Avocado Storage

POLS 4768 Practicum

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Introduction and Overview

This study aims to determine the most effective method of storing and preserving avocado. Three methods—storing avocado in oil, water, and with a cut onion—seem to be the most commonly recommended amongst cooking and housekeeping publications (Butler, 2014; Parisi, 2017). To ensure a robust test of these methods, I conducted a randomized experiment with the above three avocado storage treatments and assessed outcome variables of color, greasiness, sliminess, smell and taste.

Design and Outcome Measures

My subjects and units of analysis were 32 single serving-sized samples of extracted, mashed, and mixed ripe avocado flesh. Ripe avocados were purchased one day in advance from the same Whole Foods Grocery store. This ensured a representative sample of conventionally purchased albeit relatively high-quality avocados.

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

Each container was labelled and randomly assigned to: (1) treatment; (2) fridge storage location; and (3) taste testing sequence. After treatment, the containers were stored for two nights in one layer on two shelves in the middle portion of the fridge in their assigned locations. As much oil, water or onion as possible was removed prior to measurement.

Samples were tasted and scored by a blinded assistant according to the predetermined sequence. The assistant was blindfolded to score avocado taste, texture, and smell, then the blindfold was taken off so the assistant could score avocado color. Additionally, the assistant drank a sip of lime water as a palate cleanser before each taste.

This study assessed five outcome variables and tested five hypotheses:

Outcome variables:
- Color (green=5; brown=0)
- Greasiness (none=0; extremely=5)
- Sliminess (none=0; extremely=5)
- Smell (none=0, extremely=5)
- Taste (bad=0; fresh=5)

Hypothesis 1: Color
- All treatments should yield a positive ATE, with T3 yielding the highest ATE.

Hypothesis 2: Greasiness
- T1 should yield a positive ATE for this outcome while the other treatments should not have an effect.

Hypothesis 3: Sliminess
- Treatment effect of T2 should be positive for this outcome while the other treatments should not have an effect.

Hypothesis 4: Smell
- Treatment effect of T3 should be positive for this outcome while the other treatments should not have an effect.

Hypothesis 5: Taste
- The treatment effect of T3 should be positive while treatment effects of T1 and T2 will be negative.

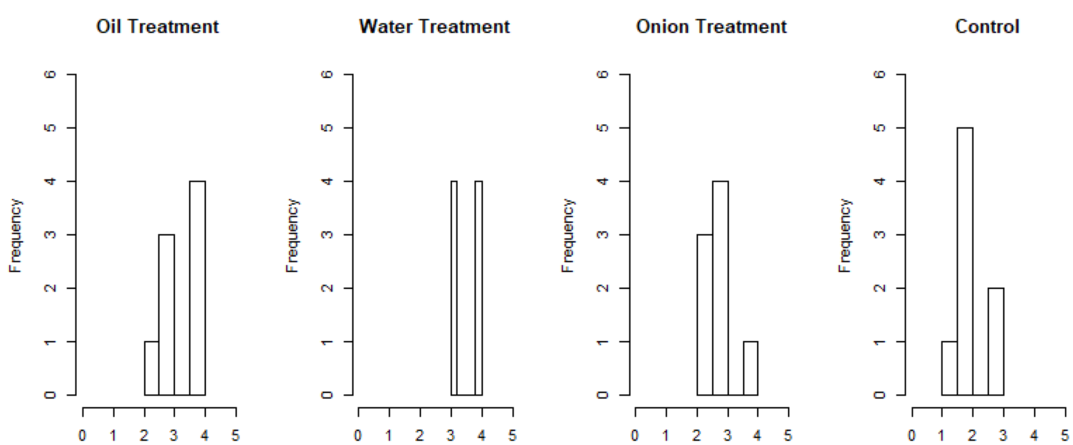
Review of Core Assumptions

Risk of attrition or non-compliance was low: subjects were inanimate and storage location was a relatively empty fridge that was used by only myself and my assistant. The process of extraction, mashing and mixing avocados ensured randomization of avocado characteristics across the purchased avocados. Randomization was executed diligently and double-checked.

Non-interference and excludability violations could occur, however. My assistant's scoring of outcome variables could have varied if he had knowledge of treatment, and to prevent this, my assistant was blinded from assignment and I removed as much semblance of treatment as possible prior to the taste test. To prevent spillover effects and ensure symmetry between measurements, my assistant took a sip of lime water as a palate cleanser prior to each taste. Additionally, I blindfolded my assistant to ensure avocado color did not influence taste.

Results

Color (green=5; brown=0)



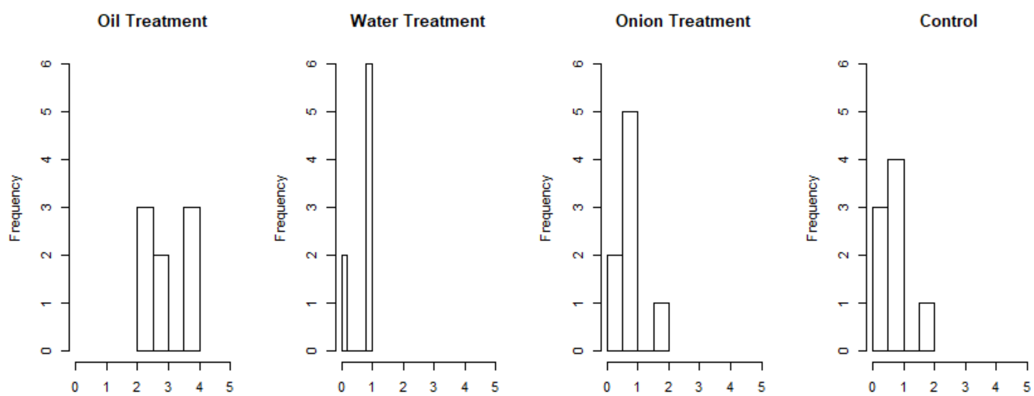
Color

	Oil	Water	Onion	All Treatments
ATE	1.25*	1.38*	0.63	1.08*
Standard Error	0.33	0.29	0.33	0.29
95% CI	[0.56, 1.88]	[0.75, 1.94]	[0.00, 1.25]	[0.50, 1.67]
P-value (Upper)	0.01	0.00	0.09	0.00
N	8	8	8	24

*Significant at 5%

Treatment had a significant positive effect on avocado color. On average, oil and water treatments improved color by 1.25 and 1.38 points respectively; these results are statistically significant using an upper-tailed sharp null hypothesis test at the 5% level. The onion treatment did improve color by 0.63 points on average but results are not statistically significant.

Greasiness (none=0; extremely=5)



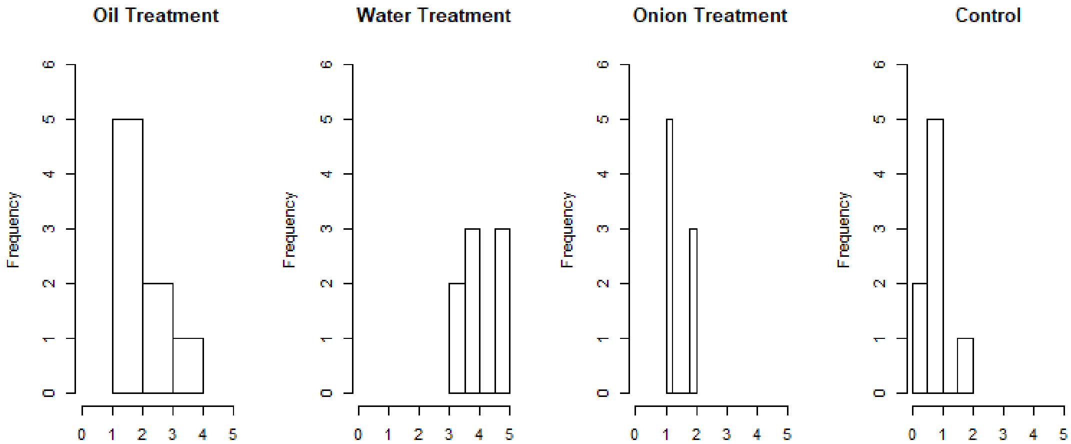
Greasiness

	Oil	Water	Onion	All Treatments
ATE	2.25*	0.00	0.13	0.79
Standard Error	0.35	0.35	0.35	0.47
95% CI	[1.50, 3.00]	[-0.50, 0.50]	[-0.50, 0.75]	[-0.12, 1.62]
P-value (Upper)	0.00	0.66	0.49	0.06
N	8	8	8	24

*Significant at 5%

Oil treatment increased greasiness by 2.25 points on average. This effect is statistically significant using an upper-tailed sharp null hypothesis test at the 5% level. Water and onion had little effect on greasiness on average.

Sliminess (none=0; extremely=5)



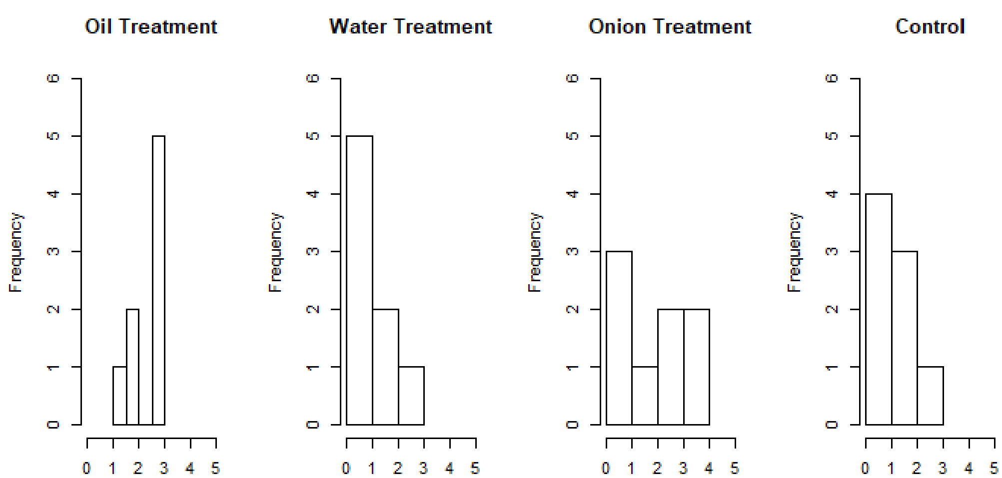
Sliminess

	Oil	Water	Onion	All Treatments
ATE	1.13*	3.25*	0.50	1.63*
Standard Error	0.47	0.35	0.29	0.52
95% CI	[0.25, 2.03]	[2.5, 3.94]	[0.00, 1.00]	[0.52, 2.58]
P-value (Upper)	0.03	0.00	0.11	0.00
N	8	8	8	24

*Significant at 5%

Treatment had a significant positive effect on sliminess. On average, oil and water treatment increased sliminess by 1.13 and 3.25 points respectively; these results are statistically significant using an upper-tailed sharp null hypothesis test at the 5% level. Onion increased sliminess by 0.50 on average but this effect was not significant.

Smell (none=0, very smelly=5)

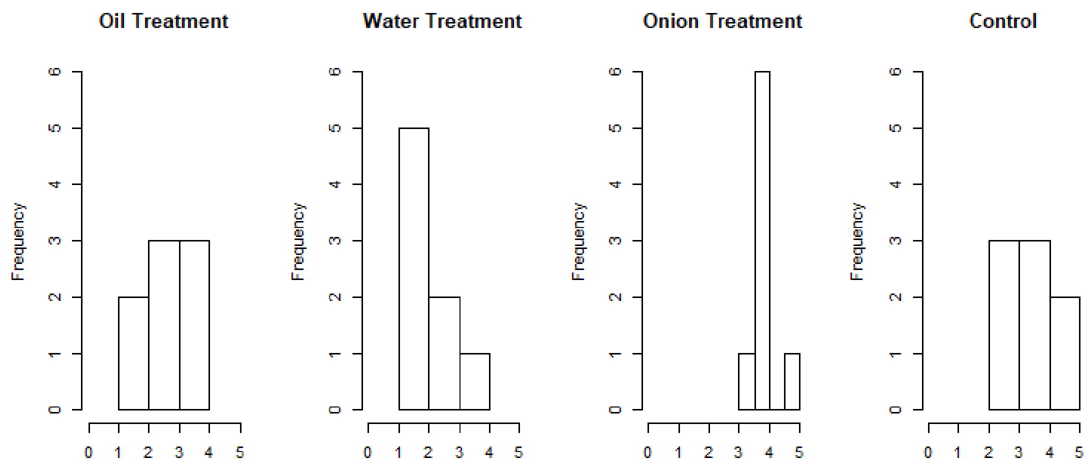


	Smell			
	Oil	Water	Onion	All Treatments
ATE	1.25*	0.13	0.75	0.71
Standard Error	0.49	0.51	0.74	0.49
95% CI	[0.25, 2.25]	[-0.78, 1.03]	[-0.63, 2.19]	[-0.23, 1.65]
P-value (Upper)	0.03	0.52	0.21	0.11
N	8	8	8	24

*Significant at 5%

Contrary to the initial hypothesis that onion would have a positive impact on smell, oil treatment instead increased smelliness by 1.25 points on average and was statistically significant using an upper-tailed sharp null hypothesis test at the 5% level. Onion did increase smelliness by 0.75 points on average, but this was not significant. On average, water increased smelliness only slightly.

Taste (bad=0; fresh=5)



	Taste			
	Oil	Water	Onion	All Treatments
ATE	-0.63	-1.5*	0.38	-0.58
Standard Error	0.54	0.55	0.44	0.49
95% CI	[-1.75, 0.41]	[-2.63, -0.38]	[-0.50, 1.25]	[-1.50, 0.33]
P-value (Two-Tailed)	0.41	0.03	0.58	0.26
N	8	8	8	24

*Significant at 5%

Unexpectedly, the water treatment had the most significant and substantial effect on taste, decreasing taste by 1.5 points on average. This effect is statistically significant using an upper-tailed sharp null hypothesis test at the 5% level. On average, oil also decreased taste, by 0.63 points. This effect is not statistically significant. Onion treatment improved taste over the control by 0.38 points on average but this effect was not significant.

Conclusion

While oil and water treatments seem to improve avocado color on average, these treatments also increase the greasiness, sliminess, smell, and taste of the avocado. On the other hand, using the onion treatment does improve color on average without negatively affecting other outcome variables, although the effect was not statistically significant. When considering preservation methods, individuals should consider the relative importance of avocado color to other characteristics given their purposes and select a method accordingly. If all of the above characteristics are important, individuals may consider using the onion treatment, since it did not significantly worsen greasiness, sliminess, smell, or taste, and may improve color over the control.

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

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

Appendix 1: 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

Appendix 2: Analysis Code

Note: Analysis Code can be found on my OSF page as ‘Practicum Analysis.R’. Dataset is also available on my OSF page as ‘Practicum Results-Final.csv’.

```
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(ri)

library(randomizr)


setwd("C:/Users/jacqw/Documents/Columbia/Spring 2019/POS 4768
Experiments/Practicum")

results <- read.csv("results-final.csv")

names(results) <-
c("containers","treat","loc","tt","Greasiness","Sliminess","Smell","Ta
ste","Color")


#Distribution of Individual Outcomes

##Greasiness

par(mfrow=c(1,5))

hist(results[results$treat=="T1",]$Greasiness,main="Oil
Treatment",ylim=c(0,6),xlim=c(0,5),

     xlab="")

hist(results[results$treat=="T2",]$Greasiness,main="Water
Treatment",ylim=c(0,6),xlim=c(0,5),

     xlab="")

hist(results[results$treat=="T3",]$Greasiness,main="Onion
Treatment",ylim=c(0,6),xlim=c(0,5),

     xlab="")

hist(results[results$treat=="T4",]$Greasiness,main="Control",ylim=c(0,
6),xlim=c(0,5),
```

```
    xlab="")


##Sliminess

par(mfrow=c(1,5))

hist(results[results$treat=="T1",]$Sliminess,main="Oil
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T2",]$Sliminess,main="Water
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T3",]$Sliminess,main="Onion
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T4",]$Sliminess,main="Control",ylim=c(0,6
),xlim=c(0,5),

    xlab="")


##Smell

par(mfrow=c(1,5))

hist(results[results$treat=="T1",]$Smell,main="Oil
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T2",]$Smell,main="Water
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T3",]$Smell,main="Onion
Treatment",ylim=c(0,6),xlim=c(0,5),

    xlab="")

hist(results[results$treat=="T4",]$Smell,main="Control",ylim=c(0,6),xl
im=c(0,5),

    xlab="")


##Taste
```

```
par(mfrow=c(1,5))

hist(results[results$treat=="T1",]$Taste,main="Oil
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T2",]$Taste,main="Water
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T3",]$Taste,main="Onion
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T4",]$Taste,main="Control",ylim=c(0,6),xl
im=c(0,5),

      xlab="")


##Color

par(mfrow=c(1,5))

hist(results[results$treat=="T1",]$Color,main="Oil
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T2",]$Color,main="Water
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T3",]$Color,main="Onion
Treatment",ylim=c(0,6),xlim=c(0,5),

      xlab="")

hist(results[results$treat=="T4",]$Color,main="Control",ylim=c(0,6),xl
im=c(0,5),

      xlab="")


results <- within(results, treat <- relevel(treat, ref = "T4"))

results <- results %>% mutate(treat_all=ifelse(treat=="T4",0,1))


#ATE, SE, CI, RI test
```

```
results <- results %>% mutate(treat_x=ifelse(treat=="T1",1,
                                           ifelse(treat=="T2",2,
                                           ifelse(treat=="T3",3,4))))


# RI
##Individual Treatment
Treatment <- 3 ###change this for each treatment
Variable <- 'Taste' ###change this for each outcome variable
X <- results %>% select(treat_x) %>% filter
(treat_x==Treatment|treat_x==4) %>%
mutate(treat=ifelse(treat_x==Treatment,1,0))%>%select(treat)
Z <- X[,1]
W <- results %>% filter (treat_x==Treatment|treat_x==4) %>%
select(Variable)
Y <- W[,1]


prob <- genprobexact(Z)
ate <- estate(Y,Z,prob=prob)


### CIs


perms <- genperms(Z=Z, maxiter = 1000)


Ys.est <- genouts(Y,Z,ate)
estdist <- gendist(Ys.est,perms,prob=prob,HT=FALSE)
dispdist(estdist,ate)
mean(estdist)
ate


### test sharp null
Ys.est <- genouts(Y,Z,ate=0)
```

```
estdist <- gendist(Ys.est,perms,prob=prob,HT=FALSE)

dispdist(estdist,ate,display.plot=TRUE)


#RI for all treatments

Variable <- 'Taste' ###change this for every outcome variable

X_all <- results %>% select(treat_x) %>%
mutate(treat=ifelse(treat_x==4,0,1))%>%select(treat)

Z_all <- X_all[,1]

W_all <- results %>% select(Variable)

Y_all <- W_all[,1]


prob_all <- genprobexact(Z_all)

ate_all <- estate(Y_all,Z_all,prob=prob_all)


### CIs


perms_all <- genperms(Z=Z_all, maxiter = 1000)


Ys.est_all <- genouts(Y_all,Z_all,ate_all)

estdist_all <- gendist(Ys.est_all,perms_all,prob=prob_all,HT=FALSE)

dispdist(estdist_all,ate_all)

mean(estdist_all)

ate_all


### test sharp null

Ys.est_all <- genouts(Y_all,Z_all,ate=0)

estdist_all <- gendist(Ys.est_all,perms_all,prob=prob_all,HT=FALSE)

dispdist(estdist_all,ate_all,display.plot=TRUE)
```