Pre-Analysis Plan: Avocado Storage

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Project Background and Overview

This study aims to determine the most effective method of storing and preserving avocado, which browns due to the catalyzation of polyphenoloxidase (Dorantes-Alvarez et al., 1998). There are many recommended methods for storing avocado, and many cooking and housekeeping publications have conducted tests to determine the best method (including Butler, 2014 and Parisi, 2017). In particular, three methods—storing avocado in oil, water, and with a cut onion—seem to be the most commonly recommended (Butler, 2014; Parisi, 2017). Olive oil contains acids that may combat polyphenoloxidase catalyzation, water acts as an oxygen barrier, and cut onions release sulfer dioxide, which preserves fruits (Parisi, 2017). Tests of these method often do not meet minimum standards for experimental design: treatment is limited to one observation each and outcomes are not blindly assessed. To ensure a more robust test of these methods, I conduct a randomized experiment with the three common avocado storage treatments and assess outcome variables of color, greasiness, sliminess, smell and taste. While there are a few more recommended avocado storage treatments, I selected the treatments that would have minimal impact on avocado characteristics after removal and would be easy for a home cook to implement to reduce issues of excludability and increase generalizability.

Design

My subjects and units of analysis are 32 single serving-sized samples of extracted, mashed, and mixed ripe avocado flesh. Ripe avocados will all be purchased one day in advance from the Belmar Whole Foods Grocery in Lakewood, CO, by an assistant. This will ensure a representative sample of conventionally purchased, albeit relatively high-quality, avocados. The process of extraction, mashing and mixing avocados will ensure randomization of avocado characteristics across the purchased avocados.

Three treatments and one control will be applied:
- T1: Store avocado in fridge with oil on top, covered by saran wrap
- T2: Storing avocado in fridge with water on top, covered by saran wrap
- T3: Storing avocado in fridge with cut onion on top, covered by saran wrap
- Control: Store avocado in fridge covered by saran wrap

Each container will be labelled and randomly assigned to: (1) treatment; (2) fridge storage location; and (3) taste testing sequence. The label will be on the bottom of the container to prevent violations of excludability. The randomization code for treatment, fridge storage location, and taste testing sequence is available in the appendix: I use complete random assignment for treatment and a random number generator corresponding to fridge location and taste-test sequence for the latter two assignments. Since I will be the one applying treatment, I will be able to ensure and double-check that the randomization procedure was properly followed.

After treatment, the containers will be stored for two nights in one layer on two shelves in the middle portion of the fridge in their assigned locations to prevent violations of excludability. It is important to ensure that the containers remain in the middle portion as fridge temperature may vary in extreme areas of the fridge. Although temperature may vary from shelf to shelf, given the relatively small area of the fridge and the fact that the cold air is being blown up from the bottom back part of the fridge, it is more important to place the contained in the middle part. Prior to measurement, any oil, water or onion will be removed prevent violations of excludability.

Samples will be tasted and scored by a blinded assistant according to the predetermined randomized sequence. Assistant will be blindfolded to score avocado taste, texture, and smell, then the blindfold will be taken off so assistant can score avocado color. Blindfolding the assistant is essential as avocado color can potentially influence taste. Additionally, the assistant will drink a sip of lime water as a palate cleanser before each taste to prevent violations of non-interference and ensure symmetry between measurements.

Outcomes and Hypothesis

I wish to assess five outcome variables and test five hypotheses:
- Color of avocado (green=5; brown=0)
- Greasiness of avocado (none=0; extremely=5)
- Sliminess of avocado (none=0; extremely=5)
- Smell of avocado (none=0, very smelly=5)
- General taste of avocado (bad=0; fresh=5)

Hypothesis 1:

- All treatments should yield a positive ATE. Parisi's (2017) test on half-cut avocados concluded that adding an onion yields the greenest avocado; this method should perform similarly for mashed avocado. Thus, T3 should yield the highest ATE for this outcome.

Hypothesis 2:

- The oil treatment has the potential to impart greasiness on the avocado, so T1 should yield a positive ATE for this outcome while the other treatments should not have an effect.

Hypothesis 3:

- According to Butler (2014), adding water can cause avocado to be slimy. Thus, the treatment effect of T2 should be positive for this outcome while the other treatments should not have an effect.

Hypothesis 4:

- The presence of an onion may impart a smell on the avocado. Thus, the treatment effect of T3 should be positive for this outcome while the other treatments should not have an effect.

Hypothesis 5:

- According to Parisi (2017), storing avocado with a cut onion yields the best-tasting avocado. It is unlikely, however, that the other treatments will yield better-tasting avocado than the control due to anticipated positive treatment effects on greasiness and sliminess. Thus, for general taste of avocado, the treatment effect of T3 should be positive while treatment effects of T1 and T2 will be negative.

Analysis

This experiment will not involve any pre-tests or covariate adjustment as random assignment will be well-established through mixing of the avocado.

I will be estimating the ATE of the three treatments using the standard difference-in-means estimator for each treatment separately versus control and for all treatments relative to control to establish if any treatment has an effect at all. I will use randomization inference to test one-tailed hypotheses at the 95% level for all outcome besides Outcome 5: general taste of avocado. For the first four outcomes, the direction of the effect we wish to test is relatively clear: treatment should either increase or improve greenness, greasiness, sliminess or smelliness of avocado relative to the control. However, given positive effects on greasiness, sliminess, or smelliness, it is likely that treatment could affect Outcome 5, the general taste of the avocado, negatively. If so, we wish to discern this effect so that we can rule out the treatment as not only ineffective but detrimental to overall outcomes. As a result, I will conduct a two-tailed hypothesis test on Outcome 5.

Discussion of Assumptions

The risk of attrition or non-compliance is low: subjects are inanimate and the storage location is a relatively empty fridge that will be used by only myself and my assistant. Two entire fridge shelves will be dedicated to storage of the subjects. There should be no issues with randomization as long as it is executed diligently and double-checked.

Non-interference and excludability violations may occur, however. My assistant's scoring of outcome variables may vary if he has knowledge of treatment, and to prevent violations of excludability, my assistant will have no knowledge of assignment and I remove as much semblance of treatment as possible prior to the taste test. To prevent spillover effects and ensure symmetry between measurements, my assistant to take a sip of lime water as a palate cleanser prior to each taste.

References

Butler, G. (2014). How to keep avocados from turning brown: We put 5 popular methods to the test. Retrieved November 3, 2019, from https://www.oregonlive.com/cooking/2014/10/keeping_avocados_from_turning.html

Dorantes-Alvarez, L., Parada-Dorantes, L., Ortiz-Moreno, A., Santiago-Pineda, T., Chiralt-Boix, A., & Barbosa-Cánovas, G. (1998). Effect of anti-browning compounds on the quality of minimally processed avocados. *Food Science and Technology International*, *4*(2), 107–113. https://doi.org/10.1177/108201329800400205

Parisi, G. (2017). How to keep avocado fresh and green. Retrieved from https://www.today.com/food/how-keep-avocado-fresh-green-t106987

Appendix

Randomization Code

```
rm(list=ls())        # clear objects in memory
set.seed(220288)    # random number seed, so that results are reproducible
library(foreign)     # package allows R to read Stata datasets
library(dplyr)
library(ri2)         # need this to do complete_ra
library(randomizr)


#Create dataframe of numbered container
assign <- data.frame("containers"=1:32)


#Random assignment of treatment
assign$treat <- complete_ra(32,m_each=c(8,8,8,8)) #T1-3 will be treatment; T4
will be control


#Random assignment of location
assign$loc <- sample(1:32, 32, replace=F)


#Random assignment of taste-test. 1: first sample; 32: last sample.
assign$tt <- sample(1:32, 32, replace=F)
```

Random assignment of location corresponds to the map of the fridge shelf below:

Higher shelf assignments

Back	1	2	3	4	5	6	7	8
Front	9	10	11	12	13	14	15	16

Lower shelf assignments

Back	17	18	19	20	21	22	23	24
Front	25	26	27	28	29	30	31	32