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Bioethanol and Gel Production Using Organic Fruit Waste

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ABSTRACT

Half of the waste that we produce comes from food and organic waste that could be reused. Meanwhile, the use of alcohol gel has been promoted during the pandemic. In this context, this project has been formulated to develop a homemade cleaning product, and to promote fruit recycling at home and in places where large amounts of this food type are discarded. The hypothesis of this article is that organic fruit waste contains sugars that produce bioethanol when oxidized, and that certain fruits (apples and quinces) are a rich source of pectin, which allows the alcohol obtained to be transformed into gel. The objective of the research was to obtain bioethanol and pectin from fruit in order to reduce organic waste from food markets and in the home, promoting maximum natural resource use by replacing the option of daily-use synthetic products. As a result, bioethanol and pectin were obtained from the organic waste of fruits such as apples and quinces, allowing homemade alcohol gel to be produced. In conclusion, the research hypothesis was proved correct, as bioethanol and pectin were produced from organic fruit waste via the fermentation and gelling processes.

Introduction

In recent years, we have become aware of the large amount of organic waste that is produced. A World Bank study shows that Latin America and the Caribbean generate around 231 million tons of waste each year (Kaza et al., 2018). In Chile, Law 20920 aims to reduce waste generation, and promote its reuse and recycling (Biblioteca del Congreso Nacional de Chile, 2016).

One of our country's main sources of organic waste is its 1150 food markets (Portal Agro Chile, 2020), in which fruit and vegetable stalls take up 92% of market space (Portal Frutícola, 2013).

Fruit contains between 75-90% water and 3-20% carbohydrates. Sucrose is the predominant oligosaccharide that they contain, and the main monosaccharides are glucose and fructose. Fruits also contain pectin, which gives them texture and consistency. Vegetable gums, found in fruit subproducts (skins and seeds), are used as thickeners in various food products (Cid, 2000; Ansorena, 2000).

Carbohydrates participate in different metabolic processes, such as fermentation, where carbohydrate molecules are transformed into different products that depend on the substrate and type of microorganism used. The main substances that are obtained from fermentation are: ethyl alcohol, lactic acid, butyric acid and acetic acid, among others. Alcoholic fermentation is a process that occurs in the absence of oxygen, carried out by yeast or bacteria. It is a process that degrades sugars and generates ethyl alcohol and carbon dioxide (Vázquez & Dacosta, 2007).

Bioethanol is obtained in two ways: the first is through the direct fermentation of sugars, such as glucose or fructose, present in fruit and vegetables; the other is through the decomposition of the sugars present in cereals, such as wheat and maize. The bioethanol that is obtained directly from fruit, cereals and/or vegetables is called first-generation bioethanol. Bioethanol can also be obtained from substances that contain cellulose, such as wood and agricultural

waste. This type of bioethanol is classed as second-generation and is known as cellulosic or lignocellulosic bioethanol (Santos & Zabala, 2016).

It is also worth emphasizing the context in which we find ourselves regarding the COVID-19 pandemic (PAHO, 2020). The Centers for Disease Control and Prevention (CDC) recommend washing your hands with soap and water whenever possible, as hand washing reduces the number of microbes and prevents infection. However, if there is no soap and water available, they recommend the use of a disinfectant such as alcohol gel to prevent people from becoming ill and spreading germs to others (CDC, 2020).

This project has been formulated to promote fruit recycling in the home and in places where a large amount of this type of food is discarded, such as food markets. It is also fundamental in the context of COVID-19, where it is necessary to use alcohol gel to prevent the spread of the disease.

The research thus aims to answer the question: Is it possible to obtain bioethanol and pectin from organic fruit waste through fermentation and gelling?

Hypothesis

Organic fruit waste contains sugars, which produce bioethanol when oxidized. Certain fruits (apples and quinces) are also a rich source of pectin, which allows the alcohol obtained to be transformed into gel.

General Objective

To obtain bioethanol and pectin from fruit in order to reduce the organic waste produced in food markets and in the home, thus promoting the maximum use of natural resources and replacing the option of daily-use synthetic products.

Specific Objectives

1. To obtain bioethanol through the fermentation process of sugars in fruits.
2. To obtain pectin from fruit waste (seeds and skins) through gelling.
3. To produce homemade alcohol gel using bioethanol and pectin.

Methodology

1. Fermentation of the fruit

Four jars were prepared with quince and four with apple in order to measure alcohol formation at 5, 10, 15 and 20 days. Each day, photographs were taken of each jar, and the degree of alcohol and pH were measured.

1.1 Materials and procedures

For each of the eight one-liter jars (four containing quince, four containing apple):

a) Take 400 grams of either quince or apple (including skins and seeds).
b) Clean the fruit.
c) Chop it into small pieces of approximately 3cm, using a 22cm knife.
d) Place the pieces of fruit into a one-liter capacity jar.
e) Pour 200 grams of sugar and 200cc of filtered water into another container.
f) Stir until the sugar dissolves and add 50 grams of dried yeast.

g) Pour the sugar, water and yeast mix into the jar containing fruit.
h) Cover and leave the fruit in a dark place for various days.
i) Put the lids on loosely and slightly open, as carbon dioxide will be produced.
j) Measure the amount of alcohol that forms in the liquid at 5, 10, 15 and 20 days. Use a vinometer to determine %Volume/Volume and apply the following formula to measure the grams of alcohol from this result:

Grams of OH= Volume (cc) x graduation x 0.8 (density OH)/100

1.2 Pectin extraction

a) Take 500 grams of green apple.
b) Clean and chop.
c) Put the fruit in a pot.
d) Add 500ml of filtered water and 10cc of lemon juice to prevent the fruit from oxidizing.
e) Cook over a medium heat for one hour, stirring occasionally.
f) Turn off the heat and allow to cool.
g) Sieve the contents of the pot, so that very solid waste is not retained. A type of natural gel should be obtained.
h) Collect all of the sieved content.
i) Place the content in a jar and cover it to then store in the refrigerator.

1.3 Alcohol gel production

Mix the bioethanol obtained from the fermentation of the fruit with the pectin extracted by gelling, using 50% bioethanol and 50% pectin.

Results

The results of the research are presented below:

1. Bioethanol production

The following steps are suggested for bioethanol production and measuring the %Volume/Volume (%V/V) obtained from the fermentation of apple and quince:

Figure 1. Fruit with water, sugar and yeast, placed in a jar and kept in a cool, dark place, with the lid left partly open.

Figure 2. Liquid filtration on day 5, 10, 15 and 20.

Figure 3. Measuring %V/V with a vinometer.

Table 1. Temperature, pH, %V/V and degree of alcohol measurements in quince and apple on day 5, 10, 15 and 20.

Table 1 shows the production of bioethanol from quince and apple at day 5, 10, 15 and 20. With both fruits, the temperature was maintained at between 21 and 22 degrees centigrade. The pH was reduced on days 15 and 20, remaining at four. The %V/V rose in both fruits as the number of days increased, with the apple standing out when compared to the quince at day 20. The degree of alcohol rose progressively over the course of the research, with apple showing a higher value on day 20 when compared to quince.

1. Pectin production

The following figures show the pectin extraction process in apples. 278 grams of pectin were obtained from 500 grams of processed apples.

Figure 4. 500g of green apples were weighed.

Figure 5. They were washed, cut into pieces and placed in a container.

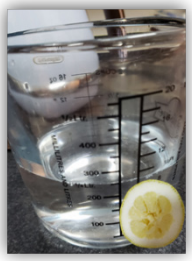

Figure 6. 500ml of water and 10cc of lemon juice were added.

Figure 7. Cooking process.

Figure 8. Cooling process.

Figure 9. Sieving process.

	Quince				Apple			
Days	**5**	**10**	**15**	**20**	**5**	**10**	**15**	**20**
Temperature	22	21	22	21	22	22	21	21
pH	5	5	4	4	5	5	4	4
% V/V	12	17	20	22	10	16	21	25
Degrees OH	9.6	13.6	16	17.6	8	12.8	16.8	20

Figure 10. Weighing the sieved product.

2. Alcohol gel production

20 days after the start of the experiment, the product of bioethanol fermentation (50%) was mixed with 50% pectin.

Figure 11. 50 grams of pectin were weighed.

Figure 12. 50ml of bioethanol was added.

Figure 13. The bioethanol was mixed with the pectin.

Figure 14. The mixture was tested.

Discussion

Apples and quinces were used to obtain bioethanol and pectin. By observing both fruits at the end of the experiment (day 20), it was observed that a higher amount of alcohol was obtained from apple than quince. With regard the pH, both fruits produced an acidic pH (4), associated with the higher amount of alcohol produced during fermentation. In alcoholic fermentation, there is a decrease in pH derived from yeast metabolism, because, in addition to CO2 and ethanol, alcoholic fermentation produces other organic acids, such as lactic acid, which produce a reduction in pH, even in small quantities (Redondo, 2014).

Pectin is a substance found mainly in fruit skins and seeds (INTA, 2018). In this project, we processed green apples to obtain pectin through gelling.

This research contributes to Law 20920, as it promotes the recycling of fruit (apple and quince) in food markets and in the home (BCN, 2016). Furthermore, given the situation of the global pandemic (PAHO, 2020), the CDC recommend constant hand washing with soap and water. However, in the event that there is no soap or water available, they suggest using alcohol gel (CDC, 2020). For this reason, apart from reducing organic waste, this project

has aimed to produce an alcohol gel that can contribute to promoting the maximum use of natural resources, replacing synthetic products with natural ones, such as homemade alcohol gel.

This project is absolutely feasible and replicable. There is a lot of organic fruit waste that is thrown away and not reused. At the same time, this research has the future objective of helping to promote the use of fruit waste, thus reducing the environmental impact that it generates and making better use of the natural resources that we have available.

Conclusion

The hypothesis of this investigation was proved correct, as bioethanol and pectin were obtained from the organic fruit waste of quince and apple, through fermentation and gelling processes. This project has a high level of feasibility and reproducibility, since there is a lot of organic fruit waste that is not reused. This research also contributes to reducing the environmental impact of organic waste and making better use of natural resources by using them to replace artificial ones. While it is true that we managed to answer the hypothesis, other questions arise that we would like to work on in a second research stage: How can we improve the germ-killing ability of homemade alcohol gel? How can we correct the appearance and aroma of the alcohol gel produced?

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