Mathematics in the Preparation and Sale of Colombian Rice Pies and Its Potential Contribution to Mathematics Education

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ABSTRACT

Background: The *pastel de arroz* [rice pie] is part of the traditional foods of the Colombian coast. Its preparation and sale encompass various unconventional mathematical processes. At this point, ethnomathematics allows the study of such processes without separating them from the social and cultural environment where they are employed. **Objective:** To study the mathematical processes involved in preparing and selling rice pies from an ethnomathematical perspective. **Design:** A qualitative methodology was applied for this purpose through an ethnographic approach. **Setting and participants:** Two cooks who are experts in making rice pies and are recognised for their work participated in the study. **Data collection and analysis:** Semi-structured interviews and participant observation were used as data collection methods, and electronic devices were also used to collect audiovisual material. The analysis of the information was categorical. **Results:** Among the main results, measurement processes, the use of non-conventional measurement units, and the use of mathematical processes, such as groping and the simple rule of three, for determining the quantities of ingredients and the price of the pies are identified. **Conclusions**: The stages of the preparation of the rice pies and the mathematical processes that are implicitly developed in them are exposed, and the importance of the connections of the results with topics related to school mathematics education and its potential contribution to this field is raised.

Keywords: Ethnomathematics; Rice pies; Measurement; Sales process.

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Matemáticas en la elaboración y venta de pasteles de arroz y su potencial aporte a la educación matemática

RESUMEN

Contexto: El pastel de arroz es parte de las comidas tradicionales de la costa colombiana, el cual en su elaboración y venta, lleva a cabo diversos procesos matemáticos no convencionales, en este punto, la etnomatemática permite el estudio de tales procesos sin separarlos del ambiente social y cultural donde son empleados. **Objetivo**: estudiar los procesos matemáticos presentes en la elaboración y venta de pasteles de arroz desde una perspectiva etnomatemática. **Diseño:** Para ello se aplicó una metodología cualitativa, por medio de un enfoque etnográfico. **Escenario y participantes:** Para el estudio participaron dos cocineros expertos en la realización de pasteles de arroz y reconocidos por su labor. **Recogida y análisis de datos:** se empleó la entrevista semiestructurada y la observación participante como método de recolección de datos, además se utilizaron dispositivos electrónicos para la recopilación de material audiovisual. El análisis de la información fue de tipo categorial. **Resultados:** Entre los principales se identifican procesos de medición, el empleo de unidades de medidas no convencionales, y la utilización de procesos matemáticos, tal como el tanteo y la regla de tres simple, para la determinación de las cantidades de los ingredientes y el precio de los pasteles. **Conclusiones:** Se exponen las etapas de la elaboración de los pasteles de arroz y los procesos matemáticos que se desarrollan de manera implícita en estos y se plantea la importancia de las conexiones de los resultados con temas afines a la Educación Matemática escolar y su potencial aporte a este campo.

Palabras clave: Etnomatemática; pastel de arroz; medición; proceso de venta.

INTRODUCTION

The *pastel de arroz* [rice pie] has long been part of the traditional and most widespread foods of the Colombian Caribbean coast (Sánchez, 2020). In Colombia, the rice pie is called *tamal* and *envuelto*. However, it receives different names and ingredients in other Latin American countries. For example, in Venezuela, it is called *hallacas*; in Chile and Argentina, *humitas*; *nacatamal* in Nicaragua; in Brazil, it has the name of *pamonha; pasteles* in Puerto Rico, and *tamales* in Cuba and Ecuador. However, its recipe is particular in each place, and so is its way and time of preparation, size, and quantity of ingredients. In Colombia, the main protein in the rice pie is chicken, pork, and beef. The importance of this dish for the Colombian Caribbean community is reflected in the renowned event *Festival del Pastel* [Pie Festival], celebrated in different cities. In the department of Atlántico, for example, the *Festival del Pastel Pital de Megua* [Pital de Megua Pie Festival], which began in 1992, is commonly carried out in the last weeks of June. This festivity benefits around

500 families, thus becoming an income source for many homes (Rodríguez, 2019).

THEORETICAL FOUNDATIONS

The ethnomathematics program has been understood in different ways. However, one of the most significant interpretations in the field was the one made by D'Ambrosio (2014), who mentions that etymologically the word supposes:

> Several ways, styles, arts, and techniques (technés or ticas) to explain, learn, know, and deal in/with (matemá) the natural, social, cultural, and imaginary environments (ethnos) of a culture, that is, ethnomathematics are the ticas de matemá in a specific etno. (p.103)

However, Aroca (2016) criticises this way of interpreting ethnomathematics and sustains: "We call ethnomathematics the art or technique of understanding, explaining, learning about, containing, and managing the natural, social, and political, depending on processes such as counting, measuring, classifying, ordering, inferring, which result from well-identified cultural groups" (p.10).

At this point, Rosa and Clark Orey (2005) mention that from a "Dambrosian" perspective, ethnomathematics includes studies of mathematical practices that are developed throughout history by specific cultures. They also state that practices imply techniques that are adapted to a particular cultural context.

When trying to triangulate these conceptions, the ethnomathematics program can be considered as the study of mathematics in different cultures or practices; however, Blanco, Higuita, and Oliveras (2014) clarify that "such meaning limits the program and even runs the risk of looking at these other cultures from the perspective of a dominant mathematics" (p. 247). On the other hand, Gerdes, cited by Miakra (2013), mentions that this author considers the terminology ethnomathematics ambiguous regarding its object of study. Therefore, he implemented the term ethnomathematicology, which takes as background the cultural context of a particular group in the study of mathematics.

As for doing ethnomathematics, D'Ambrosio and Knijnik (2020) mention that it implies carrying out fieldwork using ethnographic techniques,

such as participant observation, field diary, audio recording, and interviews; however, ethnomathematics not only implies ethnography but also relates field research and pedagogical work developed in school.

The measuring activity

According to Bishop (2005), six "universal" activities generate mathematical thinking: designing, measuring, counting, locating, playing and explaining. In light of this research, measuring is the predominant activity in elaborating rice pies. Similarly, Bishop mentions that measuring is not only a universal activity but is also crucial for the development of mathematical ideas, which includes processes such as comparing, ordering, and quantifying.

Godino et al. (2002) say that measuring consists of "assigning an identifying code to the different modalities or degrees of a characteristic of an object or perceptible phenomenon" (p. 615), in which it is not only the measurement for quantitative traits that are taken into account, which is commonly used to designate length and weight, among others. Measuring is also considered as assigning a category of qualitative features, such as the degree of satisfaction with something.

Other authors, such as Cantillo, Pupo, and Aroca (2019) state that:

> Measuring is a very important activity in people's lives; it is an activity they can carry out in different ways, depending on their context, environment, or cultural distinctions. The societal measurement systems tend to be colloquial and characteristic of that specific society. (p. 64)

Given the above, we can affirm that the measurement activity can be used differently depending on the cultural and social context in which a specific community is immersed; each town has its way of measuring (Gerdes, 2013). A measurement process, representative of the ethnomathematics of the community, is distinguished from other similar processes due to cultural roots. Measuring or the measurement process can be seen from different perspectives, as exposed by Jaraba, Martínez, and Aroca (2021), who give it a commercial and social value. This notion is supported by Zapata and Cano (2008) since they consider measuring a crucial process to execute both commercial and daily life activities.

Alsina (2019) exposes a classification in the units of measurement based on the instrument with which it is measured in such a way that there are

anthropometric units, which are those that originate when the body itself is used as a measurement instrument (for example, when using the palms and feet). On the other hand, unconventional units are given when the measurement is taken with objects that were not created to measure (using a stick to measure length). Finally, the standard units, which result when using instruments that were created especially to measure (using a tape measure). Taking these theoretical references into account, it became possible to study the mathematical methods implemented by the people interviewed to prepare rice pies in terms of the perception of measurements and the relationship between quantities.

Related research

In the ethnomathematics program, there are investigations whose problem has focused on analysing mathematical methods used in the activity of measuring in various trades; for example, Rodríguez-Nieto, García, and Aroca (2019) present unconventional measurement systems used in artisanal fishing with kites. They pointed out that the fishermen of Bocas de Ceniza use a first system of measurements given by phantom, yards, etc., for the fishing tackle, and another system of measurements based on fingers, *gemes*[1], and *cuartillo*[2] to make kites. Similarly, Jaraba, Martínez and Aroca (2021) present an analysis of the measuring activity used in the artisanal design of facemasks.

On the other hand, Rodríguez-Nieto et al. (2017) carried out a study on the non-conventional measurement methods used in the sale of passion fruit, where the use of the unit of *arpilla*[3] and *cuartillo* and their equivalence in numbers of this fruit stands out. Likewise, Rodríguez-Nieto et al. (2019) focus their research on the measurement process used in the artisan practice of making cassava buns, where they establish a relationship between the conventional measure with its equivalent unit and its sale price. According to Bishop, Castro et al. (2020) identify the "universal" mathematical activities involved in making furniture, such as measuring. Triviño (2012) carried out his study focused on using proportionality models in daily practices where he

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[1] Distance from the tip of the thumb to the index finger, separated from each other as much as possible.

[2] Measure of capacity for aggregates, quarter of a bushel, equivalent to approximately 1387 cl.

[3] Measurement based on the amount of x product that fits entirely in a raffia-based bag, a measurement frequently used by merchants.

mentions the activity of making tamales. He also analyses the relationships between situations involving quantities, such as the amount of banana leaves and rice in a *tamal*.

The problem of this research arises from our interest in understanding the mathematics used in preparing and selling rice pies, for which we seek to identify the mathematical methods and processes inherent in this practice. Thus, the study aims to answer the question: How can we identify the mathematical methods used in making and selling rice pies?

METHODOLOGY

Next, the methodology used in the research will be explained.

Type of research

In the research, a qualitative approach was used, since it allows us to see things from the point of view of those being interviewed (Rada, 2007, p. 18), facilitating the perception of the object of study. This approach shows the behaviour or characteristics of said object in detail, leading to a faithful interpretation and analysis of the study phenomenon. Considering that this research aims to understand the mathematics used to prepare rice pies, in some specific cases, an ethnographic design was chosen for its realisation (Hernández et al., 2014, p.482), since we intend to understand social systems from the point of view of the participants to make significant interpretations of the practices carried out in such systems.

Data collection techniques

In the Semillero Diversidad Matemática [Mathematical Diversity Hotbed] of the mathematics degree at the Universidad del Atlántico, we consider it essential to use the semi-structured interview and participant observation as the main data collection techniques since it involves the researcher much more with the object of study. Hernandez et al. (2014) mention that in qualitative research, "Data collection occurs in the natural and everyday environments of the participants or units of analysis. Therefore, we scheduled a meeting for the semi-structured interview, considering that this should be done in a comfortable and familiar environment for the interviewee, which, in

turn, would demonstrate the process of the practice under study for which the place of work was chosen.

The semi-structured interview format consisted of 55 questions grouped into four categories, which emerged from making rice pies: 1. Contextualisation, which allowed to know the interviewees in aspects related to their trade. The next three categories are named per processes as follows: *Process 1*. Procurement of materials *Process 2*. Preparation of rice pies. *Process 3*. Pricing. In the same way, we made an audiovisual record of the fieldwork and their literal transcriptions.

Context and population.

Rice pies are not only a traditional food in the Caribbean; their preparation is also a family income on the coast. Our cohort was families living in the department of Atlántico who make rice pies, from which we chose a sample of two people with whom we agreed upon a meeting at their workplace, where we interviewed them. The general data of the people interviewed are presented in Table 1.

Table 1

General data of the interviewees

Name	Age	Experience time	Place of residence
Esprelida	54 years old	12 years	Costa Hermosa
Javier	57 years old	32 years	Costa Hermosa

They were selected due to their journey in preparing rice pies and their social recognition due to the quality of their pies.

Information analysis method

The methodology used was categorical analysis for an adequate analysis exercise in light of the information collected, which Murcia (2017) defines as a "set of interrelated classification elements used in the sciences to

meet a specific research objective" (p.79) in which the data and information were first organised by reviewing the material. In the same way, Murcia (2017) enunciates the essence of the analysis of the categorical system and its function of relating the information:

> One of the most valuable elements of the categorical system is possibly its relational essence of the categories. This complex systemic logic allows the categories to not only be a list of concepts defined a priori or a posteriori (that is, they do not occupy a single place in the research) but, instead, that they move, some emerge, others disappear, others are transformed; that the positions of the topics of research in relationships of subordination, coordination, dependence, independence, interdependence, inclusion, opposition, superposition, derivation, mainstreaming, grouping be energised; among other possibilities. (p.81)

This made it possible to establish categories of analysis for the creation of tables and graphs, thus identifying the relationship between the data collected for a significant study on them.

RESULTS

During the study on the interviewees involved in preparing rice pies, we found that the process consisted of different phases, which will be detailed later. These phases include the development of this activity and include the purchase of ingredients, the preparation of the rice, the packaging of the pies, their cooking and sale. Next, what was found in the fieldwork will be observed in more detail.

Acquisition of ingredients or inputs

The place where the inputs for the preparation of the rice pie are purchased, such as vegetables, seasonings, rice, meats, and Bijao leaves, is of the utmost importance since their quality directly interferes with the flavour of the food. For this reason, they go to the Barranquilla market or the barn on specific days to buy these supplies to find fresh vegetables. Bijao leaves, for example, require special attention: they must have an intense green colour (Figure 1) as they must not be dry and should not break during cooking. Besides, they must be medium size since it facilitates the wrapping process.

Figure 1

Some inputs for the preparation of rice pies.

Estimated quantities

Regarding the necessary quantity of each input, señor Javier and señora Esplerida affirmed that they had established some amounts over the years and with experience. The interviewees commented that this process took a long time, which consisted of making pies and testing their flavour, using estimated amounts of each ingredient. In this way, through trial and error, they managed to find the right flavour for the pies, which, in turn, allowed them to assign specific quantities that they use to this day. When stipulating the amount of each ingredient, it is necessary to know how many pies the clients ordered. Thus, for a specific quantity of pies, they take as a basis the ingredients needed to cook 100 pies. In the interview with señor Javier, he said:

> *A: How do you know how much of each ingredient you need?*
>
> *J: Well, I have some quantities already… previously, uhm, some standard measurements, so to speak, which are the ones that make me… the ones that I take into account when it comes to the number of íes, for example, how much, how much you need… I start from the quantity of 100 pies, the amount I need for 100 pies, then, I have that quantity, the measurements, and based on those quantities, then, depending on what I am going to make, then I buy the materials for that quantity. (Javier Rivera, personal communication, April 1, 2022).*

In this way, today, señor Javier knows that to make 1000 pies, he needs two bags of rice, and to make 2000, he needs four bags (Table 2). This process is repeated for each ingredient used to prepare the rice pies.

Table 2

Estimates of amounts

Number of pies	Amount of rice given per wrapping	Amount of rice in pounds	Kilos of chicken and pork
500	1 wrap	90 lb	50 kg
1000	2 wraps	180 lb	100 kg
2000	4 wraps	360 lb	200 kg

Given the above, they use the rule of three to determine the quantity of each ingredient per number of pies based on the amounts of a specific ingredient for 100 pies. In this way, they find the accurate amount of that ingredient for an *x* number of pies.

Regarding the amount of salt, they make a relationship between its quantity and the amount of rice. At this point, señor Javier stated that:

> *The same amounts tell me, uhmm, the same amounts tell me, for example, if I add a pound of salt to 20 pounds of rice, obviously for 40 pounds of rice I add two pounds of salt, and there, increasingly depending of the amount that is going to be made. (Javier Rivera, personal communication, April 1, 2022)*

Therefore, it is evident that there is a direct relationship between the amount of salt and the amount of rice (Table 3).

After making a relationship between quantities in terms of the amount of rice-salt and its equivalence linked to the amount of cakes to prepare, they add the ingredients for rice preparation, including vegetables and seasonings. Table 4 shows the amount of each vegetable or condiment, considering the total rice/salt and the number of pies they must prepare (Table 3).

Table 3

Amount of salt per amount of rice

Amount in pounds of rice	Amount in pounds of salt	Number of pies
20 lb	1 lb	80
40 lb	2 lb	160
180 lb	9 lb	1000

Table 4

Relations between stipulated amounts per ingredient

Rice	Salt	Vegetables				Annatto	Seasoning Oregano	Garlic
		Scallion	Paprika	Carrot	Onion			
20 lb	1lb	5 lb	5 lb	6 lb	6 lb	4 oz	4 oz	½ pound
40 lb	2 lb	10 lbs	10 lb	12 lb	12 lb	½ pound	4 oz and a little more	1 lb
180 lb	9 lb	80 lb	80 lb	60 lb	70 lb	1 lb and a little more	½ lb and 4 oz	5 lb

As seen in this first part of the results, referring to the input acquisition process, señor Javier and señora Esplerida use quantity measures established through experience based on 100 pies. However, the interviewees resort to mathematical processes that allow them to know how much each ingredient they need to make more than 100 pies. In the same way, the relationships created between the quantity of each ingredient and the number of pies (amount of rice/number of pies) are highlighted, as well as those between two or more components (amount of rice/amount of salt/amount of grounded annatto) that allow them to carry out this first stage in the preparation of pies.

Preparation of the rice

In the next stage, they prepare the rice by mixing the ingredients. One of the interviewees said there is no order to put the ingredients in the mixture since this does not interfere with the final product. However, the other person interviewed presented an order for the rice preparation, as seen in Figure 2.

Figure 2

Rice preparation process

Step 1 Garlic, grounded annatto, salt, and seasonings are added to the rice.	**Step 2** A first mixture (rice preparation) is carried out.	**Step 3** Vegetables are added to the mixture.	**Step 4** The vegetables are mixed to the prepared rice.
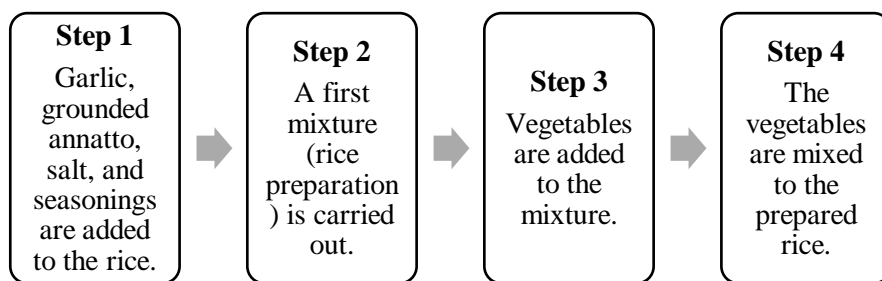
Señora Esprélida also mentions that following the steps for the correct pie preparation is imperative. For the mixing process, they use their hands and a container estimated to be equivalent to 60 lb of rice. At this point, they emphasised that only one person should mix since it is considered better for preserving the product. For a well-made mixture, stirring for about 15 minutes is necessary. After that, the flavour and colour of the rice will determine if more mixing time is necessary.

Wrapping up the pie

This phase consists of depositing and wrapping the rice and the protein, either pork or chicken, inside the Bijao leaves and finally tying up the pie. The following table shows in detail the process involved in wrapping rice pies.

Table 5

Rice pie packaging process

Photo/evidence of the process	Description
	General considerations. The amount of Bijao used to pack the pies is equivalent to four large leaves. In the same way, they use a glass with an estimated measure of 250g (pound measure).
	The ingredients are deposited on the Bijao leaf: The four large Bijao leaves are placed on the table. They deposit half the glass of rice on them. They proceed to choose the portion of meat, either pork or chicken. The missing amount of rice is poured.
	The wrapped pies go into a basket, giving way to the tying phase. For this, resistant hemp twine is used, such as in egg baskets.
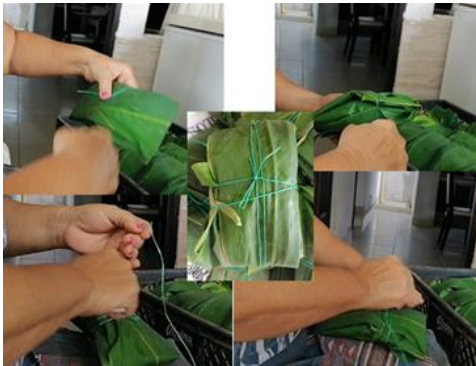
To tie the rice pie, one must firmly hold it in one hand; with the other, one passes the string around it. Each tying corresponds to a different kind of pie.

Finished product ready for cooking and sale.

In the packaging process, one can observe the importance of the quantities obtained in the first stage of the acquisition of inputs and the knowledge about dividing the number of Bijao leaves and rice to comply with the number of pies required. For this, señor Javier has a glass as a measuring instrument, which he has estimated contains the amount of rice indicated for a pie, through which he estimates when the pie needs a "little more" rice, as is the case of the mixed pie. At this point, we highlight the estimate made using the glass because of its link to the number of pies that can be obtained with its capacity and the link in the estimate of the weight in kg. The resistance of the hemp twine, in turn, must be considered according to the temperature reached during the cooking. In the same way, in this process, the tension with which the pie is tied is considered because, on the one hand, if it is too tight, it can break the Bijao leaf; on the other hand, if it is not tight enough, the pie can undo.

Cooking and selling rice pies

After being tied, 200 pies must be accumulated to start the baking stage. For this, pots with an estimated capacity of 200 pies and a tank with an estimated volume of 100 litres of water are used. Then, the water is poured into the pots and put to boil with the pies inside for four hours. Two moments are distinguished in this process: the first two hours are continuous cooking, then, after two hours, the cooks switch the pies; the ones at the bottom go on top and vice versa, so they are evenly cooked.

There are observable guidelines to determine when the pie is correctly cooked: the thickness of the pie, as it increases once the rice is cooked, and the colour of the Bijao leaf changes with the cooking. Figure 3a shows the green colour of the leaf before the cooking process, and Figure 3b shows the colour changes generated in the leaf due to the process.

Figure 3

Bijao leaf color change after cooking

Figura 3a   **Figura 3b**

Sale of rice pies

The amount of capital invested is involved in estimating the price of the pies. However, a single price is managed during the year, regardless of the decrease or increase in sales. To stipulate the profitability of the business in sales, one must first determine how much one wants to profit. At this point, señor Javier Rivera, in the interview "Estudio de métodos matemáticos empleados en la elaboración y venta de pasteles (tamales) de arroz" [Study of mathematical methods used in the preparation and sale of rice pies] (Matemáticas del pueblo, 2022, 19m05s), states:

In business, one always tries to make the business at least 100% 'utilidad' or at least 80% utilidad. That is, if I invest $100 COP, I should earn $100 COP more, that is, $200 COP; if I invest $80 COP, I should earn $80 COP more. So one takes out the calculator and calculates… if I want to earn $100 COP, then I must see for how much I should sell the pie to earn $100 COP.

Although what has been said above is mathematically incorrect, since they used the pertinent terminology, we see that señor Javier has some notion of mathematics and knows the basic operations and how to use them for his business.

When señor Javier mentions that the business must give a *utilidad* [4] of 100%, he actually refers to *rentabilidad* [5]. Contreras and Díaz (2015) define it as follows: "Rentabilidad is the difference between income and expenses, and it is the return on the investment" (p.40). We can say that *rentabilidad* is the difference between the investment of the raw material and the *utilidad*. For example, suppose señor Javier invests $200,000 COP and obtains a *utilidad* of $100,000 COP. This generates a 50% *rentabilidad*. Given the above, it would be correct to declare that señor Javier obtains a *rentabilidad* of 100% in his business.
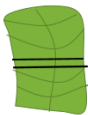
Considering the information collected in the process of stipulated measurements of each ingredient, the wrapping in the preparation of pies, and the selling process, we made the following table to show the different kinds of pies made by the respondents against their main ingredients. In the same way, the amount of rice for each type of pie is exposed, corresponding to the unit of measurement used, glasses, the type of tie, the estimated total weight of the pie, and the sale price per unit and wholesale (Table 6).

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[4] Result after subtracting all expenses from income.

[5] The level of return obtained from an invested capital that represents the management of that capital. Likewise, it indicates if the business in which it has been invested is a good business or not. Tapia, G. (2013). Profitability, utility and value. UNSA Magazine, 1-2.

Table 6

The relationship between the type of pie, weight, and tie

Type	Quantity of rice	Tie	Estimated weight	Price
Chicken pie (chicken and rice)				
			12oz	$3,000 COP/ 0.70 USD
Pork pie (pork and rice)	(1/2 lb)			
Mixed pie (chicken, pork, and rice).				
			12 ounces and a little more	$4,500 COP/ 1.19 USD
Special pie (Egg, chorizo, large piece of chicken and pork, and meat)	(1/2 lb and a little more)			

DISCUSSION

Specifically, in the field of mathematics education, the results obtained allow making connections with Basic Learning Rights and Basic Standards of Competencies [Derechos Básicos de Aprendizaje y Estándares Básicos de Competencias] in this area regarding school grades and/or specific topics to promote the types of mathematical thoughts, such as metric thinking and measurement systems and numerical thinking and number systems, as shown

below: In the Basic Competence Standards, set forth by the Ministry of National Education (2006), in the first and third-grade group, it is related to metric thinking, where it is stated that the student must make estimates of measures required in solving problems mainly related to social, economic, and science life. On the other hand, in the fourth to fifth-grade classes, students are expected to identify and use relative measures in different contexts and select units, both conventional and standardised, appropriate for different measurements. In secondary school, there are connections with the teaching of financial mathematics.

In the same way, the Basic Rights of Learning in Mathematics [Derechos Básicos de Aprendizaje en Matemáticas], by the Ministry of National Education (2016), settle that fourth-graders must learn to characterise and compare measurable attributes of objects, such as mass, capacity of containers, temperature, these concerning procedures, instruments and units of measurement; and concerning the needs to which they respond. On the other hand, it describes that in this grade, students choose standardised and non-standardised instruments and units to estimate and measure length, area, volume, capacity, weight, and mass, and from them, make the necessary calculations to solve problems. For the sixth grade, it states that students are expected to: "Propose and develop strategies for estimation, measurement, and calculation of different quantities (angles, lengths, areas, volumes, etc.) to solve problems" (p.47)

Considering the above, we observe the potential contribution of this research to mathematics education because, during the preparation of rice pies, students develop mathematical thinking. The following paragraph exposes the mathematical processes immersed in the practice, based on the Basic Standards of Competencies in Mathematics (2006):

- **Formulation, treatment, and resolution of problems**, in which strategies are created, and their feasibility is stipulated; in this particular case, this process presents price allocation, taking into account what profit is to be obtained and determining the quantity of each ingredient aiming at a specific number of pies.

- **Reasoning, which allows comparisons**, relationships such as those given between the amounts of different inputs. In the same way, this process makes it possible to give coherent explanations of the procedure for making cakes and the decisions made in it; on the other hand, it allows evaluating processes, which leads to a

continuous improvement in the execution of the necessary procedures in this activity.

- **Formulation, comparison, and exercise of procedures**. In making pies, this process is evidenced in the use of algorithmic processes to find the necessary amount of each ingredient given a specific number of pies.

- *Modelling*, where schemes repeated in this activity are identified for constructing models that represent it. This makes it easier to perform the above procedures, such as problem solving.

On the other hand, Aroca (2018) shows the importance of problematising the results found in ethnomathematical investigations so they can be taken to the classroom. This author mentions that this process must be carried out through a didactic position of parallel and comparative learning, where it can be taught in the classroom based on the cultural context, taking pedagogy and ethnomathematics hand in hand, and, besides globalised mathematics, mathematics based on the diversity of the society's culture is also taught. In this research, the measurement systems could be taught based on the activity of making rice pies. In the same way, the possibility of teaching this subject with related practices is open.

During the development of this research, we could extract several processes and moments where mathematics is present abstractly or unconventionally. Regarding the preparation of pies, unconventional units of measurement are used, according to what was expressed by Alsina (2019), because objects that were not explicitly created to measure are used, such as the *glass* with the exact measure for a rice pie or *the punch bowl*, which, when used, generates a unit of measurement around the number of pies that fit inside it, in this case, from 200 to 300 rice pies. However, they use standard measurement units when using instruments such as weight in kilograms.

With the above, we also consider the *measurement units* they use, as with *mass: pound, kilo, half a pound, four ounces, wraps,* and volume measurements such as *litres.* This allows observing the estimated relationships between units of measure, *wraps of rice/number of pies*, similar to the results obtained in the research by Rodríguez-Nieto et al. (2017), in which equivalences are observed between *cuartillo-arpilla* for the sale of passion fruit and the *litre-cuartillo* equivalence for the sale of peanuts; in terms of volume measurements, the relationship can be made between the litres of a tank to fill

the pot that holds 100 l of water and that this is the amount needed to heat 200 pies.

In the same way, we find connections with the research carried out by Rodríguez-Nieto et al. (2019), where they observed the use of conventional measures was observed in the preparation and sale of cassava buns and their use in their price estimation process for their sale. In our study, we can verify that although it is a different activity, conventional and non-conventional measures are used, such as the pot, the tank, the glass, the pound, four ounces and a little more, the wrap, litres, etc. Similarly, we found a connection with the research by Hernández, Aroca, and Salas (2022), who propose that in different cultures since the beginning of humanity, people determine the concepts of volume and capacity according to their intuition. In this case, the interviewees assign measurement units to quantities of pies or other ingredients, this with the need to measure, agreeing with Godino et al. (2002), because this assigns a code that identifies a specific object, in this case, a punch bowl has a capacity for 300 pies. This estimate is given according to their need to know the quantity of each ingredient, finding a link with the number of pies, which is the main unit of measurement that they use in this practice.

Similarly, Triviño (2012) talks about the proportionality of the amounts of banana leaves for a certain amount of rice in a tamale, as seen in the practice of making pies, where we could see that there is a direct and proportional relationship in the quantities of Bijao leaves to be used and the amount of rice and protein that a pie needs; more Bijao leaves are needed if you want to obtain a large pie, as it will prevent the pie from falling apart in the tying process and later in the cooking process.

Triviño (2012) affirms that to calculate the necessary pounds of rice, the number of tamales must be a multiple of 7 to give a natural number. Nevertheless, the rule of three is used in this investigation, starting from 100 pies. Based on this amount, they carry out all the processes. Therefore, to determine the amounts in the ingredients, the number of pies to be made does not necessarily have to be a multiple of x. In the same way, Triviño (2012) proposes that considering that the amount of rice depends on the number of tamales to be produced, which can be associated with the independent variable x to the number of tamales and a dependent variable $f(x)$ with the amount of rice to be produced. The latter illustrates a different conception of mathematics found in making pies. We can find more dependency associations, such as the number of pies – quantity of ground annatto can be obtained, which opens the possibility to other applicability of the research in mathematics education.

Considering the findings regarding the measuring activity, we remember Cantillo et al. (2019) because, when making rice pies, measuring can be appreciated in different ways; different measurement systems are generated during the activity. In the same way, the importance of this activity is evident, not only in the preparation but also in the sale of rice pies, for which we recognise that the activity of measuring is a process that allows us to execute not only activities of life but also commercial activities (Zapata & Cano, 2008).

CONCLUSIONS

Concerning the results obtained in the development of this research, we see that, in making and selling rice pies, different mathematical processes are used in each stage or process that this work entails. The main findings in each of the processes described before are described below:

1. **Procurement of materials**: During the development of this first phase, it was possible to demonstrate an unconventional way of stipulating specific amounts of ingredients for the preparation of x amount of pies by using the measure of trial, as well as using the simple rule of three when looking for exact amounts. We can even highlight the ability to relate the amounts of ingredients to each other when using them.

2. **Rice preparation:** We can consider it the beginning of the preparation of the pie since it is the moment when the ingredients are mixed, i.e., the ingredients and condiments of the first process begin to be portioned. Here señor Javier and señora Esplerida establish a relationship with capacity and volume since they use a container equivalent to 60 lbs of rice. Another finding is the time count in the mixture: they must mix it for 15 minutes, observe its appearance, and test if more than one vegetable or seasoning is needed.

3. **Pie wrapping**: In this phase, the action of dividing the rice is highlighted, for which unconventional measuring instruments are used, giving an estimate of the number of rice pies. We also consider physical properties, such as tension and resistance of the string (hemp twine) with which they tie the wraps. The patterns in tying the rice pies are also highlighted, as a special tying corresponds to a different type of rice pie.

4. **Cooking and sale**: In the cooking process, they make measurement estimates with different instruments, establishing relationships; for example, to a 100-litre pot, they assign the average size of the pan in which they cook the pies and estimate the number of pies that can be cooked in the pan. In addition, they follow observable patterns to determine whether the rice pie is cooked. For sale, notions of *utilidad* and *rentabilidad* are used to assign prices.

During the development of the article, we mentioned the time spent in each process. We consider it an important variable since offering the community a good quality product depends on this. Consequently, units such as hours and minutes are significant during the preparation of the rice and the cooking of the pies. Another factor to pay attention to is the quality of the products they acquire to prepare the pies. Obtaining good quality vegetables and condiments is, for them, a dependent variable; it is the quality to implement a sale price for the pies.

The results obtained in this investigation open the possibility of carrying out other investigative processes around the measurement systems and units and their respective estimates of quantity, the simple rule of three and concepts such as the *utilidad* and *rentabilidad* of a business in making rice pies or related practices, to demonstrate the diversity of such systems in the different societal practices.

AUTHORSHIP CONTRIBUTION STATEMENTS

MS, AC, and AA raised the research idea. MS, AC, and AA developed the theoretical section and the methodological design, which led to the writing and/or review of the draft of the article to be published. MS and AC produced and collected data for the appropriate use and subsequent analysis. AA reviewed the information in the article and provided leadership, coordination and financial support. All authors participated in the discussion and conclusion of the article.

DATA AVAILABILITY STATEMENT

Data supporting the results of this study will be made available from the corresponding author, AA, upon reasonable request.

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