Adulteration in Coffee Beans

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Abstract

Coffee is one of the most commonly consumed products in the world, with an industry worth of $225.2 billion. *Coffea arabica*, known simply as Arabica, is the current dominant cultivar of coffee, representing about 60% of global production, and is one of the more expensive varieties. The objective of this study was to detect possible adulteration of whole coffee bean products, which will most likely not have the labeled "100% Arabica" content it advertises due to the financial incentives associated with diluting coffee products with cheaper adulterants. The Qiagen DNeasy Plant Pro Kit was used to isolate DNA from four different brands of coffee, Polymerase chain reaction (PCR) followed, but our agarose gel electrophoresis showed no results. After comparing two scientific articles' methods with similar objectives, it is imperative to minimize inhibitors, use a more suitable DNA extraction kit, and even utilize real-time PCR in order to result in more amplifiable DNA from the coffee beans.

Introduction

- *Coffea arabica*, also known plainly as Arabica, is currently the dominant cultivar, representing about 60% of global production. *Coffea canephora,* known as Robusta, less acidic, more bitter, and more highly caffeinated makes up most of the remaining coffee production.
- There are financial incentives for diluting high-quality Arabica beans with the cheaper Robusta beans. This practice of adulteration is especially difficult to detect once the coffee beans have been ground and roasted. Detection of these adulterations is important to ensure consumer protection and the ability of the food and beverage industry to source high-quality products (1).
- Most coffee products will label the type of coffee bean used, however, the average consumer cannot tell whether or not this labelling is true simply by reading the packaging or looking at the coffee beans.
- One analytical solution that has been applied in the past is DNA barcoding. We utilized DNA barcoding to measure the accuracy of the advertised percentage of *Arabica* beans in the label of coffee bean packages. The coffee bean bags will most likely not have the labeled "100% Arabica" content it advertises due to the financial incentives associated with diluting Arabica coffee products with cheaper Robusta beans, or other adulterants such as cocoa beans.

Materials & Methods

1) Four different bags of coffee were used. All ranged from 12 oz to 15 oz in weight, were whole beans, labeled "light roast" and labeled "100% Arabica." The control was a leaf procured from a tree in New York.

2) Five beans were randomly picked from each bag. A manual grinder was used and was set to the Turkish grind (finest). Each bean was ground manually for 10 seconds.

3) The Qiagen DNeasy Plant Pro Kit was used; "Step 1" on the kit called for 50µL of Solution PS. This solution was recommended for samples high in phenolic compounds.

4) A second set of samples was collected from two of the coffee bags that were ground using an electric grinder. The ground mixture was then scooped out Eppendorfs. The homogenized samples of these beans were tested to see if the DNA barcode would reveal a uniform presence of the Arabica beans. These samples followed the protocol in the Qiagen DNeasy Plant Pro Kit.

5) 28 samples in total were used for the polymerase chain reaction (PCR). Agarose gel electrophoresis was then utilized to interpret the DNA samples after PCR.

Results

Following agarose gel electrophoresis, all coffee samples had failed, indicated by a lack of bars in the gel.

Discussion

Although 26 coffee samples were collected using two different DNA extraction methods, there were no yielded DNA barcodes in the gel results. Unfortunately, there was little time to dissect which part of the method could have been faulty. It's important to note, however, that processed coffee (such as those that have been roasted) have experienced some decomposition of nucleic acids at high temperatures during roasting, and that coffee is high in polyphenols, which have been known to inhibit Taq polymerase (4). A culmination of these factors makes it difficult regarding extracting PCR-grade DNA.

There is a particular study (4) which focused on obtaining PCR-grade DNA through the exploration of different methods. It was found that grinding the beans in the presence of activated charcoal or 4% polyvinylpyrrolidone (PVPP) minimizes the binding of phenolic inhibitors to DNA, resulting in more amplifiable DNA. It was also found that the most effective kit was the ClonTech NucleoSpin Plant Kit. The study had also utilized the Qiagen DNeasy kit (similar to the Qiagen DNeasy Plant Pro Kit used in our method) but had no yield in DNA from roasted beans.

Another study (3) had the same objective of identifying adulteration in coffee bean products. However, that study utilized ground roast coffee instead of whole beans. The study used a specific hybrid method of CTAB and DNeasy and real-time PCR (which collects data throughout the PCR process). Given that real-time PCR is more sensitive than conventional PCR, it would be more accurate in detecting contamination.

A combination of the changes discussed above to our method most likely would have resulted in amplifiable DNA from the coffee beans. Other factors, such as effective controls, would be necessary after successful DNA extraction and PCR. Examples of these controls would include a green Arabica bean, a green Robusta bean, and cocoa beans.

Although most food adulteration detection is done by simple eye-tests, such as distinguishing green coffee beans from those roasted, those are not entirely effective and are prone to human error. Refining DNA extraction methods of substances such as roasted coffee beans, or other roasted food products such as cocoa beans or black tea, is imperative to the product's quality and consumers' safety. Once these methods are refined, food or government agencies can utilize them to thoroughly detect these adulterations.

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