ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.17648/acta.scientiae.7707

An Ethnomathematical Study of the Preparation of Different Types of *Empanadas* in the City of Barranquilla, Colombia

Alex Junior Torres Tortello [a]
Nelsy Carolina Vanegas Ibañez [a]
Armando Alex Aroca Araújo [b]

[a] Universidad del Atlántico, Programa de Pregrado en Educación Matemática, Puerto Colombia, Colombia.
[b] Universidad del Atlántico, Licenciatura en Matemáticas, Puerto Colombia, Colombia.

Received for publication 4 May 2023. Accepted after review 28 Jun. 2023
Designated editor: Claudia Lisete Oliveira Groenwald

ABSTRACT

Background: The research problem consisted of understanding the mathematics used in making *empanadas* based on cornmeal and wheat flour. **Objective:** The main objective was to identify the measurement unit systems implemented for its preparation, emphasising the correspondence relationships in terms of quantity and size. **Design:** The research is theoretically supported by the ethnomathematics program and process investigations of the topics at the end. **Setting and participants:** This research was carried out in the municipality of Soledad and the district of Barranquilla in the department of Atlántico. Two participants were available who agreed to collaborate with this inquiry. **Data collection and analysis:** The methodology used was qualitative, with an ethnographic approach, with a method of collecting information through observation and semi-structured interviews and audiovisual recording through electronic devices. The analysis of the information was done through category recognition. **Results:** The results to highlight are the phases of preparation of the dough, preparation of the filling, assembly of the *empanadas* and the frying process. Different mathematical processes are evidenced for their development, such as measurement unit systems, estimation and proportion. **Conclusion:** The discussion suggests that these results may have connections to favour the teaching of some topics in mathematics education.

Keywords: Ethnomathematics, Mathematics education, Fried foods, *Empanadas*, Measurement system.

Corresponding author: Armando Alex Aroca Araújo. Email: armandoaroca@mail.uniatlantico.edu.co

Un estudio etnomatemático de la elaboración de diferentes tipos de empanadas en la ciudad de Barranquilla, Colombia

RESUMEN

Contexto: El problema de investigación consistió en la comprensión de las matemáticas empleadas en el proceso de elaboración de empanadas a base de maíz y trigo. **Objeto:** El objetivo principal fue identificar los conceptos matemáticos implementado para su elaboración, haciendo énfasis en las relaciones de correspondencia en cuanto a cantidad y tamaño. **Diseño:** La investigación está respaldada teóricamente por el Programa Etnomatemáticas e investigaciones de procesos de los temas a fines. **Escenario y Participantes:** Esta investigación se llevó a cabo en el municipio de Soledad y el distrito de Barranquilla del departamento del Atlántico. Se dispuso de dos participantes que accedieron a colaborar con esta indagación. **Recopilación y análisis de datos:** La metodología empleada fue de tipo cualitativa, de enfoque etnográfico, con método de recolección de información por medio de la observación y la entrevista semiestructurada, y el registro audiovisual por medio de dispositivos electrónicos. El análisis de la información se hizo a través de un reconocimiento de categorías. **Resultados:** Los resultados a destacar son las fases de preparación de la masa, preparación del relleno, armado de las empanadas y proceso de freír donde se evidencian diferentes procesos matemáticos para su desarrollo como sistemas de unidades de medidas, estimación y proporción. **Conclusión:** La discusión plantea que estos resultados pueden tener conexiones para favorecer la enseñanza de algunos temas en educación matemática.

Palabras clave: Etnomatemática, Educación matemática, Fritos. Empanadas, Sistema de medidas.

INTRODUCTION

The empanada

The *empanada* (*in-pains*, *in-panata*) is a food prepared by enclosing some stuffing in dough or bread and baking it (Wong, 2017). It is a food made mainly from wheat flour or ground corn. They contain different types of filling. The wheat-flour *empanadas* may be filled with mozzarella cheese, ham, pineapple and/or shredded chicken; while ground-corn *empanadas* can be filled with salty cheese, shredded meat or chicken. The *empanadas* go through a frying or baking process.

This dish is of Arab origin and has inspired various dishes in countries such as Spain, France, and Italy (Hernández, 2020). In Colombia, the *empanada* became a typical food. Recent studies show

that its trading reaches around 12 million *empanadas* purchased per day. The cities or departments that most consume this food are Valle del Cauca, Medellín, Bogotá, and Barranquilla (Hernández, 2020).

In Colombian towns, they are usually sold as street or fixed sales in Colombian family home businesses. Beyond this, we want as a research group to analyse what mathematics is developed in this practice, as has been done in other investigations that analysed food preparation, for example, the identification of mathematical concepts in the preparation of the tortilla, such as circumference, circle, and cylinder (Rodríguez Nieto, 2021). Likewise, Rodríguez (2022) relates the themes of geometric figures, angles with equal measures, segments with equal measures, vertices, edges, parallelism, and perpendicularity with the preparation of *sancocho de Guandú* [pigeons peas Colombian soup]. On the other hand, an investigation relates the conventional and unconventional measurement systems with the production of the *bollo de yuca* [cassava bun] (Rodríguez, 2020). Similarly, we observe that by preparing food, students can practice thinking, reasoning, quantifying, interpreting, and modelling calculus situations (Zorzoli, Giuggiolini & Mastroianni, 2005). For example, Carpio et al. (2022) use the calculation of ingredients, weight-volume conversions, and temperature scales and how they could be connected with school mathematics education. Several investigations have already analysed the mathematics used in food preparation or local kitchens. There are also projects in mathematics education that implement the kitchen to address contextualised mathematics, reaching a more significant process for students, as is the case of: "Aprender matemáticas en diferentes espacios: la cocina" [Learning mathematics in different spaces: the kitchen] (Ortiz et al., 2019) and "Taller de cocina y matemáticas en educación infantil" [Workshop of cooking and mathematics in early childhood education] (Morales et al., 2015), among others.

Theoretical support

To understand the mathematics used in the artisan elaboration of *empanadas*, we must have a theoretical base to support the investigation, which we find in the ethnomathematics program. This program, a field of research, today has various interpretations; however, we can find a pattern in these interpretations as the field of study that analyses the forms of production and communication of mathematics in a specific

practice (Aroca, 2022). For Rosa and Orey (2005, p.365), "This program arose to confront the taboos that mathematics is a field of universal study, without traditions and cultural roots" because there was a belief that mathematics exists only in the academic and scientific field.

As D'Ambrosio (2016, p.9) states, "Ethnomathematics is now considered a sub-area of the history of mathematics and mathematics education, with a very natural relationship with anthropology". In addition, he analyses "the mathematics applied by cultural, urban or rural groups, groups of workers, professionals, children, indigenous societies, and others who identify themselves by common objectives or traditions" (D'ambrosio, 2008, p.19). Finally, D'Ambrosio and Knijnik (2020) propose that ethnomathematics owes its formation to the cultural relativism perspective, also stating that ethnomathematics opposes ethnocentric theorisations. Furthermore, they say that in mathematical research, fieldwork uses ethnographic techniques, such as participant observation, audio recording, and interviews.

For Gerdes (1994, p.19), ethnomathematics is like free culture mathematics and a priori universal knowledge. Likewise, he states that ethnomathematics emerge after other ethnosciences. The mathematician states that they are not only a cultural claim but a socio-political relationship that generates various educational processes. On the other hand, Yojcom et al. (2016) affirm that ethnomathematics is born from the relationship between mathematicians, historians, educators, and anthropologists.

D'Ambrosio (2016), considered the father of ethnomathematics, says the following, based on Powel and Frankenstein (1997):

> (…) the actual concept of ethnomathematics is primeval in nature since it recognises different perceptions of space and time and the emergence of specific ways for observing, comparing, classifying, ordering, measuring, quantifying and inferring as strategies to satisfy the pulsions of survival and transcendence. (p. 7)

From the quote above, it follows that mathematics is present in most situations, not in a conventional way as taught in school, but the way people use mathematical methods in their daily lives, as stated by D'Ambrosio and Knijnik (2020, p.284): "When ethnomathematics refers to "other" mathematics, what is at stake is not to say that we can replace

the teaching of school mathematics by the other mathematics".

Mathematical concepts

To discuss measurement unit systems, we must understand what measurements and associated concepts are and how they are represented. For example, let us start with *magnitude*, defined as the properties or qualities of objects or phenomena that tend to take numerical values, such as *length*, *weight*, *speed*, etc. (Godino, Batanero, & Roa, 2002).

By *amount/quantity*, we understand the "aspect by which portions of the same thing or set of the same class of things are differentiated from each other, by which these portions or sets can be measured or counted" (Godino, Batanero, & Roa, 2002).

On the other hand, for us, *measurement* is the "action or process by which numbers and units of references are assigned to attributes of entities of the physical world by applying an adequate instrument to measure the property in question of the body or system considered" (Ayala, Malagón, & Sandoval, 2011, p.46). The measurement process consists of four essential aspects, which are the idealisation of the properties of the object to be measured, methods to obtain the numbers of the studied body, the assignment of a unit to express the result objectively, and last but not least, the implementation of instruments to measure accurately (Galina, 2008, p. 11). A clear example is magnitudes such as *time*, weight, length, *mass*, *electric current*, and *temperature*, which can be measured by quantities, thus giving a metric system. Several of these concepts are present in the preparation of *empanadas*.

That said, measurement unit systems are composed of sets of measurement units in which no magnitude is associated with more than one unit (Calderón, 2015). On the other hand, people also use in their daily lives the International System of Units (SI), established by an organisation in charge of measuring and applying magnitudes and quantities (Almeida, 2002), Centro Español de Metrología (2019), which defines the system as follows:

> (…) it is a consistent system of units for use in all facets of life, including international trade, manufacturing, safety, health, and environmental protection, and the basic science that underpins it all. The underlying system

> of magnitudes under the SI and the equations that relate them are based on the current description of nature and are familiar to all scientists, technologists, and engineers. (p.11)

However, other measurement systems coexist with the SI, such as the Avoirdupois system, which accommodates the pound, the ounce, and other units, used mainly in the USA and the UK (Francisco, 2012). We also highlight the system of unconventional measures –of great importance since, in this paper, we present measurement by estimation– which, according to Bright (1976), is a visual or manipulative calculation process that disregards the help of a measurement tool (p.89), for example, for more inclusive mathematics education. Today, we prefer not to distinguish between conventional and unconventional measurement systems because, due to the relationship of power and coloniality that it brings, what does conventional measure mean? Why is it conventional? Are not the "un" conventional measurements used historically and daily in specific practices as well as those that "yes" are conventional? However, this is not the central theme of this research; therefore, we will not focus on it.

In this research work, we can observe instruments –scales, test tubes, stopwatches, and thermometers– displaying units such as pounds, kilograms, grams, litres, millilitres, seconds, minutes, and centigrades. However, these measurement units are not the only ones found in this investigation; we also detected estimates, such as a little, a little more, a handful, half a bottle, high flame, and low flame, corresponding to the magnitudes of mass, volume, time, and temperature. From the above, we conclude that the SI is not the only system qualified to measure, since the measures can be presented in several forms, considering the persons' contexts (Muñoz, Torres, & Aroca, 2022). As Bishop (2005) states, mathematical ideas are constructed by humans through cultural history.

Magnitudes are expressed by quantities, and through them, the concepts of proportions and proportionality emerge. Given that "the proportion is a scheme that establishes relationships between relationships (a ratio is a relationship between two variables, and the proportion is an equivalence relationship between two ratios) and implies the use of second-order logic" (Obando, Vasco, & Arboleda, 2014). Besides, according to Godino et al. (2017), when we solve contextualised proportionality problems, the magnitudes and their measurements

interact; in other words, we establish relationships between the quantities.

On the other hand, proportionality is classified into different criteria, where the context or field of application and the levels of algebraisation of the mathematical practices carried out play a fundamental role (Godino et al., 2017). We assume these references of authors in mathematics education or didactics of mathematics are extensive to the social practices we have analysed based on the ethnomathematics program, since many of these processes are also represented in said practices.

Based on the above, we infer that there are different ways to measure and count the quantities of a set of quantifiable things. For this reason, this research work intends to examine those techniques of measures that people use when carrying out their work when producing empanadas.

METHODOLOGY

The basic characteristics of the methodology of this research are presented below.

Type of research

The methodology on which we rely is of a qualitative type, which, according to Angrosino (2002), "intends to approach the world 'out there' (outside specialised research environments such as laboratories) and understand, describe, and sometimes explain social phenomena 'from the inside' in several different ways" (p.10). Thus, our first step was to identify the sample, a specific population sector about/from whom we can learn, analyse the practice, and identify mathematical processes, such as the measurement unit systems implemented in preparing *empanadas*. For this reason, we chose an ethnographic investigative approach, with which, according to Romero & Hernández (2015), we can reach the "communities' cultures more transparently and attached to reality" (p.74); thus, a collection of information can be achieved from immersion in the context of the persons being studied.

Background and participants

In many Colombian neighbourhoods, it is easy to find stalls selling fried food. Among them, we can easily find *empanadas* for sale. The sample included two people who were willing to collaborate in the research process, with whom we agreed on some field visits to their workplace. These vendors considered the *empanada* business an alternative to enhance their household income. The respondents' general data are shown in Table 1.

Table 1

Respondents' details

Name	Age	Experience time
Nuris	40 years old	2 years
Andrea	24 years old	5 years

Data collection mode

To collect the data, we used participant observation, as "it is a data collection technique whose purpose is to explore and describe environments... it implies going deeply into social situations and maintaining an active role, attentive to details, situations, happenings, events, and interactions" (Albert, 2007, p. 232). This method allowed the collection of sufficient data for this investigation.

The first step in this process was to visit sites where *empanadas* were sold and inspect digital sales platforms to communicate with their manufacturers and verify with them if they wanted to contribute to the investigation. This prior inquiry process made it possible to rule out the participation of nine people out of the 11 to whom the request was made. Next, we conducted a semi-structured interview to "start with planned questions, which can be adjusted to the interviewees" (Díaz et al., 2013). This kind of interview is more dynamic and allows interviewers to address different topics. The audiovisual documentation was the register of the process. The categories of the interview were presentation, ingredients, preparation of the dough, preparation of the filling, assembly of the *empanadas*, and the frying process. The second step was to record the route of each process while asking questions, thus registering the

creative action from different planes where the resulting artisanal product was highlighted. Finally, these files were systematised within a team with video editing capacity, organising the interview in such a way that it made oral and visual sense.

To analyse the information, we proceeded through a categorical analysis, taking into account that its production "reflects, in some way, the academic history of the research... [which] has allowed us to guide the design of the instruments collection and generation of information, showing the need to introduce some instruments and have initially unexpected participants" (Aristizábal & Galeano, 2008, p. 164). Through this method, we implemented categories to organise the information collected, ordering the videos with the evidence for each preparation. Once the organisation was completed, we transcribed the audiovisual record. Later, we designed tables to organise the mathematical information on the preparation of the *empanadas* and the characteristics of the process, considering mathematical aspects, such as the relationship established between the amounts of a specific ingredient for preparing a certain amount of filling or *empanadas* (proportion); the systems of measurement units (SI, Avoirdupos, and estimation), the measurement objects and the instruments that allow them to shape the *empanadas*.

Immersion method

After the interview, the producers, Nuris and Andrea, were asked whether they would allow us to participate in the manufacturing while they demonstrated how they made *empanadas*, so we would interact in the vendors' operational context and thoroughly analyse the object of study.

RESULTS

Within the fieldwork framework, we found different methods to make *empanadas*: one is *based* on *corn dough* and the other on *wheat flour*. Despite their significant difference, they share similar phases to obtain the final product (the *empanadas*), which will be analysed and compared in constructing a method based on mathematical processes. The ingredients will be indicated with the intended amounts implemented in this process. However, the investigation must first

consider the properties and characteristics of the dough used to produce the *empanadas*.

Corn dough and wheat flour dough

The interviewees used different doughs to make the *empanadas*. Nuris sourced yellow corn dough from a supplier and modified it to meet the specific requirements for her product preparation. Andrea, with a *secret formula*, uses wheat flour as the main ingredient.

The outstanding characteristics of the corn dough and the dough based on wheat flour can be explained in the following table for comparison.

Table 2

Comparing doughs for the preparation of fried empanadas

Aspects	Corn dough	Wheat flour dough
Colour	Strong cream 	Light cream 
Texture	Semisoft	Soft
Flexibility	It breaks easily so that precise cuts can be made.	It will stretch a lot, so its cuts require moulds or knives to avoid deforming the product.
Handling	The dough is manipulated with the hands to soften and shape.	It is manipulated with the hands but needs utensils, such as a baker's rolling pin, to stretch and shape.

The differences in the two doughs used for preparing the empanadas are flagrant; however, they do not prevent them from sharing the same particular structure. However, they must meet several requirements according to the product the *empanada* vendors wish to offer their customers. Thus, the first mathematical data is the number of ingredients needed so that the corn and wheat-based doughs reach good consistencies: to the seven pounds of corn flour, they add 40 millilitres of water; then, the dough is kneaded for four minutes to reach the flexibility needed to assemble the *empanada* and thus achieve proper handling. In turn, for 14 pounds of cornmeal, 100 millilitres of water is added, and then the dough must be kneaded for eight to ten minutes for the desired texture. To one kilo of wheat flour, they add 350 millilitres of water, 250 grams of butter, 100 grams of powdered milk, 25 grams of salt, 85 grams of sugar and two eggs. The resulting dough is kneaded for five minutes for soft flexibility. Hence, the relationship between the kneading process and time plays a prominent role in *empanada* production. On the other hand, we observed the original colour of the dough (cream or light yellow) and the colour it must reach when fried (yellow or gold). According to Singh (2006), "Red and yellow attract attention and stimulate the appetite" (p. 787), which explains why people are so attracted to *empanadas*.

Ingredient estimation

The cooks must estimate the amount of the several ingredients, which vary according to the types and quantities of *empanadas* they must produce.

Corn dough *empanadas* require previously prepared ingredients, such as the dough and the *empanada* filling. Filling preparation is time-consuming. Nuris states that she makes the *empanadas* "to her taste". Using touch, she takes a handful of cornmeal in her hand and thus knows the amount of dough for an empanada; she applies an estimate (*ad oculos*) to calculate how much filling to put in the dough when making the *empanadas*. To buy the ingredients, she uses measurement units such as pounds, grams, and millilitres (Table 3).

Table 3

Proportions of the ingredients to prepare corn empanadas

Ingredient	Amount of ingredients	Ingredient quantity conversion	Weekdays/weekends	Results
 Salt	A little	Three tablespoons (not full)	Weekdays	About seven of corn dough
	A little more	Five tablespoons (not full)	Weekend	14 lb of corn dough
 Water	A little bit and	40 mL	Weekdays	35 corn dumplings
	A little more	100 ml	Weekend	70 corn dumplings
 Corn dough	7 lb		Weekdays	35 corn dough empanadas
	14 lb		Weekend	70 corn dough empanadas
 Vegetables	A tomato and an onion	80 gr of tomato and 75 gr of onion	Weekday	½ lb beef and ½ lb chicken stewed
		90 gr of tomato and 80 gr of onion	Weekends	1 lb of beef and 1 lb of chicken stewed
 Beef	½ pound		Weekdays	18 empanadas
	1 lb		Weekends	35 empanadas

 Breast	½ pound		Weekdays	17 empanadas
	1 lb		Weekend	35 empanadas
 Oil	Half a bottle	A bottle and a half	Between weekdays and weekends	35 empanadas or 70 fried empanadas

In Table 3, we registered the quantities Nuris told us when preparing the *empanadas*. From the register, we can see three systems of measurement units: the unconventional system, since, while seasoning the corn dough, she uses the terms “a little” and “a little more” to calculate the amount of salt and water you should add to the dough. In the same way, to fry the *empanadas*, she measures the amount of oil in half a bottle. She uses the SI –the metric system–for the vegetables, using grams. For the rest of the ingredients, they use the pound, which belongs to the Avoirdupois system.

Conversely, one can consider the notion of direct proportionality: the greater the quantity of ingredients like dough, protein, and vegetables, the more dumplings and filling can be produced. The previous analysis takes as reference parts of interviews with Nuris, such as the following:

> *Alex(A): Do the ingredients of the dough have any specific order?*
> *Nuris(N_u): No, I buy it like this, ready-made. The only thing I add is salt to taste when I knead it.*
> *Nelsy(N_e): What portion of water do you add to the dough, or does the dough come ready for you?*
> *N_u: I add a little bit of water and salt, enough for the dough not to be too watery, otherwise, the empanada may fall apart.*
> *A: For the stir-fry or the stir-fry of the filling, what vegetables*

do you usually use?
N_u: Tomato, onion, seasonings.
N_e: How much of the filling do you prepare? And how many empanadas can you fill with it?
N_u: Well, I always prepare about 60 or more empanadas with half chicken breast –the same with a half shoulder.
N_e: ¿Approximately how much oil do you add to the frying pot?
N_u: It depends on the pan, I always buy 3 litres. And I pour half of it into the pan.

(Dialogue between the interviewee Nuris and the interviewers Alex, Nelsy, and Armando, 2022)

The wheat flour *empanadas* needed more ingredients and precise measurements because, according to Andrea, they *make gourmet empanadas*. Thus, the ingredients are expressed with measurement units such as kilo, pound, grams, litre, millilitres, by estimate, a combination of different measurement systems (Table 4).

Table 4

Ingredients used to make wheat flour empanadas

Ingredients	Quantity	Results
 **Wheat flour**	**1 kg**	
 **Water**	**350 ml**	
 **Butter**	**250 gr**	
 **Milk powder**	**100 g**	**1 1/2 kg of dough**

 **Salt**	**25 g**		
 **Sugar**	**80 g**		
 **Eggs**	**2**		
 **Wheat dough**	**1 1/2 kilo**	**50 empanadas**	
 **Chicken breast**	**1 lb**		
 **Ham**	**Half pack (9 slices)**	**Filling**	
Mozzarella cheese	**3/4 parts of the block**		
 **Shredded corn**	**1 cup**		
 **Oil**	**1 litre**		

Table 4 shows the amounts of each ingredient applied to obtain

the indicated results. The previous measurements and estimates are the product of the experience of the *empanada* vendors to improve and/or maintain the quality of their empanadas. In Andrea's case, she implements a scale to measure in grams. In this phase, the units used by the interviewee are evident: kilograms, grams, pounds, millilitres, litres, and estimates: half the package, ¾ of the block, and one cup. Thus, we conclude that when making wheat flour-based empanadas, they used three systems of measurement units: the International System (SI), the Avoirdupois system, and the estimate, given that these systems are put into practice in their day-to-day.

Phases for the preparation of *empanadas*

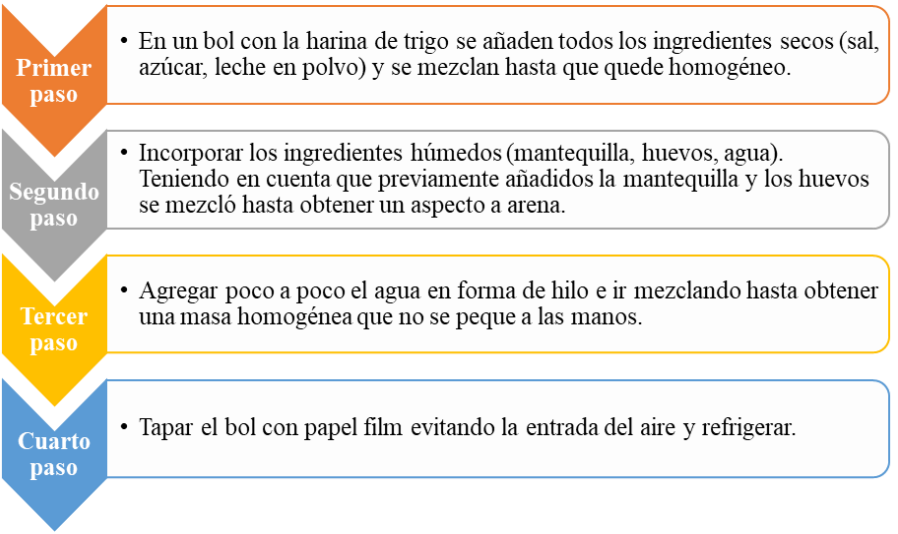
Preparing *empanadas* requires a series of steps to reach the expected final product. Therefore, we believe it is essential to analyse the phases of this production process.

First phase - Preparation of the dough

The process developed to prepare the dough based on wheat flour required the ingredients previously shown in Table 4, which had to be incorporated, following specific guidelines to obtain the desired dough (Figure 1).

Figure 1[1]

Wheat flour dough preparation process



We appreciate the measurement unit system implemented for the resulting dough in this phase. Tactile-visual estimation is also highlighted because the cooks analyse the consistency of the dough, which is mixed until it gets a sand-like texture when they determine whether it is ready for the next ingredient. Then, they drift in a thread-like manner the water on the dough while mixing it to reach a smoother and more elastic texture. We also analyse the perception of textures and their classification, understanding that this can be soft or rigid, lumpy or smooth, sticky or smooth, which are mathematical terms widely used in

[1]**Bol**: according to the Spanish Royal Academy (RAE) bol is the graphic adaptation of the English word bowl, which designates a type of round container without handles.
Sand-like: It is the homogeneous mixture resulting from incorporating the dry ingredients and part of the wet ones, which are butter and eggs, giving an appearance similar to sand both due to its colour and how grainy and loose it is.
Thread-like: refers to the thin water line that forms when it is incorporated into the mixture.

primary grades and everyday life.

Second stage - Preparing the filling

Nuris says she prepares the *empanada* filling the night before to save time and increase the marinade. She explains that an hour before starting to chop the vegetables, she boils the beef and at the same time puts the chicken to cook so that they are soft and rested. When the beef and chicken are shredded, they dice the tomatoes and onions. Then, they heat the pan on the stove over medium heat. They add the chopped vegetables to fry and apply seasonings, sauces and a little salt. Finally, they add the protein (beef or chicken) and let it rest for 10 minutes. They pack them in plastic containers (Figure 2).

Figure 2

Protein packaging

In Andrea's case, since her empanadas have her special recipe and are on request, she makes different fillings. During the interview, we witnessed the preparation of three different types of fillings, each with a specific amount of ingredients distributed according to the orders (Table 5).

Table 5

Amounts used to make the filling

Filling	Quantities	Results
Cheese with ham	A little less than half of thick slices of ham 1/3 of the grated cheese	Five empanadas
Chicken, cheese, and ham	150 g of chicken 1/3 of the grated cheese 1/2 of the ham that was left	Ten empanadas
Chicken, cheese, ham, and corn in sauce	200 g chicken 1/3 of the grated cheese 1/2 of the ham left 1 cup corn A part of the sauce	15 empanadas

From the previous table, we highlight the application of the conventional and non-conventional measurement unit systems, presenting units, such as the gram, and, unconventionally, through "A little less than half of the thick slice of ham", "a cup of corn", "a part of the sauce" or, a certain amount of "grated cheese" and "the ham left". A distribution process establishes the quantity needed for each ingredient for the various fillings. Thus, they get five *empanadas* with the first filling, ten with the second, and 15 with the third filling. In summary, the fillings of the *empanadas* have essential information that reflects the mathematical thinking of the respondents.

The process implemented to prepare the filling was progressive or by steps. It began with cooking the ingredients needed, such as the chicken and the sauce, in the case of the wheat flour empanadas, given it

is the longest step and requires great precision in temperature control so that dish flour is not affected either because all the water evaporates, leaving it too dry or, failing that, it remains raw. Due to not spending enough time on the stove, we analysed how the temperature was controlled and the time each process took using the following table.

Table 6

Cooking times and temperature control

Proccess	Cooking time	Temperature	Switch	Fire
Chicken breast cooking	30 min	Medium-high		
Add ingredients to season the sauce		Minimum		
Heat the sauce	10 min	High		
Thicken the sauce		Minimum		

In this phase, temperature control is key to preparing a sauce with the necessary qualities to meet consumers' tastes. During this process, they make equivalence judgments and evaluate the proportion of the magnitudes, thus establishing that the higher the flame, the higher the temperature (direct relationship), and the higher the temperature, the less

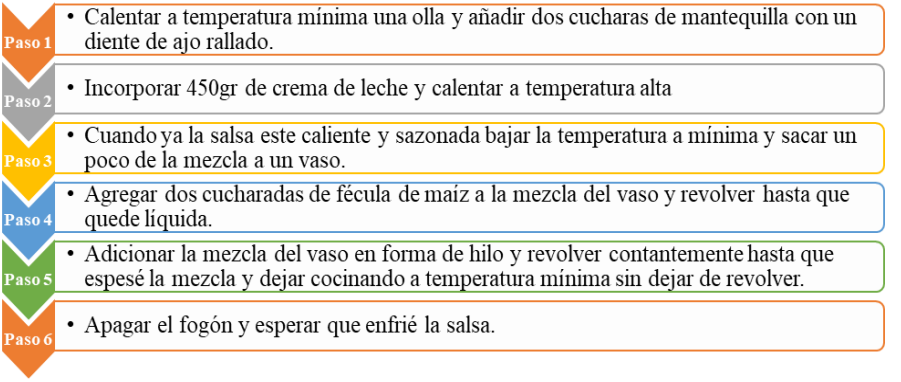
time the *empanada* should be on the stove (inverse relationship), since there is the risk that it comes out raw, tasting unpleasant.

Continuing the preparation process of the *empanadas*, they made the corresponding cuts to divide the ingredients into small quantities, facilitating their separation and introduction into the crushed dough. The steps were:

- First, the chicken breast was covered with water and put to boil for 30 minutes at a high temperature in a pot (approximately 250 ml of water), along with the vegetables and a little salt (to taste) that seasoned the food.
- While the breast was cooking, the ham was sliced into medium squares, the mozzarella cheese grated, and the cup of shelled corn separated.
- After the chicken breast had been cooked and allowed to cool, it was shredded into fine strands.
- Next, we made the sauce for one of the fillings (Figure 3).

Figure 3

Process of preparing the sauce for the filling



- Later, the ingredients were divided as indicated in Table 5 to organise the different fillings.

- Once the sauce had cooled, it was added to the specific filling (chicken, cheese, ham, and corn in the sauce).

With all the fillings ready, the next phase began. From the previous steps, we continued to observe the implementation of a system of measures to control the temperature and the ingredients to obtain the necessary texture for the subsequent folding of the *empanadas*. In the same sense, the proportion applied when separating each of the ingredients of the fillings and obtaining the required amount of *empanadas* was evident.

Third phase - *Empanada* folding process

In this phase, various implements were required to help give shape or structure to the *empanadas*. To assemble the corn-dough ones, Nuris took a small amount of the total dough, indicating that this varies depending on the size of the *empanada*. Then, this quantity was moulded in a sphere-like form and placed on top of a plastic that will help shape it so that it does not stick to any of the other utensils. Next, she crushed that sphere with a stone or flat heavy article to obtain a round-shaped figure, an *arepa*. Subsequently, she drew an imaginary line in the centre and added a tablespoon of filling, extending it above that imaginary line but without reaching the ends, as can be seen in Figure 4.

Figure 4

Imaginary line to add the filling to an empanada

Later, the stone was removed, and the figure obtained was folded, with the help of the plastic, guided by the filling. Then, Nuris lightly pressed the edges of the empanada so they came together and prevented the filling from coming out. Finally, the edges of the *empanada* were cut for a better shape and size and marked according to the different fillings.

To assemble the wheat flour dough *empanadas*, Andrea uses a rolling pin and a mould. The steps to assemble the empanadas are as follows:

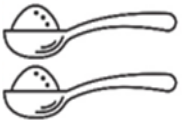
1. On a clean table, add wheat flour to prevent the dough from sticking to it.
2. Take a small amount of the dough, approximately 25 gr, spread it on the table using the rolling pin and turn it to a circular shape. The thickness that the rolled dough should have is half a centimetre and can be calculated by taking the dough and supporting it in your hand. If you can clearly see your fingers underneath, it means that it has the optimal thickness to assemble the empanada.
3. Next, place the extended dough in the empanada mould and add the amount of filling required in the centre for the

empanada that is being assembled.

4. Finally, the mould is closed, the excess dough can be removed, and the *empanada* is marked according to the different fillings (Table 7).

Table 7

Differentiating quantities and brands according to filling

Filling	**Quantities**	**To**	**Differentiating marks**	**Results**
Cheese with ham	Two small tablespoons 	One cheese empanada with ham	Unmarked	
Chicken, cheese, and ham	Two small tablespoons 	One chicken empanada	Edges folded	
Chicken, cheese, ham, and corn in sauce	Two large tablespoons 	One chicken empanada with corn in sauce	Pinches of fine herbs	

From the above, we can be infer that the system of measurement units applied by Andrea is unconventional when organising the *empanadas* according to the estimate, which she makes by adding a

certain amount of filling, allocating two small tablespoons of filling for a “normal” *empanada* and the chicken, cheese, and ham *empanada*. However, for the chicken, cheese, ham, and corn-in-sauce *empanada*, we must add two large tablespoons since they are more expensive and require more filling. In this way, the relationship between more filling, higher price, and the classification of three types of empanadas is evident.

Fourth phase - Frying process

During this process, it is essential to mind the temperature because, if it is not the exact point for frying the *empanadas*, they may remain raw or burn, resulting in a low-quality product. When working with different doughs, the way they are fried also varies. Nuris believes the flame must be kept high to get a boiling hot temperature. Andrea explains that to fry the *empanadas*, the pan must be hot. The amount of oil added is based on the size of the pan and the quantity of *empanadas*. The condition that must be met to carry out an optimal process is that the oil exceeds the *empanadas*, giving them enough space to float. According to the pan used, they used a litre of oil.

The steps that must be carried out to fry the empanadas are illustrated in Figure 5. The description of each step is presented later.

Figure 5

Steps to fry

1. Add the oil and wait for it to heat to a high temperature. A test that can be carried out to find out whether the oil has reached the optimal temperature is by putting a small ball of dough in it; if the dough takes longer than 30 seconds to rise and produces only a few bubbles, this is an indicator that the oil temperature is too low. If it rises very fast, in less than 15 seconds, and too many bubbles come out, so the bubbles cover entirely the *empanada*, then the oil is too hot. If the dough ball ascends to the surface within 20 to 30 seconds, with moderately quick bubble formation not entirely covering the *empanadas*, then the oil is at the optimal temperature for frying them.
2. With the oil ready, lower the temperature to medium-high (Table 8) and gently place the *empanadas*.
3. We observe that the colour of the *empanadas* changes in the process. When it reaches a golden hue similar to butter, in Andrea's words, the *empanada* is turned over so that it cooks and browns the other side. This process takes around five minutes: two and a half minutes for each side.

4. Once the previous step has been completed, remove the *empanadas* using a skimmer, which allows the excess oil to drain, and transfer them to a container with napkins so they finish draining and do not feel greasy when consumed. The indicators to remove the empanadas from the pan are their colour and hardness (when tapped gently, it sounds like a drum).

A good frying process arouses customer interest as it is a quality product with good flavour, colour, and texture. Important elements are the temperature control precision obtained with the position of the switch and the intensity of the flame. In the same way, characteristics such as the colour and behaviour of the oil with the *empanadas* –whether or not bubbles come out– allow the cooks to calculate when to turn over the *empanada* and remove it from the oil.

Table 8

Times and temperature control for frying

Process	Cooking time	Temperature	Switch	Fire
Heat the oil	2 min	High		
Fry the empanadas	5 min	Medium high		

Table 8 shows the magnitude of the temperature; in its data, a concept of proportionality that could well be problematised in mathematics education emerges together with the other topics that have been described: measurement systems, temperature perceptions, the concept filling, mass, volume, shape, relationships, among other

mathematical or physical topics.

CONCLUSIONS AND DISCUSSION

Throughout this investigation, various mathematical processes were evidenced in each phase. In the first phase, we observed the portions the cooks used to obtain a certain amount of dough, that is, each interviewee's system of units. In this first stage, we could see two different measurement cases: one of the respondents uses the empirical method, as is the case of señora Nuris, who uses her hand as a measuring tool, and the other respondent, señora Andrea, uses the SI because she has an electronic scale. This case shows what D'Ambrosio and Knijnik (2020) called other mathematical perspectives regarding educational mathematics.

In the second phase, it is worth highlighting the connection that the preparation of the *empanada* filling has with proportionality, which became evident based on proportional reasoning, defined as the ability to differentiate the multiplicative relationship between two quantities and extend that relationship to another pair of quantities (Lamon, 2007). This served them to establish judgments about the amounts each filling should contain and, thus, obtain the *empanadas*.

Proportionality is a critical issue in preparing *empanadas* since, in its contextualisation, magnitudes and their respective measures intervene (Godino et al., 2017). Thus, when interviewing Nuris and Andrea, we perceived information that represents a symbiotic metric system of practice, which puts into practice magnitudes, processes or metric concepts typical of practice but also others that are established by the SI and that are used commercially (Centro Español de Metrología, 2019). Likewise, the interview revealed great agreement with the definition of quantity that they proposed (Godino, Batanero, & Roa, 2002).

In the third phase, mass and volume relationships were presented to determine the amount of dough to implement to assemble an *empanada* and its filling. By estimating measures, the vendors make statements according to specific criteria that experience has given them. Therefore, the amount of dough for an *empanada* is a handful, for cornmeal *empanadas*, and a tablespoon of stewed beef or chicken for the filling that must be spread from the centre of the *empanada*, dividing it

into two parts but without reaching the ends. For the wheat flour *empanadas*, despite controlling the quantities that are used through a scale and a mould, the cooks also consider particular criteria such as the thickness of the dough that, when placed in the hand, shows the palm figure.

This third stage of the investigation expresses well in which situations the measurement systems executed by the interviewees were presented, following what Ayala, Malagón, and Sandoval (2011) stated since, when making the *empanadas*, the action of assigning numbers is manifested. Similarly, it is consistent with the concept by Watty and López (1997) since the two cooks label and classify the different modalities. For this reason, we believe that measuring and measurement systems are fundamental to making *empanadas*. Likewise, these processes are of the utmost importance in school mathematics education for developing mathematical concepts, as Muñoz, Torres, and Aroca (2022) affirm.

In the fourth phase, the accuracy in temperature control is evident when we analyse situations that allow reasoning about the appropriate moment to incorporate, turn, and remove the *empanadas* from the oil. In this phase, they make measurements and/or estimates by visually assessing characteristics that occur in the process, such as placing a small ball of dough in the oil and watching how long it takes to rise and float, which shows whether the oil is cold or hot; another situation is when they determine when to turn over and take the *empanada* out according to the bubbles generated in the frying process and the colour of the *empanadas* when they are ready. These processes, very different from those that are classically presented in school textbooks, are more in line with the mathematics teacher's and their students' reality, which can undoubtedly allow them a better degree of communication, debate, and development of mathematical knowledge in math classes.

The last stage of the results presents what could be called non-conventional methods of temperature measurement used by Nuris and Andrea, which we insist should be called *measurement systems*. The emergence of these mathematical resources as physical phenomena and socially shared with a mathematical language (Godino, Batanero, & Roa, 2002) are evident in these practices analysed in ethnomathematical studies.

The phases seen previously show connections between the mathematics of artisan practice and school mathematics, such as the assembly and shape of the *empanadas* related to geometric figures (circle, semicircle, etc.), equivalence relations, the use of conventional and unconventional measures, proportionality, among other processes constantly evidenced in daily life.

Finally, the research carried out could be adapted through didactic activities with themes of measurement systems, volume, and proportionality supported by basic competence standards such as "I solve and formulate problems that require estimation techniques" (MEN, 2006) in the 6th and 7th grades of the Colombian educational system. These activities could contribute significantly to mathematics education since they could not only strengthen knowledge in the topics mentioned above but also show awareness and connection with reality. At the same time, they could allow students and teachers to have a more systematic approach to local gastronomy.

AUTHORSHIP CONTRIBUTION STATEMENTS

The three authors, Alex Torres, Nelsy Vanegas, and Armando Aroca, raised the research problem. Alex and Nelsy collected and analysed the data to develop the theoretical part, the methodological design, and the writing of the draft of the article. Armando guided us to reach the objective of the article and also analysed the draft, correcting it to make it more technical. Finally, the conclusions and discussions show the three authors' contribution to the development of this research.

DATA AVAILABILITY STATEMENT

The evidence that supports the observations that this work has entailed is kept by Armando Aroca, who will give access to it under reasonable request.

REFERENCES

Almeida, G. & Valadares, J. (2002). *Sistema internacional de unidades (si), grandezas e unidades físicas, Terminología, Símbolos e*

Recomendações: Grandezas e Unidades Físicas, Terminologia, símbolos e Recomendações. v. 3. (p. 1-244). Plátano Editora.

Aroca-Araújo, A. (2022). Un enfoque didáctico del programa de Etnomatemáticas. *Tecné, Episteme y Didaxis: TED*, (52), 211-248. http://doi.org/10.17227/ted.num52-13743 .

Ayala, M. M., Malagón, J. F., & Sandoval, S. (2011). Magnitudes, medición y fenomenologías. *Revista de Enseñanza de la Física*, *24*(1), 43-54.

Bishop, A. (2005). *Aproximación sociocultural a la educación matemática*. v.1. (p.18-197). Universidad del Valle.

BIPM. (2019). El sistema internacional de unidades**.** *Centro Español de metrología*, **(**9). (11-39).

Bright, G. (1976). *Estimation as Part of Learning to Measure. National Council of Teachers of Mathematics Yearbook*. v.38. (p.87-104). Reston, VA: NCTM.

Calderón Nepamuceno, D. M**.** (2015). Patrones y Sistemas de unidades [Presentación en Power Point]. Repositorio Institucional. http://ri.uaemex.mx/oca/bitstream/20.500.11799/32529/1/secme-28839.pdf.

Carpio Rico, A. M., et al. (2022). *Fortalecimiento de las competencias de cálculo matemático en la etapa 4 de procesamiento artesanal de alimentos lácteos, mediante el aprendizaje basado en problemas, creando un app híbrida denominada Edualimentos para estudiantes de la media Institución Educativa departamental Rural de Ricaurte Guamal-Magdalena.* Universidad de Cartagena.

D'ambrosio, U. (2013). *Etnomatemática - elo entre as tradições e a modernidade***.** (5). (p.3-64). Belo Horizonte: Autêntica Editora.

D'ambrosio, U. (2016). The ethnomathematics Program and a Culture of Peace. *Journalofmathe-matics and Culture*, *10*(1).

D'ambrosio, U. (2008). Etnomatemática: *Eslabón entre las tradiciones y la modernidad*, *1*. Limusa.

D'ambrosio, U. & Knijnik, G. (2020). Ethnomathematics. *LERMAN, S. (eds) Encyclopedia of Mathematics Education.* (2), 283-288.

Francisco, C. H. (2012). *Estudo sobre as unidades de medidas das grandezas físicas básicas: comprimento, massa e tempo*. Universidade Estadual Paulista Júlio de Mesquita Filho. http://hdl.handle.net/11449/119119

Galeano-Marín, M. E. & Aristizábal Salazar, M. N. (2008). Cómo se construye un sistema categorial**.** *Estudios de Derecho*, *65*(145), 161–188.

Galina, E. (2008). Medida, geometría y el proceso de medir**.** *Revista de la Unión Matemática Argentina*, *50*(1), 1-23.

Gerdes, P. (1994). Reflections on ethnomathematics*. For the Learning of mathematics*, *14*(2), 19-22.

Godino, J. D., et al. (2017). Significados pragmáticos y configuraciones ontosemióticas en el estudio de la proporcionalidad. *In Actas del Segundo Congreso Internacional Virtual sobre el Enfoque Ontosemiótico del Conocimiento y la instrucción Matemáticos.* (p.1-13). CIVEOS.

Godino, J. D., Batanero, C. & Roa, R. (2002). *Medida de magnitudes y su didáctica para maestros*. (p.613-691). Departamento de Didáctica de la Matemática.

Gómez, M. J. A. (2006). La investigación educativa: claves teoricas. *Góndola, Enseñanza y Aprendizaje de las Ciencias*, *8*(1), 66-77.

Hernández-Montoya, L. E. (2020). *Estudio de la vida útil de una masa de maíz amarillo para la elaboración de empanadas en la empresa maquiempanadas.* Universidad Católica de Manizales. http://doi.org/10.1590/1981-6723.02319

Lamon, S. (2007). Rational numbers and proportional reasoning. Toward a theoretical Framework for Research**.** *En F. K. LesterHandbook of Research on Mathematics Teaching and Learning*, *1*(2), (629– 667).

Morales Gutiérrez, M. Á., et al. (2015). *Taller de cocina y matemáticas en educación infantil*. Universidad de Almería. http://hdl.handle.net/10835/3615

Muñoz-Jiménez, O., Torres Nevado, G. & Aroca Araujo, A. (2022). Análisis de tres magnitudes en una práctica artesanal en el

municipio de Galapa, Atlántico, Colombia. *Revista Boletín Redipe, 11*(5), (121-143).

Obando, G., Vasco, C. & Arboleda, L. C. (2014). Enseñanza y aprendizaje de la razón, la proporción y la proporcionalidad: un estado del arte. *Relime* [online]. *17*(1), (59-81).

Ortiz Matilla, S & Sabariego Arenas, M. (2019). *Aprender matemáticas en diferentes espacios: la cocina.* Universidad de Cantabria. http://hdl.handle.net/10902/17323

Rodriguez-Nieto, C. A. (2021). Conexiones etnomatemáticas entre conceptos geométricos en la elaboración de las tortillas de Chilpancingo, México. *Revista de investigación, Desarrollo e innovación. 11*(2), (273-296).

Rodriguez-Nieto, C. A. & Escobar-Ramírez, Y. C. (2022). *Conexiones Etnomatemáticas en la elaboración del Sancocho de Guandú y su Comercialización en Sibarco, Colombia. Bolema*, *36*(74), (971-1002).

Rodríguez-Nieto, C. A. (2020). Explorando las conexiones entre sistemas de medidas usados en prácticas cotidianas en el municipio de Baranoa. *Revista de investigación educativa de la Rediech. 11*(857), (1-31).

Romero, M. A. & Hernández, A. R. (2015). El método etnográfico y su relación con el análisis de dominio. *Biblios,* (61), (70-84).

Singh, S. (2006) “Impact of color on marketing”, Management Decision. *Emerald insight, 44*(6), (783-789).

Zorzoli, G.; Giuggiolini, I.; Mastroianni, A. (2005). *Competencias básicas en matemática aplicadas al área de la elaboración de alimentos.* v.1. (*p*. 96). Banco Interamericano de Desarrollo.