ANEXOS

ANEXO I

Questionário

Sobre os experimentos realizados, escolha um valor na escala de concordância.

	Não concordo	Discordo mais do que concordo	Mais ou menos	Concordo mais do que discordo	Concordo muito
O experimento do Arroz-doce é legal.	**1**	**2**	**3**	**4**	**5**
O experimento máscara de especiarias é legal.	**1**	**2**	**3**	**4**	**5**
O experimento da eletrólise é legal.	**1**	**2**	**3**	**4**	**5**
O sabão feito com diferentes gorduras é legal.	**1**	**2**	**3**	**4**	**5**
O experimento plástico nadador é legal.	**1**	**2**	**3**	**4**	**5**
O experimento água com espuma é legal.	**1**	**2**	**3**	**4**	**5**
O experimento do lava lamp é legal.	**1**	**2**	**3**	**4**	**5**

A explicação química foi clara.	**1**	**2**	**3**	**4**	**5**
A explicação química foi desnecessária.	**1**	**2**	**3**	**4**	**5**
A explicação química foi chata.	**1**	**2**	**3**	**4**	**5**
A explicação química foi complicada.	**1**	**2**	**3**	**4**	**5**
A explicação química foi legal.	**1**	**2**	**3**	**4**	**5**

A explicação histórica foi clara.	**1**	**2**	**3**	**4**	**5**
A explicação histórica foi desnecessária.	**1**	**2**	**3**	**4**	**5**
A explicação histórica foi chata.	**1**	**2**	**3**	**4**	**5**
A explicação histórica foi complicada.	**1**	**2**	**3**	**4**	**5**
A explicação histórica foi legal.	**1**	**2**	**3**	**4**	**5**

Eu gosto de química.	**1**	**2**	**3**	**4**	**5**
O experimento ajuda a entender melhor química	**1**	**2**	**3**	**4**	**5**
Após a apresentação eu passei a gostar mais de química.	**1**	**2**	**3**	**4**	**5**
Esta apresentação serviu para entender mais os conteúdos de química.	**1**	**2**	**3**	**4**	**5**
Esta apresentação serviu para perceber mais a química na minha vida.	**1**	**2**	**3**	**4**	**5**

ANEXO II

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Chemistry experiments with a historical approach: promoting interdisciplinary teaching

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Chemistry experiments with a historical approach promoting interdisciplinary teaching

Anne M. Sousa, Walter R. Waldman*

Laboratório de Ciências Químicas, Universidade Estadual do Norte Fluminense, Av. Alberto Lamego, 2000 - Zip code 28013-6
Campos dos Goytacazes – RJ, Brazil

* - capiwalter@gmail.com

Abstract

The Itinerant Museum of Chemistry History is an outreach activity that aims to be auxiliary
science teaching in Campos dos Goytacazes (RJ – Brazil), bringing students together with th
practice of science and its history. We develop and adapt chemistry experiments within a historic
context about products contemporary to students, such as soap, beer, candle, paint, food and spice
This paper presents our work about spices and their use in food preservation. Samples of a typic
Brazilian dessert called rice pudding were prepared with cinnamon and cloves, under differe
conditions and the appearance of decomposing microorganisms on the surface of the desserts wa
visually monitored as a function of time. Both the cloves and cinnamon, cooked with rice, presente
activity in controlling the microbial activity. This activity showed a strong visual impact with th
students with the advantage of encouraging them to repeat the experiment with other spices
seasonings at home.

Keywords: Demonstrations, Hands-On Learning / Manipulatives, Food Science

Introduction

In an outreach activity of *Universidade Estadual do Norte Fluminense Darcy Ribeiro*, we have created an Itinerant Museum of Chemistry History, with the aim of visiting public schools to demonstrate chemistry experiments in a historical context. The itinerancy of the Museum was chosen because a national survey showed that 96% of the Brazilian population did not visit a science museum in 2006 (1). Almost half of this 96% stated that they have a science museum very far from their home or even had no science museums in their cities.

Spices have had a broad context in history, and were important due to their chemical characteristics, as well as the status that they brought Europeans because the need to bring them from overseas made them a valuable commodity. The elevated vapor pressure and chemical characteristics from spices' essential oils was responsible for their use by people who had reduced access to fresh food, who used spices to mask the bad smell and flavor of spoiling food. People subsequently noticed that these same spices even helped to preserve food in general (2,3). The spice property of masking odors was used during the Black Plague, in the Middle Ages. According to the theories of that time, the smell released by sick and dead people was responsible for the spread of the disease. Physicians of the day used a kind of beak full of spices (Figure 1) to mask the smell of dead and sick people (4) in order to avoid contamination. The Black Plague was a special case because of the very intense foul odor from all the bodily fluids, such as breath, saliva and blood from the lungs (56).

Figure 1: Masks used by doctors during the Black Plague. Illustration of a physician prepared to have contact with sick and dead people (7) (left), and picture from Århus Steno Museum, in Denmark (8) (right).

To illustrate this masking property, boxes with a hole that fit a funnel full of cloves and cinnamon were prepared (Figure 2), and students could breathe the air inside this funnel. The students were asked to breathe hard through the funnel full of spices, not knowing that inside the box was a piece of rotten meat, which demonstrated the ability of spices to mask strong odors.

Figure 2: Picture of box with rotten meat inside (left) used to demonstrate the masking odor property of spices, and the funnel with spices inside (right).

The antimicrobial activity of spices, one of the reasons for their trade during the Age of Exploration, can be demonstrated by experiments using some regional recipes, as we did for this paper with Brazilian rice-pudding. At that time, before the widespread use of refrigeration, an excessive amount of sugar was used to disguise the enormous quantity of the spices which were intended to help preserve the dishes (9,10). This use of spices is being studied even today, and some researchers have shown that cloves, cinnamon and oregano suppress the growth Escherichia coli, present in raw meats (11,12,13,14).

Essential oils are mixtures of hydrocarbons, esters, alcohols, phenols and carboxylic compounds. In cinnamon and clove, spices used in this experiment, the most important essential oils are the cinnamaldehyde and eugenol (Figure 3).

CYNNAMALDEHYDE EUGENOL

Figure 3: Molecular structures of eugenol (right), and cinnamaldehyde (left).

Chemistry teaching is a great challenge in Brazilian public schools, due to undertrained teachers and a lack of infrastructure for practical classes. In this paper we propose a low cost interdisciplinary experiment, easy and safe to conduct, in order to engage and motivate students on the subject discussed. The experiment is based on an adaptation of a popular dish of Brazilian cuisine called rice pudding, some spices, and spoilage at room temperature. The time comparison of the appearance of visible microbial life was a parameter of the spices' antimicrobial efficiency.

Experimental Part

2 grams of freshly grated cinnamon powder, 2 grams of cloves, 2 grams of cinnamon powder whose expiration date had expired, 350 mL of sugar solution 40 $g.L^{-1}$, 100 mL beakers, heating plate, and 140 grams of rice were used.

The general preparation of each sample was the following: sugar solution (50 mL) was added to a beaker and heated until boiling. After boiling, 20 g of rice and 1 gram of spice was added to the beaker until the water contained inside the beaker dried. After cooling to room temperature, the rice pudding was transferred to a plastic pot and covered with a plastic film. The control sample was prepared without spice additions. Some samples were prepared with spices sprinkled on the rice pudding surface after cooling to room temperature.

It is important to note the operational flexibility of this experiment, with the possibility of using a common stove, common pans and ordinary or regional spices.

All experiments had as a parameter of measurement the presence of visible microorganisms on the rice-pudding surface. As it is possible to have the development of non-visible microorganisms during the experiment, students were encouraged not to eat the material used on experiment and not to uncover the plastic pots. To dispose of the materials after the experiment, all plastic pots were put in a pressure cooker with water and heated until boiling, before being discarded in a common trash.

Results and discussion

Spice effect

Comparative experiments with samples of rice pudding, cooked with and without spices and after being left out of the refrigerator, showed great difference in the activity of decomposing microorganisms after five days at room temperature. As can be seen in Figure 1Figure 4, while it is no longer possible to view the rice due to the development of microorganisms on the surface of the control, the rice pudding cooked with cloves and with cinnamon did not present signs of decomposing microorganisms.

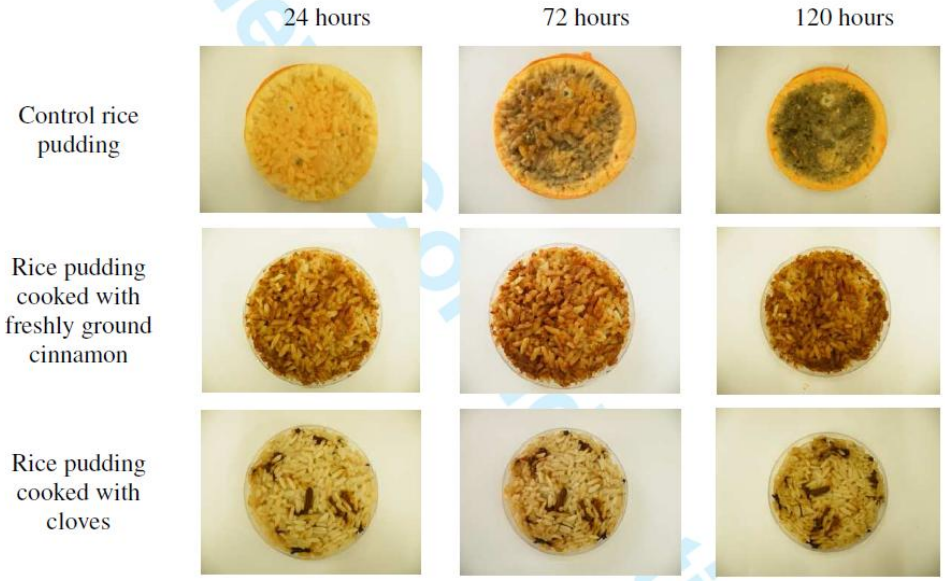

Figure 4: Efficiency of cloves and cinnamon in the conservation of rice pudding compared with the control rice pudding, observed after one, three and five days at room temperature.

It is important to remark that the experiment was replicated several times during its development, and different microorganisms were observed each time. These differences occur because of the heterogeneity of the microbial population from the air. So replicates made at different times may catch different microbes, but there was always antimicrobial activity in the samples cooked with cloves and cinnamon. This peculiarity allows interdisciplinary interaction with Biology teachers.

Volatility effects

Some spices, like cinnamon, are sold already ground in order to save efforts in their use. Good cooks and chemists know the problem of grinding spices months, or even days, before their use; that of the volatility of some compounds. The best way to use the spices with volatile compounds is to grind them as close as possible to their preparation time. In order to test this idea we developed this experiment comparing a sample of rice pudding cooked with an amount of just-ground cinnamon with another sample of rice pudding cooked with an amount of supermarket cinnamon after its expiration date. The use of expired cinnamon was done to emphasize the differences and create an opportunity to discuss the importance of this kind of information in food products.

As we can observe in Figure 5, on the right, the sample with expired cinnamon showed the development of visible microorganisms while the sample with freshly-ground cinnamon did not show any development during the experiment (Figure 5, left).

Figure 5: Evidence of substance loss by volatilization comparing rice pudding cooked with freshly-ground cinnamon and rice-pudding cooked with expired pre-ground cinnamon, after 7 days at room temperature.

This result can be explained by the fact that a greater surface area both can accelerate the loss of antimicrobial substances by volatility and allow major oxygen access to the antimicrobial substances, causing their oxidation.

Addition after or before cooking?

The rice pudding prepared in Brazil is always partially covered with a thin layer of ground cinnamon before being consumed, in order to flavor the dessert. With the proposed experiment in this paper, we can test if the simple presence of the spices may have antimicrobial activity, even if they are not cooked together with the rice pudding. The spice weight was the same as that of the spices used in cooking in order to compare the effects.

In Figure 6 we have the rice pudding cooked without spices and just sprinkled with cinnamon or cloves after cooking. It is possible to observe that both methods presented microbial growth, mainly in areas with no spice covering, unlike the desserts cooked with spices. These results show that the step of boiling with water helps to extract the actives and distribute them better throughout the dessert.

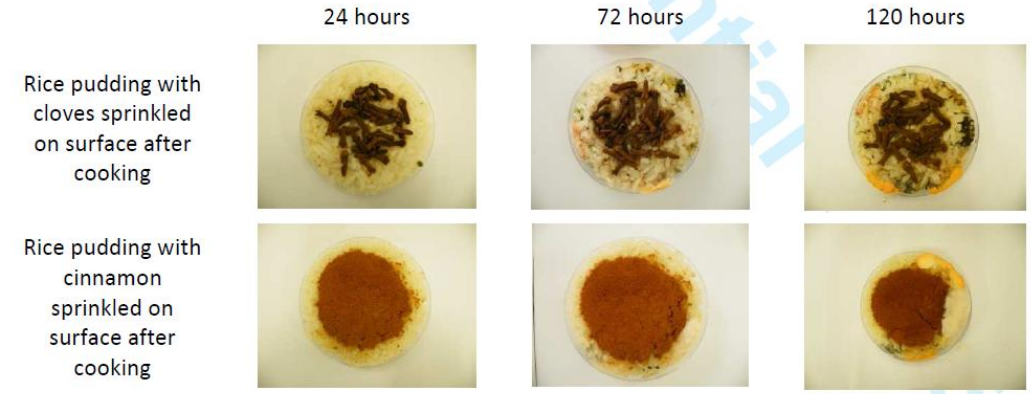

Figure 6: Samples of rice pudding cooked with freshly-ground cinnamon (left), and samples cooked without spices, but sprinkled with freshly-cinnamon after cooking (right).

Conclusion

The experiment with rice pudding showed good contextualization to discuss the antimicrobial activity and some aspects of actives volatility, in addition to offering a consistent ease of execution, and interesting visual appeal of the spoiled food, especially for teenagers, according to our experience with visits to public schools. The students showed interest in and eagerly discussed the possibilities of testing the experiment with local spices, teas and other categories of foods and seasonings.

This kind of experiment, based on a typical regional dish, associated with local aspects of culture and history, can contribute to science teaching, showing the evolution of several kinds of raw material uses, such as spices. Such an experiment allows interdisciplinary connections of chemistry or biology to history and local culture.

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