

CASE STUDY: GUAVA, FILMS AND MINERALS

Authors: Pablyana Leila Rodrigues da Cunha and Salete Linhares Queiroz

Part I - The Time of Guava Fruit

Martins' Tropical Fruits, a producer of guava, acerola, and mango, is located in the metropolitan region of Fortaleza, a city in the Northeast of Brazil. In the last six months, guava production has accounted for 30% of the company's turnover. To increase turnover, the directors, Amanda and Clara Martins, decided to expand the fruit distribution radius. They presented this intention at a meeting with the production team and the research and development team.

Both teams accepted the idea; however, at a certain point, Pedro, the production manager, raised an important question about the demands that this new strategy would bring.

"We think it's a great idea, but we're worried about the fruit's shelf life. By taking them to more distant cities, we're worried that they won't arrive at their destination with the right quality, as we'll need more time between production and the final consumer."

"True, Pedro. This concern is very pertinent. It's a fundamental question to think about before we expand the marketing of guava," said Clara.

"What does the research and development team think about this? Do you have any strategies for working on the issue of the shelf life of guava?" Amanda asked.

"We have been researching the coating of fruit with natural polymers such as starch. We can devote more time to this aspect and allocate part of the team to intensifying research into guava coatings," said Patrícia, the research team's manager.

Everyone agreed with Patrícia and the following day she gathered her collaborators who, after several discussions, suggested developing corn starch films and starch films with added zeolites. Zeolites are crystalline minerals composed of aluminosilicates. Structurally, these materials are formed by a three-dimensional network of interconnected tetrahedrons, containing channels and cavities of molecular dimensions. The addition of zeolite can form porous structures in the polymer matrix, making it difficult for water to pass through the film.

Once the research had been designed, Patrícia delegated the responsibility for its development to the chemist Cláudio, who prepared biodegradable films from a combination of an aqueous solution of gelatine and sorbitol (1), and an aqueous solution of cornstarch and sorbitol (2). The solution for preparing the starch film with zeolite (starch/zeolite) was made in the same way, but after mixing solution (1) with solution (2), a small amount of zeolite was added.

In summary, two film types were prepared: starch film and starch/zeolite film. 10 mL of the film solutions were used, dispersed on polypropylene plates and left to stand for 48 hours to dry and

form the films.

Claudio evaluated the films macroscopically and made the observations described in Table 1.

Table 1. Appearance of gelatine and cornstarch composite films with and without added zeolite.

FILM	APPEARANCE
Starch	Almost translucent films
Starch/zeolite	Virtually opaque films

The chemist inferred that the starch/zeolite films were practically opaque due to the possible uniform dispersion of the zeolite in the prepared film. He then decided to carry out Scanning Electron Microscopy (SEM) analyses to better characterize the films. After receiving the results, Cláudio made observations on the micrograph images, described in Table 2.

Table 2. Observations on the surfaces of films made up of gelatine and cornstarch with and without added zeolite.

FILM	SURFACE HOMOGENEITY	SURFACE OBSERVATIONS
Starch	Homogeneous, without cracks and bubbles	Surface with few irregularities, no evidence of residue or starch granules.
Starch/zeolite	Homogeneous, without cracks and bubbles	Rough surface, no visible exposed zeolitic crystals.

The lack of visible exposed zeolite crystals on the surface of the films suggested to the chemist that there was a strong interaction between the zeolite crystals and the starch structure of the film.

Given the results obtained, Cláudio believes that he can help the company answer the question posed about the possibility of expanding the distribution radius of guava sale.

Classroom Activity

1. What do you already know about the case? In other words, what have you read about similar situations? What experiences have you had that relate to the subject of the case?
2. Based on the narrative, propose a question for your group to investigate. Attention: the question must take into account the context of the narrative and the possible answers must provide information so that the characters can take action to solve the problem they are facing.
3. Based on the narrative, build hypotheses about the possible answers to the research question formulated by your group.

Homework Activity

1. In view of the discussion that took place in class, what do you think it would be interesting to know in order to solve the case, in terms of scientific content (in the area of Natural Sciences) and general content (other areas of knowledge)?

2. Is there any additional information about the context of the case that would allow the group to make more precise hypotheses and formulate a clearer research question? If so, please indicate what it is so that it can be provided by the teacher as far as possible.
3. Research and select a scientific text (articles, dissertations, theses, etc.) that deals with the subject of the case (biofilms for food packaging), which can help you understand and solve the case. Present a summary of the text and indicate the information from it that you consider most relevant, justifying your answer.

Part II - Covering Guava Fruits

After analyzing the information provided by the SEM, Claudio scheduled a meeting with the directors and the production management of Martins' Tropical Fruits to present the results. At one point during the meeting, Claudio commented:

“Dear all, to know whether our film solutions are suitable for protecting fruit, we need to test them for covering guava”.

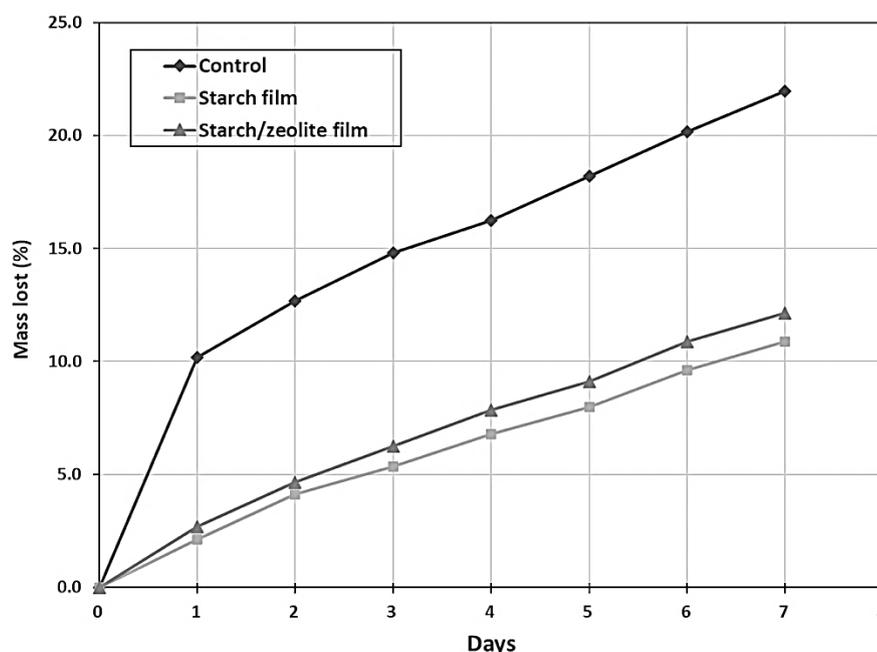
“Good, Claudio. I think the production management staff can help,” said Amanda.

“Of course! I suggest choosing guava fruits for the tests that are light green in color, around 8cm in diameter, without any slight or serious defects. We'll sort them out and send them to you, Claudio,” promised Pedro, the production manager.

Once he had the fruit samples, Cláudio began coating them. After preparing the film solutions, the sanitized guava fruits were immersed in a beaker containing the solutions using metal tweezers and then placed back on the tray for drying. They were all kept in an air-conditioned room at a temperature of approximately 22°C. In addition, a control group was used in which the fruits were immersed in distilled water instead of the film solutions.

The mass loss of fruit over the days was measured. The percentage of mass loss was analyzed using the difference between the initial mass and the final mass obtained. From this experiment, Cláudio plotted the graph with the results illustrated in Figure 1.

Figure 1. Mass loss (%) of treated and untreated guava fruits during 8 days of storage.



Classroom Activity

1. How does the data obtained by Cláudio help the group answer the question(s) posed in the previous

step? Can the hypotheses constructed in the previous lesson be confirmed or refuted with the new data? Justify your answer.

2. Establish relationships between the data presented so far and then draw up statements that can be provided to Cláudio, in order to enlighten him about the efficiency of the films in protecting guava fruit and which one would be the best for this application. The greater the number of statements with the appropriate justifications, the more satisfactory the group's response will be.

Homework Activity

1. Research and present new forms of analysis that can be used to collaborate with Cláudio in deciding which is the best film to suggest to the company's board of directors and argue in favor of one of them, or a set of them. In order to build the group's argument in favor of the chosen analytical process(es), it is suggested that they look for support in the following aspects: complexity of the procedure, cost, amount of sample needed to carry out the analysis, analysis time, among others that the group deems interesting. The arguments constructed should also include a discussion of experimental data in the form of tables and/or graphs, obtained from articles, dissertations or theses, among other types of publications, which illustrate the relevance of the chosen form(s) of analysis.
2. What are the main sectors or groups in society directly affected by the possibility of using biopolymer films to protect fruit? Find information to back up your assertions.

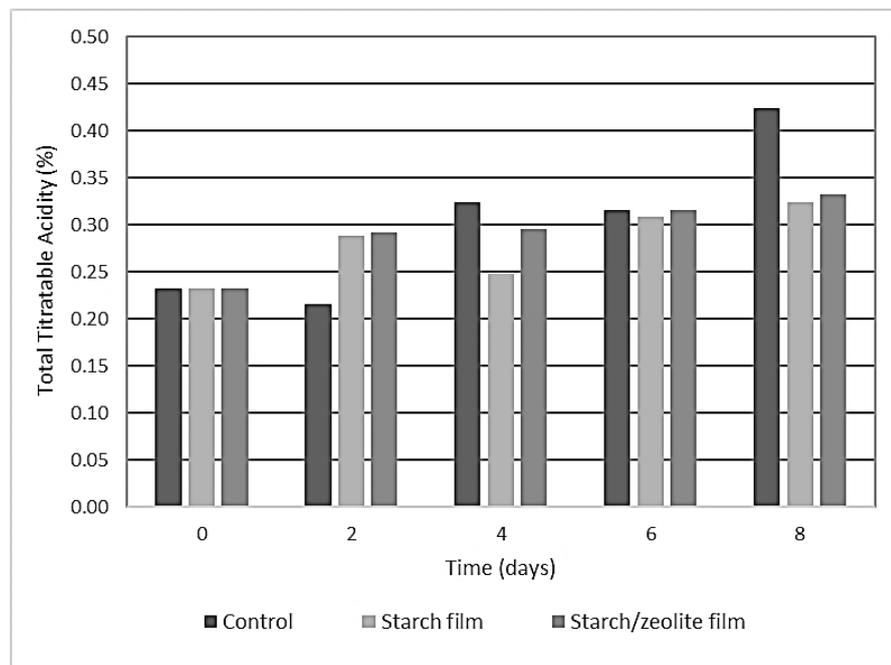
Part III - The Guava Impasse

Once the coating and mass loss results had been obtained, Cláudio was very excited: both films looked promising for use, as they reduced the mass loss of the guava fruits. However, the question remained: how to decide which of the film solutions was the most suitable for coating the guava fruits? And did zeolite enhance the action of the coatings?

Faced with this impasse, Cláudio decided to carry out two more experiments on the coated guava samples and the control fruits (uncoated): Total Titratable Acidity (ATT) and Total Soluble Solids (TSS).

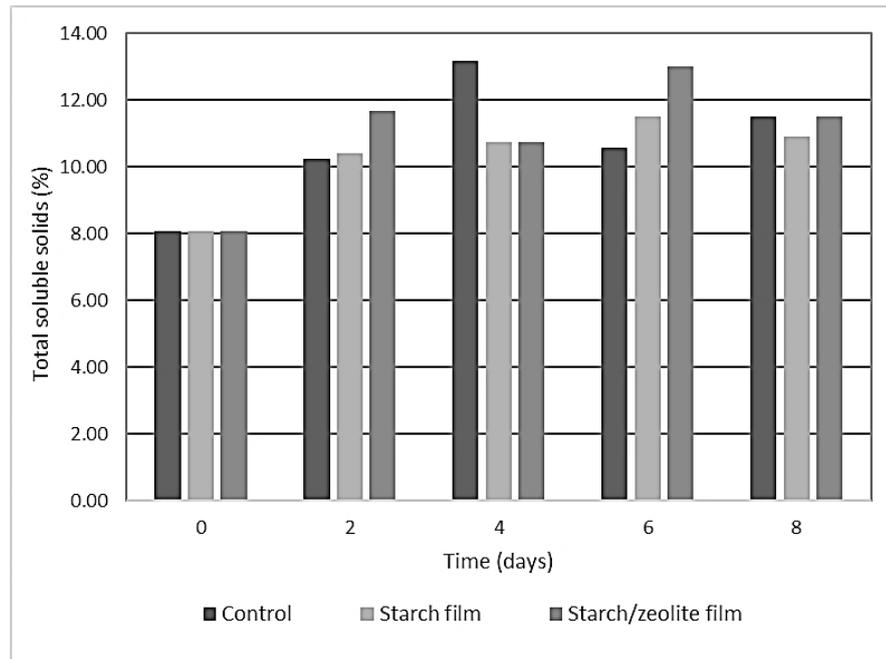
To determine the total titratable acidity (TTA), 1g samples of the fruit's edible tissue were used and mixed with water for a total of 50 mL. Titration was carried out with a 0.1 mol/L NaOH solution. From this experiment, Cláudio plotted the graph illustrated in Figure 1.

Figure 1. Total Titratable Acidity (%) of treated and untreated guava fruit samples during 8 days of storage.



To determine the total soluble solids (TSS) content, crushed samples were analyzed in a refractometer, with the results expressed as a percentage. Based on this experiment, Cláudio plotted the graph illustrated in Figure 2.

Figure 2: Total soluble solids (%) of treated and untreated guava fruit samples during 8 days of storage.



With the results and the other analyses already carried out on the films and the guava fruit samples, Cláudio can decide which is the best biofilm for covering the guava fruits and present a proposal to the company's board of directors and production team.

Classroom Activity

- 1a) What relationships (similarities, differences, curiosities, etc.) can you establish between the character's proposal and the one offered by your group to help you decide which would be the best film for covering the guava fruits?
- 1b) What criteria did Cláudio use that your group didn't, and vice versa?
- 1c) Do you think it would be appropriate to change the experimental procedures you chose, given what the character decided? Argue in favor of your answer.
2. Establish relationships between the data presented in Figures 1 and 2, and then draw up statements that can be provided to the character to help him achieve his purpose, mentioned above: to prepare starch films that can be used to protect the guava fruits produced by Martins' Tropical Fruits. The greater the number of statements and recommendations with the appropriate justifications, the more satisfactory the group's response will be.

Homework Activity

1. Create and complete the summary table below, which summarizes the actions and results obtained at all stages of the study.

Problem situation: In this section, present the problem situation of the case. In other words, you need to briefly describe the narrative and the problem that the main characters are facing.

Problem: In this section, present the problem/issue to be solved in the case. As every problem must start with a question, the question must be formulated in such a way as to end with a **question mark**.

Hypotheses: In this section, present the hypotheses formulated to solve the problem. Hypotheses are assumptions made as preliminary answers to the problem at hand. The same problem can have many hypotheses, which are possible solutions for solving it. With this in mind, state your **basic hypothesis**, which is the main explanation you have for the proposed problem. Then state the **secondary hypotheses**, which are complementary statements and/or other possible answers to the problem. These can cover in detail what the basic hypothesis states in general, as well as aspects not specified in the main hypothesis.

Research planning: In this section, describe the steps and resources you used to propose a research plan to test your hypotheses. Add images to make your answer clearer. Finally, conclude your answer by pointing out whether you made any changes to your initial plan when it was compared to the plan presented by the characters in the case.

Data: In this section, present the empirical data or data from other sources that you have worked with, which has allowed you to test your hypotheses and the comprehensiveness of your answer to the problem. Add images to make your answer clearer.

Conclusion: In this item, present the group's conclusion regarding the problem of the case.

Justifications: In this section, present the justifications that support the conclusion stated above. Try to gather as many justifications as possible and present them in such a way that they are supported by the available data (in this case, add images to make the answer clearer) and by knowledge reported in the literature.

Suggestions for future work: In this section, considering all the knowledge they have on the subject, make suggestions for new research Cláudio could carry out to continue contributing to the discoveries about starch biofilms. Suggestions could include both work involving the collection of experimental data, such as that which they carried out during the case, and work involving the use of biofilms from a social perspective (i.e., involving socio-scientific issues).
