Open Bottle Storage:

Discovering Optimal Method to Preserve an Open Bottle of Grain Whisky

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Abstract

Our experiment is designed to discover the best method to maintain the taste of an open bottle of whisky in its initial bottle opening condition. There are many theories on how best to store an open bottle of whisky, but all are based on speculation. We tested 15 methods to prove the most efficient method. We used 6 bottles of bourbon and 6 bottles of a blended scotch. One sealed bottle each was set aside as the control. We poured the rest to create 28 specimens using in various methods to preserve the whisky. After a year in storage we had 4 tasters blind taste each method each against the control and rate how similar it was to the control. All scores for each method were then averaged together.

We found that the best method was to decant to 120 or 60 ml amber glass bottles right after the bottle was opened. Then storing those bottles upright in a dark temperature controlled environment was the most effective methodology since heat, light and headspace proved the most detrimental factors for whisky.

Other findings included the harmful effect of the commercial product, “Private Preserve.” The effects of vacuum sealing are still unknown and may actually be harmful. Further, exposing whisky to 90 minutes of air (“letting a whisky breath”) produced no discernable change whisky. Perceived changes in taste are therefore not in the whisky itself, instead the taster’s palate.

Introduction

Many whisky lovers have opened a bottle of whisky only to enjoy a few drams, and then put the rest of bottle away for another time. What is the ideal method to preserve the initial taste of that bottle of whisky? While there are many schools of thought on the subject, they come from the research done in wine or a chemistry class from ages ago. No one was able to provide a definitive “best” way to preserve the initial bottling condition of a whisky. Our experiment is designed to test the idea that decanting, vacuum sealing, and finally storing in a dark temperature controlled environment will prove to be the best method to preserve the initial taste of a freshly opened bottle of whisky.

Methods and Materials

After polling a panel of whisky experts and industry professionals we gathered a list of the most common storage methods and reasons why they might be the most effective:

- No Action: alcohol is very stable
- Cool Dark Place: to prevent light and temperature reactions
- Upright Bottle Position: to prevent cork degradation
- Argon Gas: to prevent oxidation
- Decanting: to prevent oxidation by removing headspace
- Paraffin Wax Seal: to create a barrier that would prevent oxidation and leaks
- Headspace Air Exposure Dependency: alcohol is pretty stable, but can oxidize given at least a 50% ratio of air to alcohol in bottle over a long enough period of time

As our objective is to find the "best" method to store an open bottle of whisky, we sought the storage method that produced the least measurable impact on the taste of the whisky. The goal being a stored whisky that was indistinguishable from the initial bottle opening condition.

We chose two types of whisky, a bourbon and a blended scotch as they are the most widely sold whiskies in the world. We purchased six bottles of a single barrel bourbon all from the same barrel, at the same store, and from a sealed case. This was the best we could to guaranteed that all six bottles would taste the same. The second class of whisky was a blended scotch. We bought six bottles at the same store, all from a sealed case.

We set aside one bottle each of scotch and bourbon in as close to a neutral environment as possible as controls to taste against later. Control bottles were kept seal intact, and then placed in a cardboard box to block light. That box was then stored in a temperature controlled environment between 23.5-25.5° C. The other bottles were opened and were stored in 27 different methods for one year.

No Action

We broke this down into a few specific methods. Method one would be to mimic what many people might do at home. We opened a full 750 ml bottle of whisky and poured out 30 ml every month over the course of a year (Appendix 1. Specimen #F and #S). Method two was an attempt to mimic the environment of a typical bar/home bar. We took a 750 ml bottle and filled with 150 ml of whisky, then left it on a shelf in indirect sunlight behind a double-paned glass window and two sheets of paper folded in half (Appendix 1. Specimen #N and #V). The third method was to see what happens to 180 ml of scotch poured out in a double old fashioned glass and exposed to open air for 90 minutes in a dark temperature controlled environment (Appendix 1. Specimen #M).

Cool Dark Place

We defined cool as a constantly temperature controlled environment between 23.5-25.5° C and dark we defined as being kept in a sealed cardboard box. We tested a bottle left under this condition by using a 750 ml bottle filled with 150 ml of whisky and keeping it in a dark temperature controlled environment (Appendix 1. Specimen #Q and #BB).

Upright Bottle Position

There were already ample studies that show alcohol will eat away cork so there was no need to repeat that study here.

Argon Gas/"Private Preserve"

While pure argon is attainable, it is not easy to obtain. Most people use a product called "Private Preserve." "Private Preserve" is a wine preserver that is a pure blend of nitrogen (N2), carbon dioxide (CO2) and argon (AR). To test this, we filled a 750 ml bottle with 150 ml of whisky and sprayed 15 second of "Private Preserve" inside (Appendix 1. Specimen #W and #T). We created an additional set of bottles that have also been vacuum sealed (Appendix 1. Specimen #H and #G). All bottles were stored upright in a dark temperature controlled environment to eliminate other variables.

Decanted

Decanted in this context would be to eliminate the headspace in a bottle by pouring whisky into a smaller bottle. While pouring into a single bottle just big enough to hold the remaining whisky left seems optimal, after further consideration it was not. This is because every time you take a pour to drink, you would need to decant what was left (yet again) to a smaller bottle. The optimal route would be to decant to bottles small enough to finish at one sitting, but large enough not to degrade the taste. We chose 120 ml amber glass round boston bottles with

polycone caps (Appendix 1. Specimen #U and #D). We also tried a 60 ml version that was also vacuum sealed (Appendix 1. Specimen #Y) to see if there was a difference in taste. Finally, all bottles were stored upright in dark temperature controlled environment to eliminate all other variables.

Paraffin Wax/Vacuum Seal

The goal of paraffin is to strengthen a seal. While paraffin wax is resistant to many substances including alcohol, it would only be a liquid barrier as paraffin permeable to gases. We replaced paraffin with an external vacuum seal which would create an airtight seal.

The method of vacuum sealing we used was primarily to create a perfect seal, not necessarily to remove air from within the bottle. (Although this might have occurred during the sealing process.) First we took a 750 ml bottle filled with 150 ml of whisky. Next the bottle was sealed with its regular cap. Then the entire bottle was placed into a "FoodSaver Bag" which was vacuum sealed with the "FoodSaver FM2000" (Appendix 1. Specimen #I and #A). We also tested the effectiveness of vacuum seals with the "Private Preserve" specimens (Appendix 1. Specimen #H and #G). Finally, all bottles were stored upright in a dark temperature controlled environment to eliminate other variables.

Headspace Air Exposure Dependency and Displacement

We tested the effects of varying headspace through several permutations. One was a 750 ml bottle filled with 325 ml of whisky (Appendix 1. Specimen #R and #B). Another set was with 120 ml amber glass round boston bottles with a polycone caps filled with 120 ml, 90 ml, 60 ml or 30 ml of whisky and then vacuum sealed (Appendix 1. Specimen #E, #AA, #C, #O, #K, #L, #X and #Z).

We thought of a new way to store whisky that would allow for very small pours and eliminate headspace. This method would be through displacement. We would have a 750 ml bottle filled with 325 ml of bourbon. Then we would add enough sanitized glass marbles to displace the air so the bottle would be effectively full (Appendix 1. Specimen #J).

Procedure: Tasting and ABV

After one year the ABV of key specimen were taken with an alcoholmeter right before tasting. Tasting was done blind on a separate floor segregated from where specimens were being prepared to mitigate potential contamination of tasters with sounds etc. Each bourbon specimen was tasted by the same panel of 4 people on the same day.

The day began by opening the control. Then 7 specimens were rated. A meal was given to reset each taster's palate. Then another 7 specimens were rated. Each specimen was poured into identical glassware. Each glass had the specimen label written upon the side. Specimens were brought out at a rate of roughly one every 3 minutes. This same procedure was done a week later in the same way to rate scotch specimens.

To rate each specimen each taster filled out a scorecard (Table 1). That scorecard had 3 parts that followed the general whisky rating format: nose, palate and finish. However instead of an overall letter grade, the taster marked where on the scale each part of a specimen would be categorized. This is because letter grades were too closely related to quality and we are not concerned with quality. We are concerned with differences in taste compared to the control.

Table 1. An example of a filled out specimen scorecard.

<#A>	Nose	Palate	Finish
Indistinguishable			
Vague hint of difference			X
Barely noticeable difference only if looking hard for one	X		
Slight difference, but not much		X	
Noticeable difference, but pretty close			
Noticeable difference, but passable			
Very noticeable difference			
Totally different			
I hate you making me try this			

Results

The scorecard of all tasters were merged together by specimen. Each mark was converted using a weighted point scale (Table 2). Then all scores for each storage method were averaged together (Table 3).

Table 2. Points assigned to each mark. Lower is better.

Mark to Point Conversion Scale	Point Value
Indistinguishable	0
Vague hint of difference	1
Barely noticeable difference only if looking hard for one	2
Slight difference, but not much	3
Noticeable difference, but pretty close	4
Noticeable difference, but passable	5
Very noticeable difference	7
Totally different	10
I hate you making me try this	14

Table 3. Average total score by storage method. Lower is better.

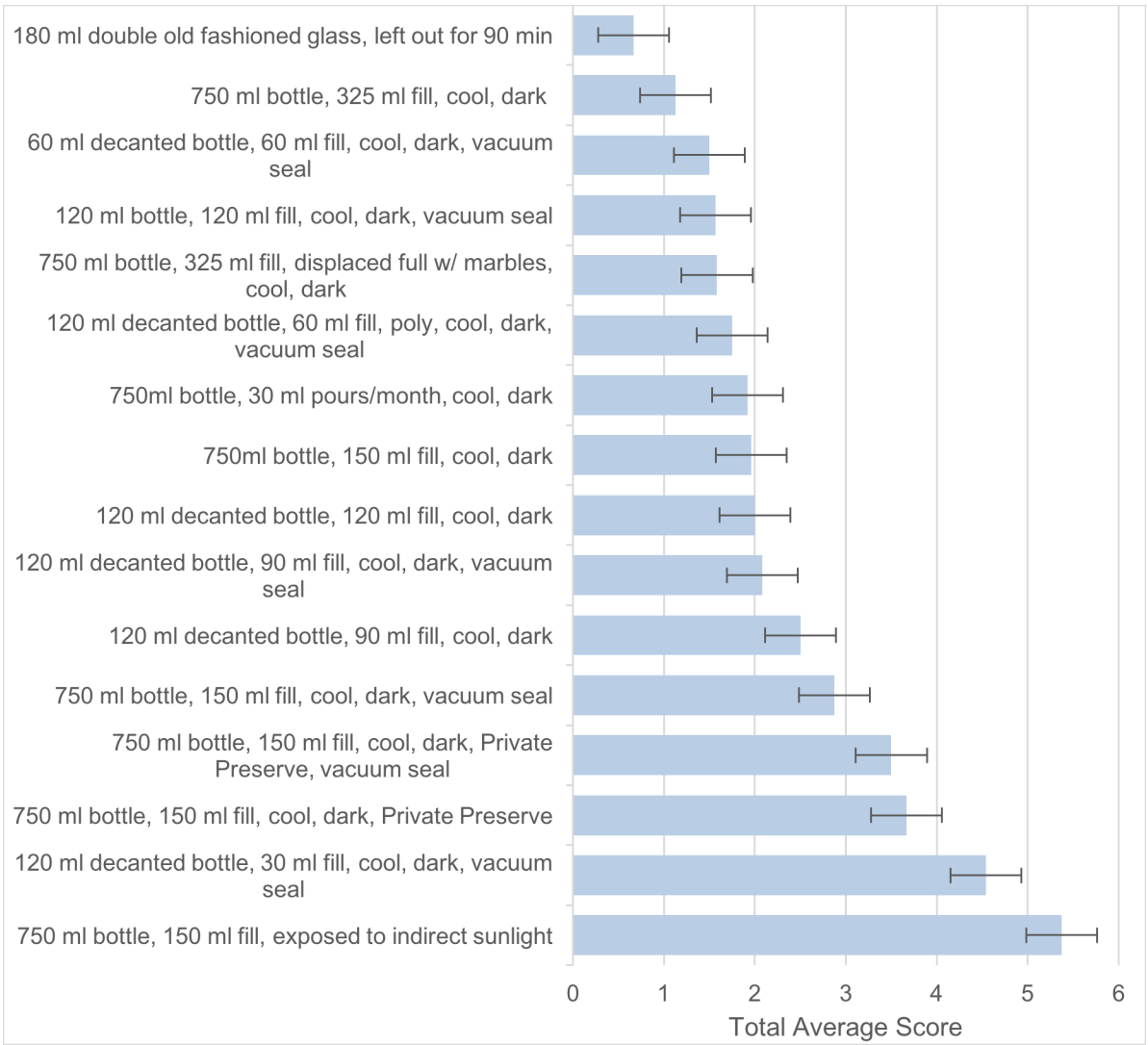
Specimen	Short Description	Total Avg	Nose Avg	Palate Avg	Finish Avg
V,N	750 ml bottle, 150 ml fill, exposed to indirect sunlight	5.38	5.13	5.88	5.13
Z,L	120 ml decanted bottle, 30 ml fill, cool, dark, vacuum seal	4.54	3.75	5.75	4.13
T,W	750 ml bottle, 150 ml fill, cool, dark, Private Preserve	3.67	3.75	3.75	3.50
G,H	750 ml bottle, 150 ml fill, cool, dark, Private Preserve, vacuum seal	3.50	3.00	3.75	3.75
A,I	750 ml bottle, 150 ml fill, cool, dark, vacuum seal	2.88	2.50	3.38	2.75
O	120 ml decanted bottle, 90 ml fill, cool, dark	2.50	1.75	3.00	2.75
P	120 ml decanted bottle, 90 ml fill, cool, dark, vacuum seal	2.08	1.50	2.25	2.50
D,U	120 ml decanted bottle, 120 ml fill, cool, dark	2.00	1.25	2.38	2.38
BB,Q	750ml bottle, 150 ml fill, cool, dark	1.96	2.00	2.13	1.75
S,F	750ml bottle, 30 ml pours/month, cool, dark	1.92	1.00	2.25	2.50
X,K	120 ml decanted bottle, 60 ml fill, poly, cool, dark, vacuum seal	1.75	1.13	2.13	2.00
J	750 ml bottle, 325 ml fill, displaced full w/ marbles, cool, dark	1.58	1.50	1.50	1.75
AA,C,E	120 ml bottle, 120 ml fill, cool, dark, vacuum seal	1.56	0.94	2.00	1.75
Y	60 ml decanted bottle, 60 ml fill, cool, dark, vacuum seal	1.50	1.00	1.75	1.75
B,R	750 ml bottle, 325 ml fill, cool, dark	1.13	1.25	1.25	0.88
M	180 ml double old fashioned glass, left out for 90 min	0.67	0.75	0.50	0.75

Next we established the standard deviation by comparing the average scores of #AA and #C which were identical samples held in identical storage methods. There was a deviation of

0.33 points on nose, 1.25 on palate and 0.25 on finish creating an average standard deviation of 0.39.

The findings support the best way to store an open bottle of whisky is to decant to 60 ml or 120 ml bottles, vacuum sealed, and stored in a dark temperature controlled environment (Figure 1). The difference between the two size bottles is 0.06 points which is well under the standard deviation and nearly everyone rated the two identically. There was also no detectable change in ABV among any of the specimens tested.

Figure 1. Average total score by storage method. Lower is better.



Conclusion and Discussion

Our initial hypothesis as to the best way to store an open bottle of whisky was to decant to smaller bottles to remove headspace, then vacuum seal, and finally store it in a dark temperature controlled environment. We were proved correct, however the displacement method we created gave nearly identical results (Table 3. specimen #J) with a difference of only 0.08 points. That is well under the standard deviation of 0.39. We do not suggest this method however, since fluid dynamics mean a bit too much whisky “sticks” to the marbles and between marbles used to displace the air.

The value of vacuum sealing is uncertain. In fact, it could actually be harmful to whisky. One set of data showed a benefit of 0.44 points. A different set yielded a degradation by -0.92. Yet another set showed a benefit of 0.17. While this gave us an average of -0.10 worse which is well under the standard deviation, with such far flung results no conclusion could be sensibly given. Further study must be done.

Removal of headspace in a bottle is clearly the winning strategy which should be applied in conjunction with storage upright in a dark temperature controlled environment. In 4/5 cases, methods with the least headspace were rated higher than similar methods with more headspace. There was an exception which was a 120 ml decanted bottle filled to 60 ml stored in a dark temperature controlled environment (Table 3. specimen #X, K). We are not certain why these particular specimens did slightly better than expected. We suspect that there was greater amount of change than reported, but that change made the whisky taste better so the amount of change was not reported correctly.

The finding show that keeping whisky upright in a dark temperature controlled environment is the single most import factor when storing an open bottle of whisky. It is the

difference between a whisky that has a “barely noticeable difference only if looking hard for one” (Table 3. specimen #BB, Q) to “noticeable difference but passable” (Table 3. specimen #V, N). It created the widest difference in taste by 3.42 points.

The result we were most surprised by was that “Private Preserve” actually degraded the whisky by a rather significant -1.63 points. This was so surprising that many did not believe it so we plan to redo this part of the study to see if the results are the same. We suspect that forceful injection of “Private Preserve” changed the equilibrium of the headspace or the esters on top of the whisky so drastically that in order to restore headspace equilibrium the whisky changed. Whether or not this theory is true is questionable but, you are certainly better off just keeping whisky in a dark temperature controlled environment without “Private Preserve.”

There is an idea prevalent in the whisky world that letting a whisky “open up” changes the flavor of the whisky (Table 3. specimen #M). According to our study it does not. It was close to indistinguishable at a mere 0.67 points. There is a chance that the control pour was sitting too long by tasters thus also “opening up” the control as well, but we are doubtful of this because the results are so closely aligned and the time elapse was so large. We think what happens when you let a whisky “open up” is the whisky remains virtually unchanged, but the taster’s senses are what have changed. This also brings up questions as to how strong of a force oxidation has on whisky. While oxidation may play a part in changing the taste of a stored whisky over time, we are skeptical that oxidation is the actual reaction that accounts for the major changes in taste of a stored whisky. We plan to do another study on this to further explore this concept.

The point at which to decant into smaller bottles is a tricky issue. A half empty bottle will remain very stable over the course of the year (Table 3. specimen #B, R) with a difference of only 1.13 points. Even a 4/5 empty bottle (Table 3. specimen #BB, Q) will remain relatively

stable with a difference of 1.96 if stored in a dark temperature controlled environment. However, each of those bottles were only opened twice; once to create the fill level and once for tasting. This would be equivalent to drinking 4/5 of a bottle the first night it was opened. Then a year later drinking the last 1/5. That is not how most bottles of whisky are consumed. Bottles are generally opened many times. Each time that bottle was opened there was slight degradation as shown by specimen #S, F (Table 3). Also if the bottle uses cork as a seal, the cork could be bad or even ruin the whisky by falling apart and being dissolved in the alcohol. If you plan to reopen an open bottle many times or are unsure of the quality of the cork, the best time to decant would be immediately after opening the bottle. This limits the number of times a bottle is opened to the smallest possible amount and mitigate any issues with cork.

It is clear that doing something to preserve an open bottle of whisky is a good idea. A bottle left out in indirect sunlight and slight temperature variation (Table 3. specimen #V,N) similar to a shelf at many bars is clearly harmful to whisky. It washes out the color and yielded a change in taste by 3.88 points. It was however not as quite bad as we suspected it would have been. This was surprising as well since many tasters noted that they have experienced tasting a new bottle of whisky that tasted good, but coming back to a previously opened bottle of whisky and having it taste “foul.” We have a few suspicions as to what would cause a stored whisky to taste foul. One possibility is exposure to significant heat during storage. The samples we used were only exposed to very moderate variations in temperature. Another possibility would be a bad cork. There is are a few variations we did not test for in this study. We did test a heavily peated whisky. There is a possibly that peated whisky reacts differently, as the scotch we used had almost no peat. We also did not test with a single malt scotch. There is a chance a single malt will matter since the scotch we used was a blend. A high ABV whisky was not tested either and a

higher ABV could change things. The whiskies we used were only at 40 ABV. We plan to test each one of these scenarios in the near future.

Our results provide the following guide for the preservation of whisky: If you do not plan to finish that bottle that quickly, or it is a special bottle that you want to preserve as perfectly as possible, or you are concerned about the quality of the cork, you should decant the remaining whisky immediately after opening a bottle and taking your initial pours. Decant the remaining bottle to 60 ml amber glass bottles with polycone caps and filling the bottle completely. If you do not have enough whisky left in the end to completely fill the final 60 ml bottle, find a bottle small enough that the remaining whisky would completely fill or drink it. I chose 60 ml bottles because they are small enough to easily finish at one time, yet not too small to make decanting difficult. Label them. Then keep those bottles in a dark temperature controlled environment.

If you plan to drink a freshly cracked bottle of whisky quickly enough that the bottle will be completely finished in under 1 or 2 months do not bother doing anything beyond keeping the bottle upright in a dark temperature controlled environment. The change would be minimal. So minimal most people would not be able to taste a difference.

Appendix I: Reference guide of all 28 storage methods employed and the raw average data.

Specimen Label	Description of specimen	Total Avg	Nose Avg	Palate Avg	Finish Avg
A	Scotch- 750 ml screw bottle, 150 ml fill, cool, dark, vacuum sealed	2.33	2.00	3.00	2.00
AA	Scotch- 120 ml decanted bottle, 120 ml fill, polycone cap, cool, dark, vacuum sealed	1.78	1.33	2.00	2.00
B	Scotch- 750 ml screw bottle, 325 ml fill, cool, dark	1.00	1.00	1.00	1.00
BB	Scotch- 750 ml screw bottle, 150 ml fill, cool, dark	1.75	1.50	2.00	1.75
C	Scotch- 120 ml decanted bottle, 120 ml fill, polycone cap, cool, dark, vacuum sealed	2.17	1.00	3.25	2.25
D	Scotch- 120 ml decanted bottle, 120 ml fill, polycone cap, cool, dark	2.25	1.25	2.75	2.75
E	Bourbon- 120 ml decanted bottle, 120 ml fill, polycone cap, cool, dark, vacuum sealed	0.75	0.50	0.75	1.00
F	Bourbon- 750 ml cork bottle, 30 ml pours/month cool, dark	2.17	1.25	2.50	2.75
G	Scotch- 750 ml screw bottle, 150 ml fill, cool, dark, Private Preserve, vacuum sealed	2.50	2.50	2.75	2.25
H	Bourbon- 750 ml screw bottle, 150ml fill, cool, dark, Private Preserve, vacuum sealed	4.50	3.50	4.75	5.25
I	Bourbon- 750 ml screw bottle, 150 ml fill, cool, dark, vacuum sealed	3.42	3.00	3.75	3.50
J	Bourbon- 750 ml screw bottle, 325 ml fill, displaced full with marbles, cool, dark	1.58	1.50	1.50	1.75
K	Bourbon- 120 ml decanted bottle, 60 ml fill, polycone cap, cool, dark, vacuum sealed	2.00	1.25	2.25	2.50
L	Bourbon- 120 ml decanted bottle, 30 ml fill, polycone cap, cool, dark, vacuum sealed	4.25	3.00	5.50	4.25
M	Scotch- 180 ml fill, double old glass left out for 90 min	0.67	0.75	0.50	0.75
N	Bourbon- 750 ml cork bottle, 150 ml fill, exposed to indirect sunlight	3.58	4.00	4.25	2.50
O	Bourbon- 120 ml decanted bottle, 90 ml fill, polycone cap, cool, dark	2.50	1.75	3.00	2.75
P	Scotch- 120 ml decanted bottle, 3oz fill, polycone cap, cool, dark, vacuum sealed	2.08	1.50	2.25	2.50
Q	Bourbon- 750 ml cork bottle, 150 ml fill, cool, dark	2.17	2.50	2.25	1.75
R	Bourbon- 750 ml cork bottle, 325 ml fill, cool, dark	1.25	1.50	1.50	0.75
S	Scotch- 750 ml screw bottle, 30 ml pours/month cool, dark	1.67	0.75	2.00	2.25
T	Scotch- 750 ml screw bottle, 150 ml fill, cool, dark, Private Preserve	2.75	3.25	2.75	2.25
U	Bourbon- 120 ml decanted bottle, 120 ml fill, polycone cap, cool, dark	1.75	1.25	2.00	2.00
V	Scotch- 750 ml screw bottle, 150 ml fill, exposed to indirect sunlight	7.17	6.25	7.50	7.75
W	Bourbon- 750 ml cork bottle, 150 ml fill, cool, dark, Private Preserve	4.58	4.25	4.75	4.75
X	Scotch- 120 ml decanted bottle, 60 ml fill, polycone cap, cool, dark, vacuum sealed	1.50	1.00	2.00	1.50
Y	Bourbon- 60 ml decanted bottle, 60 ml fill, polycone cap, cool, dark, vacuum sealed	1.50	1.00	1.75	1.75
Z	Scotch- 120 ml decanted bottle, 30 ml fill, polycone cap, cool, dark, vacuum sealed	4.83	4.50	6.00	4.00