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Itinerant Chemistry History Museum - discussions on "biotechnology"

Cristiani Miranda David Gossani, Luís César Passoni, Walter Ruggeri Waldman
LCQUI - CCT / Universidade Estadual do Norte Fluminense Darcy Ribeiro
walterw @uenf.br

Abstract. *The approach to the subject 'biotechnology' by the Itinerant Chemistry History Museum includes the explanation of the theme to demystify the term and the science that is involved with it, together with the development of easily executable experiments using readily available materials for demonstration of the concepts.*

Keywords. Biotechnology, Itinerant museum, History, Experiments.

1. Introduction

In recent evaluation by PISA (Programme for International Student Assessment) carried out with 15 year-old students all over the world, it was shown that Brazil had the worst performance in sciences among countries with similar economic and geographical situation, like Argentina, Uruguay and Chile [1]. For the authors, some of the important facts for this lower performance are the lack of interest in science by the students and the high deficiency of teachers with specific formation in sciences.

Regarding the lack of interest in sciences [2], research done in 2007 by the Ministry of Science and Technology (MCT) revealed that 58% of the Brazilians interviewees have little or any interest in science and technology and 73% gets little or none information on science and technology. In both cases, the main alleged reason was to do not understand the subject (respectively 37% and 32%). In the same research, only 4% of the interviewees declared to have visited a museum of science in the last year. The 96% of the interviewees that did not visit any museum of science in the last year, 35% alleged that there are not any museums of science in their area and 12% alleged that the museums are very far, in other words, 47% alleged problems of location of the museums for not visiting them. Once science museums are supposed to be a place for dialog between the society and the scientific production [3], this absence of contact with science museums may have strait connection with the lack of interest in sciences observed for a significant part of the Brazilian teenager population.

Low salaries and inadequate work conditions has shrunk the number and skills of teachers in sciences to inadequate numbers, been necessary even to count on teachers without specific formation for the discipline that they teaches. For secondary schools, only 9% of physics teachers and 13% of the chemistry teachers have academy degree in the discipline that they teach [4], to this point it is common that history or Portuguese teachers goes on science teaching. This lack of specific formation may be one of the components responsible for students' low motivation by the inability to do experiments that could connect theory with reality. Together with this deficiency in the science teacher formation, we must to consider the inadequate structure of the schools for practical activities.

The "Itinerant Chemistry History Museum" (ICHM) appears in this context to deliver experiments that could promote historical background to theoretical concepts and its link to day by day life and technology. Allchin demonstrated that historically backgrounded experiments may be more efficient than the usual experiments in teaching of sciences [5]. The historical approach adopted by the ICHM is clearly stated in the declaration of I.I. Rabbi, physics professor of the University of Columbia, in "Project Physics" first page [6]:

"*I propose that science be taught, at whatever level, from the lowest to the highest, in the humanistic way. It should be taught with a certain historical understanding, with a certain philosophical understanding, with a social understanding and a human understanding, in the sense of the biography, the nature of the people who made this construction, the triumphs, the trials, the tribulations.*"

The experiments are planed to be low cost and easy to made, employing house hold goods or ones easily available in stores. The experiments will be followed by explanations of the concepts in simple terms, in order to make them useful also by chemistry teachers without specific formation.

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The experiment chosen to demonstrate biotechnology was brewing. Beer was probably discovered by the Sumerians in the year 9.000 B.C. it is believed that stored grains, especially barley, were observed to become sweet if in contact with water. That happens due to the action of enzymes that are present in the grains, which are activated with watering and convert the starch of the grain in malted sugar. These enzymes are present in larger amount in the barley. Those grains were used to make thickened porridge like soups. When left aside for some days, the porridge became effervescent and somewhat alcoholic. The fermentation occurred due to wild yeasts that converted the malted sugar of the grain in alcohol and CO_2. That was a primitive form of beer [**7**].

Beer had a very important role for Egyptian culture. In several documents it is mentioned the great variety of beers that existed at that time. Beer was the most mentioned food in an analysis done on the Egyptian literature. According to the legend,

the beer existence might have saved mankind from the destruction. Rá, the god of the Sun, noticed that mankind was plotting against him and ordered the goddess Harthor to punish humans. Although, later, Rá was afraid that nobody would remain to worship him, due to the Harthor's great cruelty. He then prepared a great amount of beer and it dyed it red so that it was similar to blood and spread it on the fields, the spilt reflected Harthor image as in a great mirror. Admired with her own image, the goddess approached it and tried the beverage, got drunk and felt to sleep, forgetting about her bloody mission. From them on, Harthor became the goddess for beer and fermentation.

1.1 Nutrition and potability of water

In the beginning most of the beer was consumed with little time of fermentation. At that time beer had low alcoholic content compared with the current patterns, and great amounts of suspended yeast, which made it rich in proteins and vitamins. Proteins were mainly found in meat, a scarce commodity at the transition from hunting to agriculture.

The use of hot water for the production of beer made it much safer for drinking than fresh water, which was usually contaminated with microorganisms from human waste. This took no long to be noticed, if it was not possible to get clear running water from sources somewhat distant from villages, then beer was preferred for consumption. Beer was then a nutritious safe to consume liquid.

1.2. Medicinal beer

Besides being nutritious and a safe source of water, beer was also a source of medicines, and so was used by the Egyptians and Mesopotamians. In Egypt the beer was used as moderate sedative, and was the base for the production of several medicines done with herbs and spices. The oldest registration about the use of the alcohol in the medicine is a cuneiform writing from Nippur, about 2100 B.C. that contains a list of prescriptions that used beer as main ingredient.

2. Experimental

All of the experiments were designed with seeds of integral wheat instead of barley, due to it easy to find in stores at Campos of Goytacazes city, where UENF is located.

2.1. Control of the malting condition

For this experiment, it was used integral wheat, water, ordinary whitewash, absorbent paper, coffee filter paper, funnel and pots with cover.

Table 1: Identification codes for germination pots.

Pot	Solution
1	Water
2	OS
3	OS 1/2
4	OS 1/4
5	OS 1/8

First it was made about 100mL of saturated solution of ordinary whitewash. The solution was left to allow for decantation of undissolved whitewash. The suspension was then filtered to obtain a translucent solution. This filtration can be made with two coffee filters assembled one inside the other. The obtained filtrate, 80mL, was called original solution (OS). Half of the OS, 40 mL, was put aside for the experiment, the other half was diluted to 80mL again. This procedure was repeated twice. If no volumetric flasks are available, the volume measurement for the dilutions may be done with small coffee cups, each coffee cup holds about 40 to 50 mL. Five pots were prepared by covering the bottom with a filter paper bent three times. It was poured 40mL (one coffee cup) of water in pot 1; 40ml of

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the OS in pot 2; 40ml of 50% diluted OS (called OS 1/2) in the pot 3; 40mL of the 25% diluted OS (called OS 1/4) in the pot 4 and 40mL of the 12,5% diluted OS (called OS 1/8) in pot 5. One dozen of grains of integral wheat were then put in each pot and allowed to germinate.

2.2. Fermentation as a function of stirring

For this experiment, one will need sugar, bakery yeast, water, kitassato, glass tube, basin, universal support, latex hose, heating plate with stirring and thermometer. A system for measurement of CO_2 was assembled as follows: In a basin half full of water three graduate cylinders completely full of water were carefully introduced up side down letting no air to enter the cylinders, the cylinders were clamped to the support. Each fermentation system was linked to one of these cylinders by latex hose so to bring the CO_2 formed in the fermentation to the measuring cylinder. For the fermentation, three kitassato flasks were prepared with 30g of sugar and 20g of yeast in 200mL of water for each flask. The flasks were topped and a hose was connected to the lateral opening, the other end of the hose was introduced in the measuring cylinder. All solutions were kept in 30^{o}C constant temperature. The flask 1 was kept under moderate agitation for thirty minutes. The flask 2 stood still during the experiment and was stirred at the end of the time. The flask 3 was stirred during one minute, every four minutes, summoning six stirring cycles by the end of 30 minutes time.

2.3 Fermentation as a function of grain processing

For this experiment wheat, bakery yeast, water, backer and heating plate were used. Three different systems were prepared for fermentation: (1) with grain of raw integral wheat, (2) with grain of integral wheat cooked during one hour and (3) with grain of malted integral wheat, using the conditions determined in the experiment described in **2.1**. To each flask was added a mixture of 30g of mashed grains, 200mL of water and 10g of bakery yeast.

3. Results and discussions

3.1 Control of the malting condition

For the malting of the grain it is necessary to leave it in moisture to allow for germination and then to the transformation of starch into sugar. However, the moisture condition also allow for fungi growth, which is harmful for the process. To avoid fungi, the grains were left to germinate in the presence of whitewash. This experiment was conduced to identify what is the ideal concentration of whitewash for the control of fungi during the malting of the grains, with no influence in germination, with low cost materials and minimum of laboratory apparatus.

Figure 1: Germination results as a function of the solution with 50% from saturated solution used for hydration.

The pot 1 (water) presented great proliferation of fungi with low seeds' development. At pot 2 (OS) no fungi was observed although the germination was also low. In pot 3 (OS 1/2) the seeds had an excellent germination, and no proliferation of fungi occurred (Figure 1). It was observed that in the pot 4 (OS 1/4) a good germination happened but with large proliferation of fungi. In pot 5 (OS 1/8) few grains germinated and large amount of fungi was observed (Table 2).

Table 2: Germination tests results.

Pot	Fungi proliferation	Germination
1	Yes	Not good (Fungi presence)
2	No	Not good (Ca^{2+} in excess)
3	No	Good
4	Yes	Good
5	Yes	Not good (Fungi presence)

When irrigated with water only or with low concentration of whitewash proliferation of fungi is observed, therefore the malt obtained in these conditions should not be used because of contamination risk and the interferences on flavor. With the saturated solution of whitewash fungi were not observed, although the seeds did not germinate, probably due to the high pH of the solution. The best results were obtained for the

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50% dilution of the original solution. In this condition all seeds germinated and no fungus was observed. This solution was chosen for the malting of the grain.

3.2. Fermentation as a function of stirring

This experiment was done to check out for the amount of CO_2 produced in different agitation conditions at 30^{o}C constant temperature. Some laboratory goods are required to accomplish with this experiment, especially for keeping constant temperature.

It was observed that the solution 1 did not liberate CO_2 probably due to stirring that oxygenated the solution allowing for the aerobics breathing of the yeasts that produces neither CO_2 nor ethanol. From flask 2, 136mL of CO_2 were collected, the lack of stirring allowed for yeast anaerobic metabolism liberating ethanol and CO_2. In flask 3, 92mL of CO_2 was measured, an intermediate value, in good agreement with intermediate stirring condition.

3.3 Fermentation as a function of grain processing

It was observed that no fermentation happened over two hours nor with the raw integral grain, nor with the cooked integral grain, however with the malted integral grain a constant production of small bubbles of CO_2 was observed after 40 minutes stand, evidencing the fermentation process. The fermentation did not occur in flasks 1 and 2 because the seeds are rich in starch that is not available for immediate consumption by the yeast, which prefers sugars as sucrose, glucose or maltose. On the other hand, with the malted grain, the fermentation began quickly, being noticeable by the bubbles. The fermentation happened quickly because of the malting process that converts starch into simple sugars that are readily consumed by the yeasts. For experiment with grain of raw integral wheat, after around a week, a characteristic odor of fermented beverage was noticed.

4. Conclusions

The germination experiment allows by alternative procedures, the dilution of the whitewash solutions with smaller gaps, allowing a better precision in the determination of the best concentration for the malting process and better visualization of the results. It is an introductory exercise to the scientific methodology and allows an interdisciplinary approach with biology.

The fermentation with stirring experiment is of easy execution, despite of the need for some laboratory goods, and allows observing, in one hour time, the effects of the introduction of oxygen in the fermentation system.

The fermentation as a function of grain processing experiment allows visualizing the importance of the malting process in the fermentation of grains, attributed to the alteration of the chemical composition of the grain.

The proposed experiments permit flexible execution conditions, in spite of some experiments that need some laboratory apparatus for its accomplishment. The execution easiness of the suggested experiments incites the students to reproduce them varying the conditions, stimulating the interest for the experimental practice.

5. References

[1] http://www.estadao.com.br/ext/especiais/2007/11/oecd.pdf [01/06/2008]

[2] Moreira IC, Massarani L. Percepção Pública da Ciência e Tecnologia no Brasil. http://www.mct.gov.br/index.php/content/view/50875.html [07/06/2008]

[3] Rodari P, Merzagora M. The role of science centres and museums in the dialogue between science and society. Journal of Science Communication 2007;6(2):1-2

[4] Ruiz A.I., Ramos M.N., Hingel M. Escassez de Professores no Ensino Médio: Soluções Emergenciais e Estruturais. http://portal.mec.gov.br/cne/arquivos/pdf/escassez1.pdf [07/06/2008]

[5] Allchin D. History of Science-With Labs. Science and Education 1999;8:619-632 *apud* Stinner A, McMillan BA, Metz D, Jilek JM, Klassen S. The Renewal of Case Studies in Science Education. Science & Education, 2003;12:617-663

[6] The Project Physics Course. 1st edn. New York: Holt, Rinehart & Winston; 1970 *apud* Holton G. What Historians of Science and Science Educators Can Do for One Another. Science and Education 2003;12:603-616

[7] Standage,T. História do mundo em seis copos. Rio de Janeiro: Jorge Zahar Ed; 2005.