.

Material Processing Activities Based on the Time Required. At this point we discuss the time required for processing ingredients in the process of roasting peanuts and spices (garlic, aromatic ginger, cayenne pepper, and red chili) on medium heat. Based on the information obtained from observations and interviews, the data obtained can be summarized in Table 2.

Based on the data in the Table 1, the following modelling can be made:

$$\frac{y_1}{x_1} = \frac{56}{2.8} = 20$$

Table 2. The ratio of the amount of ingredients to the time it takes to cook

The amount of material (x)	Approximate time is needed (y)
2.8 kg	± 56 min
4.2 kg	± 84 min
5.6 kg	± 112 min

$$\frac{y_2}{x_2} = \frac{84}{4.2} = 20$$

$$\frac{y_3}{x_3} = \frac{112}{5.6} = 20$$

From the data above, the average ratio is

$$\bar{x} = \frac{20 + 20 + 20}{3} = \frac{60}{3} = 20 \tag{3}$$

With the mathematical model no. 3, it is known that the ratio of the ingredients to the time required is 1:20, which means that every 1 kg of processed raw material will take about 20 min, with 20 being the proportion constant. From this explanation, the formed mathematical model is:

$$\frac{y_1}{x_1} = 20$$

From the mathematical modelling obtained the equation:

$$y = 20xorx = \frac{1}{20}y \tag{4}$$

Description:

$x =$ the amount of ingredients.
$y =$ the time is needed.

The formation of the Eq. (4), it can be concluded that y or the time required is directly proportional to x weight of the material with the equation $\frac{y}{x} = k$ where k is a constant of proportion. This activity is one of the applications of the direct proportion mathematical model. By looking at the mathematical model, it can be seen that when the measurement of material is increased (x), then the time required is also increasing (y). Thus, it meets the definition of direct proportion.

The Relationship Between the Weight of Peanuts and the Weight of the Pecel Sauce. Based on the interview, the number of peanuts in chili processing is used as the main benchmark in various matters, such as determining the cost of grinding and the range of how much *pecel* sauce can be made. Doing a proportion between a lot of beans and a lot of ready-to-package pecel sauce will make it easier to calculate the exact weight of the *pecel* sauce produced. Table 3 displays data obtained from observations and interviews.

So, a mathematical model can be made as follows:

$$\frac{y_1}{x_1} = \frac{y_2}{x_2} = \frac{y_3}{x_3}$$

$$\frac{54}{3} = \frac{72}{4} = \frac{90}{5} = 18$$

$$\frac{y_1}{x_1} = \frac{53}{3} = 18ory_1 = 18x_1 \tag{5}$$

Table 3. The relationship between the weight of peanuts and the weight of the *pecel* sauce

The weight of peanuts (x)	The weight of *pecel* sauce (y)
3 kg	± 54 ounce
4 kg	± 72 ounce
5 kg	± 90 ounce

$(x) = 1$ ounce $= 0.1$ kg.

$$y = 18x \, or \, x = \frac{1}{18} y \tag{6}$$

Description
$y =$ the weight of sauce (ounce)
$x =$ the weight of peanuts (kg)

From the mathematical model (6), it is obtained that the ratio of the weight of peanuts to the amount of chili produced is 1:18, which means that every 1 kg of processed peanuts will produce a range of 18 ounce of chili *pecel*, with 18 being the constant ratio. With the formation of the above equation, it can be concluded that y or weight of the *pecel* sauce is directly proportional to x, the number of peanuts, with the equation $\frac{y}{x} = k$ where k is a constant of proportion. By looking at the mathematical model no. 6, the relationship between the weight of peanuts and the weight of the *pecel* sauce shows the example of direct proportion.

The Relationship Between the Weight of the Pecel Sauce and the Price Given. After going through the stages of making the *pecel* sauce, the next step is the packaging of the *pecel* sauce. According to the informant, the packaging of the informants was divided into several different units of weight. Table 4 illustrates the weight of *pecel* sauce per pack at the given price.

The first step is to equalize the unit of weight on the chili *pecel* packaging. The results of the weight equation can be seen as follows.

$$1 \, ounce : 2 \, ounce : \frac{1}{4} kg$$

$$1 \, ounce : 2 \, ounce : 2.5 \, ounce$$

$$1 : 2 : 2.5 \tag{7}$$

Table 4. The weight of *pecel* sauce and its price

The weight of *pecel* sauce (x)	Price (y)
1 ounce	Rp 5,000
2 ounce	Rp 10,000
$\frac{1}{4}$ Kg	Rp 12,500

We obtained the proportion between the weight of the chili and the price is

$$\frac{y}{x}=\frac{\text{Rp } 5{,}000}{1}=\frac{\text{Rp } 10{,}000}{2}=\frac{\text{Rp } 12{,}500}{2.5}$$

$$\frac{y}{x}=\frac{5000}{1}=\frac{10000}{2}=\frac{12500}{2.5}=5000 \tag{8}$$

Based on the proportion model (7) it can be seen that the proportion ratio is 1:5000 with the weight of chili *pecel* per unit weight ounce (x) representing Rp5000 of the price obtained (y). With this proportion ratio, a proportion model is obtained.

$$y = x \times 5000 \, or \, x = \frac{y}{5000}$$

Description.

x = weight of *pecel* sauce per package (ounces).

y = price of *pecel* sauce per package.

Based on the proportion model no. 8, it shows the application of proportion mathematics by influencing the weight of the *pecel* sauce and the price. The higher the weight of the *pecel* sauce, the higher the price set and in reverse.

3.2 The Concept of Inverse Proportion

The concept of inverse proportion of value is related to the number of workers with the time needed. Preparing the main ingredients for *pecel* sauce includes peeling garlic and aromatic ginger, separating the stalks from chilies, and cutting all of these ingredients. According to the informant, it took about one hour and 20 min to be able to prepare the ingredients alone. The situation changes if there is an increase in workers' number. When two people carry out the preparation of materials, it takes less time to complete. It can be analogized in Table 5.

Based on the data in the Table 4, the following equation can be made:

$$1 \times 70 = 70$$

$$2 \times 35 = 70$$

Table 5. The relationship between the number of workers and the time required

Number of workers (x)	Time is taken (y)
1	± 70 min
2	± 35 min
4	± 17.5 min

By taking the proportion constant, which is the average of the two conditions above, we get the following results:

$$x^{-} = \frac{70 + 70}{2} = 70 \tag{9}$$

The model of the problem can be formed as follows:

$$y = \frac{70}{x} \, or \, x = \frac{70}{y} \tag{10}$$

Description:
x = the number of workers.
y = time taken.

With the mathematical model of no, 10, it is known that the estimated time used for this activity (y) will be shorter when more energy is available (x). Vice versa, when more and more manpower is available (x), then the estimated time required will be shorter (y). From the model above, it meets the definition of an inverse proportion.

4 Conclusion

In making Blitar typical *pecel* sauce, there is a concept of a value proportion found in (a) measuring the ingredients needed in making *pecel* sauce, (b) the relationship between the time required and the number of ingredients processed, (c) the relationship between the weight of peanuts and the weight of the *pecel* sauce, and (d) the relationship between the weight of the chili per package and the price given, and the concept of reverse proportion can be found from the relationship between the number of workers and the time required. Based on these conclusions, the learning of mathematics should be related to ethnoscience studies found in the surrounding area.

References

1. R. N. F. Utami, D. Muhtadi, N. Ratnaningsih, S. Sukirwan, dan H. Hamid, "Etnomatematika: Eksplorasi Candi Borobudur," JP3M (Jurnal Penelit. Pendidik. dan Pengajaran Mat., vol. 6, no. 1, hal. 13–26, 2020, doi: https://doi.org/10.37058/jp3m.v6i1.1438.
2. I. Rachmawati, "Eksplorasi Etnomatematika Masyarakat Sidoarjo," MATHEdunesa, vol. 1, no. 1, 2012.
3. M. Mulyadi, "Eksplorasi Etnomatematika pada Proses Produksi Gula Kelapa di Desa Klesem Kebonagung Pacitan," HISTOGRAM J. Pendidik. Mat., vol. 4, no. 1, hal. 163–176, Agu 2020, doi: https://doi.org/10.31100/histogram.v4i1.582.
4. A. J. Bishop, Cultural Conflicts in the Mathematics Education of Indigenous People. Clyton, Victoria: Monash University, 1994.
5. L. Putri, "Eksplorasi Etnomatematika Kesenian Rebana Sebagai Sumber Belajar Matematika Pada Jenjang Mi," J. Ilm. Pendidik. Dasar UNISSULA, vol. 4, no. 1, hal. 136837, 2017, doi: https://doi.org/10.30659/pendas.4.1.
6. Kementrian Pendidikan dan Kebudayaan, Modul 3 Asyiknya Berdagang: Matematika Paket B Setara SMP/MTs. Jakarta: Direktorat Pembinaan Pendidikan Keaksaraan dan Kesetaraan., 2017.

7. N. T. Huda, “Etnomatematika Pada Bentuk Jajanan Pasar di Daerah Istimewa Yogyakarta,” JNPM (Jurnal Nas. Pendidik. Mat., vol. 2, no. 2, hal. 217, 2018, doi: https://doi.org/10.33603/jnpm.v2i2.870.
8. B. M. Miles dan M. Huberman, Qualitative Data Analysis: An Expanded Sourcebook. Thousand Oaks, California: Sage Publications, 1994.
9. M. Ponidi &Nugroho, Modul Pembelajaran SMP Terbuka kelas VII. Kementerian Pendidikan dan Kebudayaan Direktorat Jenderal Pendidikan Anak Usia Dini Pendidikan Dasar dan Pendidikan Menengah Direktorat Sekolah Menengah Pertama, 2020.