IDENTIFICATION OF STUDENTS' MENTAL MODELS ABOUT THE MILK TRANSFORMATION INTO YOGURT

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A review of the scientific literature reveals that there are still few researches on the conceptions of secondary school students about chemical reactions involving microorganisms, especially those related to the mental models that students use in their explanations. This paper describes a study concerning the different mental models related to the milk transformation into yogurt with 83 students from a Spanish secondary school of 8th and 9th grade (13-16 years) developed in the framework of a research that intends to use the elaboration of this product as a context for the teaching and learning of chemical reactions through modeling approaches. In order to identify the mental models of the students, in this paper we consider the milk transformation into yogurt as a process in which its main components are: the entities involved (milk and bacteria), the interaction between them and the result (yogurt). A simplified school model of this process would involve students considering that bacteria use the sugar in milk to transform it into lactic acid through a chemical reaction to obtain the necessary energy. Using this scheme in interaction with the students' answers, the underlying mental models were identified. Although almost half of the students showed great difficulties explaining the process, five models have been identified. Students often consider the milk transformation into yogurt primarily as a physical process of agglutination or change of state. These models are far from a school model of reference in which the bacteria have a fundamental role in the transformation of milk into yogurt by a chemical reaction.

Keywords: mental models, chemical reactions, microorganisms.

INTRODUCTION

The modeling-based science teaching consists in approaching concepts through simpler representations that help students to construct and understand the phenomena studied (Justi and Gilbert, 2002). Teaching through models should be understood as a good practice for the acquisition of scientific knowledge in compulsory education (Aragón, Oliva, Navarrete, 2014). The different didactic proposals on modeling in the classroom, start from the students' explanation of what their mental models are about the object of study (Acher, 2014), understanding that these models are the anchor point from which they could develop more complex models.

Despite the fact that mental models have received great attention in the area of science education, especially those related with physical and chemical phenomena, it has not been this way in the study of chemical reactions involving microorganisms (Muñoz-Campos, Franco-Mariscal and Blanco-López, 2017). The transformation of milk into yogurt shows a phenomenon of great relevance in daily life (Simonneaux, 2000) but it has been little studied from the perspective of the mental models of the students (Moreno and Lopez, 2013). The aim of this study is to identify possible models in the explanations given by the students. Specifically, this research focuses exclusively on the progression of the model of students aged 13-16 years of the process of the milk transformation into yogurt and the concept of chemical reaction involved (Muñoz-Campos, Blanco-López and Franco-Mariscal , 2015).

METHODS

This study was conducted with a sample of 83 secondary school students in two different Secondary schools in Malaga (Spain), 40 grade 8 students (13-14 years) and 43 grade 9 students (15-16 years old). 41% were boys and 59% were girls. This paper analyzes one of the tasks proposed in a questionnaire designed for this purpose, formulated as*: "Assuming that you have very powerful glasses, make a representation of the process of milk transformation into yogurt (fermentation), knowing that the most important components in*

this process are sugar (lactose), lactic acid and bacteria. Explain your representation." In order to identify the mental models of the students, we start from a scheme that considers the milk transformation into yogurt as a process (Chi et al., 1994), in which its main components are: the entities involved (milk and bacteria), the interaction between them and the result (yogurt). A simplified school model (target model) of this process would imply that the students considered the bacteria would use the sugar contained in the milk would transform it into lactic acid through a chemical reaction and will obtain the necessary energy. Yogurt has very similar composition to milk and the most important difference is the presence of lactic acid that gives the acid taste and texture that it presents. Using this scheme in interaction with the students' answers, the underlying mental models were identified. In order to categorize the students' answers, the drawings and explanations offered by them were analyzed.

RESULTS

The identified models, from lowest to highest degree of proximity to the target model, are shown in Table 1. An idea of progress is used in models with two dimensions: whether the students' explanations contemplate or not the bacteria and the type of specific transformation that happens, understood as a physical change to a chemical change.

Table 1.Mental models on the milk transformation into yogurt.

Models	Does the model include bacteria?	Type of interaction	Frequencies		Percentages	
			Grade 8	Grade 9	Grade 8	Grade 9
--		Not explained or explanation can not identify a model	20	18	50.0	41.5
1	No	Change of State	6	14	15.0	32.5
2	Yes	Mixture	3	1	7.5	2.5
3 4		Change of State	2	6	5.0	14.0
5		Bacteria as a binder	4	4	10.0	9.5
		Milk fermentation in the presence of bacteria	5	0	12.5	0
		Total	40	43	100	100

Practically half of the students in the two grades were not able to offer an explanation of the process or, it was not possible to establish it by its simplicity. However, we have found five models discussed below.

Model 1. Transformation is understood as a physical process very similar to a change of state, where the milk components are joining until they are together. It is the most popular model found in both grades, by 15% of 8th grade students and 32.5% of grade 9.

Model 2. The process is shown as a macroscopic mixture of milk, sugar, lactic acid and bacteria. Although bacteria are considered in this model, students are not able to express it in microscopic terms, but as macroscopic drawings. This model was found in 7.5% and 2.5% of grades 8 and 9, respectively.

Model 3. It involves a physical process in which bacteria appear, without interaction with the milk components. The transformation consists in the joining of milk components with the bacteria. This model is similar to model 1 in terms of interaction type, except that students incorporate bacteria into their drawings and / or explanations. The representation used for bacteria implies that students have already had some knowledge of them although they are unable to show what role they play in the process. This model was mostly found in grade 9 students (14%) and was only used by 5% of grade 8 students.

Model 4. This model involves a physical process in which the bacteria are responsible for the milk components joining. The students' drawings show how the milk components and bacteria are separated; with the yogurt the bacteria are joining the milk components. This model was found in both grades in a similar percentage around 10%.

Model 5. Involves a process in which milk is fermented when bacteria are added, but without indicating that the fermentation is a chemical process that takes place through a chemical reaction. This model was only found in 8th grade students (12.5%).

CONCLUSIONS

From the study findings presented above, we can conclude that the students participating in this research present great difficulties in explaining the milk transformation into yogurt referred to the submicroscopic domain (Moreno and López, 2013). Among their answers, we have been able to identify 5 models to explain this process in which the students consider the milk fermentation as a physical process of agglutination or change of state. We consider these results to be insufficient, with only 6% of the students reaching the target model (5 of the 83 participants). The proposed models are still far from those in which bacteria have a fundamental role in the transformation of milk into yogurt by a chemical reaction. Hence our interest in designing and implementing a teaching sequence on this topic as it may contribute to improve the understanding of this process as the students learn to construct models to understand the science that surrounds them. Accordingly, the results obtained suggest that the yogurt elaboration in the classroom can constitute an adequate daily context to work modeling and chemical reactions in biological contexts, allowing not only the students to better understand the concept but also to be able to transfer it to daily life situations related to health and food.

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