Martian Bread: Fermentation based on bacteria from human microbiota

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Abstract

Through this bakery experiment, we will test an alternative way of bread fermentation. The aim is to prepare a bread only with ingredients present or produced in the station. On Mars, you won't have a packet of baking powder in the kitchen and the chance you'll find yeast in the soil are minimal. We are proposing to test a lactic fermentation with Lactobacillus directly isolated from our buccal mucosae. This fermentation will be compared to a positive control, a sourdough bread.

1 Introduction

The Apollo 11 mission brought the first humans on the moon and back in 8 days 3 hours and 19 minutes. An inhabited mission to Mars will take years – the one-way trip is estimated at 6 months at the shortest. The organization of such a journey requires spectacular scientific and technological skills, including the transport of hundreds of tons of material and resources. The solution? A completely autonomous station including at the food level. We'll try to elucidate that point with this experiment dedicated to the making of Martian bread, more precisely a sourdough bread from ingredients directly produced in the station. The question of the flour production, and thus the cereal planting, is raised by our botanist Mario Sundic. The water, already present on the red planet in the form of ice, can be harvested and purified in consumable water. We will then attempt to produce bread through fermentation based on *Lactobacillus* isolated from our oral mucosa. If the experiment is successful, the only remaining issues will be the manufacturing of salt, and the high-temperature cooking of the bread...

2 Bread fermentation

The consequence of bread fermentation is a swelling of the dough due to a gas liberation. Most of the time, the gas emission is in reality carbon dioxide which comes from microorganisms metabolism. The anaerobic microorganisms are able to catabolized glucose molecules in absence of oxygen. This reaction is called "fermentation". This process is favored in case of big amount of sugar and very little oxygen, as the life conditions on Earth before the atmosphere formation. It exists a few kind of fermentation reactions, used by different types of microorganisms. Here are the two main:

2.1 The alcoholic fermentation

The alcoholic fermentation is mostly used by yeast. The glucose is transformed in ethanol and carbon dioxide with production of ATP:

$$C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2CO_2$$

2.2 The lactic fermentation

The lactic fermentation is used by some bacteria and animal cells and converts the glucose into lactic acid with a slight ATP production:

$$C_6H_{12}O_6 \rightarrow 2\ CH_3COCOOH$$

3 Sourdough

Most of the baker use the alcoholic fermentation via *Saccharomyces Cerevisae*. This is the most efficient way of bread fermentation. Sourdough bread is also in the game. The sourdough contains a symbiotic culture of yeast and bacteria, more specifically Lactobacillus.

Sourdough bread fermentation is a dual fermentation: on one hand, the alcoholic fermentation by the yeast, and on the other hand, the lactic fermentation by the *Lactobacillus*, along with the lactic acid production responsible of the acid taste of the bread. The classical, natural sourdough is simply made by a mix of flour and water. Bacteria and yeast from the air will develop and grow in the mixture. After a couple of days, the sourdough is full of bubbles and the temperature raised slightly, confirming the presence of microorganisms. Despite the limited gas emission, sourdough bread has the advantages to have a better conservation and nutritional quality than the yeast bread.

The aim of this experiment is to test a bread fermentation based only on lactic fermentation by *Lactobacillus*. No matter the destination, we will always find *Lactobacillus*... in our own body; yeasts are not present on Mars. Through this experiment, we will try to make a sourdough bread based on a *Lactobacillus* culture isolated from our oral mucosae.

4 Lactobacillus isolation

Lactobacillus are gram positive, anaerobic and non-pathogen bacteria. There are frequently used in fermentation of dairy products, leading to cheese and yogurt. Bacteria will be isolated from saliva and grew in the selected media "De Man, Rogosa and Sharpe agar" (MRS, [1]). Colonies will be picked up and amplified to reach cultures of a billion *Lactobacillus*, which will be added in the flour/water mixture in view to make a sourdough 100% bacteria. After incubation, bubbles will appear and the sourdough will start living. A classical sourdough will be made in parallel, as a positive control.

5 Bread preparation

Once the sourdough ready, the next step is the bread preparation. We will follow the recipe below:

Ingredients

- 150 g of refreshed sourdough
- 300 g of water
- 450 g of flour
- 10 g of salt

Protocol

1. Mix up the ingredients.
2. Incubate 10 minutes for water absorption.
3. Knead the dough until you obtain an elastic dough without tear.
4. Incubate 4 hours at RT (or 25-30°C) : the dough must double in volume.
5. Shape.
6. Incubate 1 hour.
7. Moisten and incise.
8. Bake during 30-40 minutes at 220°C

If the results are concluding, this experiment will prove that it is possible to make a bread on an "improvised way". Exploring alternative bakery and way to feed human is primordial for future inhabited spatial mission.

About the author

Ariane Sablon graduated in Biomedical Sciences at the Université catholique de Louvain (UCLouvain, Belgium) with a specialization in human physiopathology. During this program, Ariane incorporated several laboratory research groups. As her Master thesis, she worked during one year on innate immunity and cytokines signaling, where she practiced the Crispr-Cas9 method on human cell lines. Then, she spent several months in Montreal, Canada in a lab interested in metabolism, especially in liver diseases and diabetes. She's now doing a PhD in cancerology, more precisely on new treatments for chemotherapy resistant lymphomas. Through this different experiences, Ariane learned to create, reason, perform, analyze and interpret experiments. Beside the scientific aspect, it also made her acquire a team spirit and forged her mind to be critical. Today she feels comfortable with the idea of managing a project in biology and to schedule some experiments to reach the goals.

References

[1] J.C. De Man, D. Rogosa, and M. Elisabeth Sharpe. A medium for the cultivation of lactobacilli. *Journal of Applied Microbiology*, 23(1):130–135, 1960.