Are Yolk Kidding Me?

1. Introduction

At some point in our lives, we have all most likely come across various kinds of kitchen gadgets—anything from vegetable choppers to strawberry stem removers. We wonder, do these tools actually work or are they more for fun and aesthetics? In our case, we conducted a controlled experiment to examine the efficiency of a certain type of egg yolk separator, as pictured below in *Figure 1*.

Figure 1. The type of egg separator we used.

2. Statistical Question

Is there a difference in the time it takes to separate egg yolks from whites when using an egg separator tool compared to the traditional method of using eggshells?

$H_0 : \mu_d = 0$

$H_a : \mu_d \neq 0$

Where μ_d is the true mean difference in time, in seconds, it takes to separate egg yolks from egg whites (egg yolk separator - eggshells).

3. Data Collection

While designing our experiment, the first factor we considered was variability among eggs in general. At the most basic level, this would be variability in the type of egg, which we eliminated by only using the Kirkland Signature Organic Large Eggs, Free Range. We also took note of differences between and within cartons of eggs, since eggs can vary in size of yolk and amount of white. For example, eggs with more whites may require more time to separate from the yolks, or larger yolks may be harder to juggle with eggshells. To account for this confounding variable, we used a matched pairs design by weight in grams. We assigned and labeled all 60 eggs with a unique number from 1 through 60, then weighed each egg (see *Figure 2*). We recorded the weights on a spreadsheet and sorted them from smallest to largest, then paired the eggs based on those weights (two smallest eggs together, next two smallest eggs, etc.). The labeled numbers on the eggs helped us keep track of individual eggs in each pair.

Figure 2. Weighing each of the eggs.

After creating the matched pairs, we flipped a coin for one of the eggs in each pair to randomly assign it to one of the two treatments: heads was for the egg yolk separator and tails was for the eggshells. The remaining egg in the pair would receive the other treatment. For the egg separator treatment, the person would crack the egg into the separator and then whirl it around until the white drained through the separator (see *Figure 3*). For the eggshell treatment, the person would use two eggshell halves to juggle the yolk and let the white separate and fall out (see *Figure 4*). Each of our treatment groups had 30 eggs.

Figure 3. The egg yolk separator treatment.

Figure 4. The eggshell treatment.

As we continued to crack the eggs, we would also expect to naturally get better at separating the yolks and whites, which could introduce some confounding into our experiment. However, our matched pairs design also balances out such confounding variables associated with natural improvement over time because we would be examining the difference in separating times between similar eggs that are cracked at around the same point in time, and theoretically, at the same skill level. We also controlled for confounding in skill level between people by having

the same person crack both of the eggs in each pair. This way, each egg was matched to another egg of similar weight and cracked by the same person. We had a total of two people crack all 60 eggs.

We collected the data by using a stopwatch to measure the separating time, in seconds, starting from the first crack of the egg to the last of the white separating from the yolk. Once we collected the raw data from all 60 eggs, we subtracted the time it took using eggshells from the time it took using the separator for each pair to find the difference.

Egg Number	Weight (g)	Pair (Small to Large)	Coin Flip	Treatment	Time (s)	Difference (S - E)
32	56.35	1	Heads	Yolk Separator	35.47	6.51
59	56.78		Tails	Eggshell	28.96	
57	57.08	2	Tails	Eggshell	33.25	-8.34
41	57.62		Heads	Yolk Separator	24.91	
24	58	3	Heads	Yolk Separator	33.79	-13.14
46	58.1		Tails	Eggshell	46.93	
44	58.18	4	Heads	Yolk Separator	26.53	1.16
30	58.27		Tails	Eggshell	25.37	
49	58.71	5	Tails	Eggshell	31.81	-6.34
39	58.75		Heads	Yolk Separator	25.47	
56	58.77	6	Heads	Yolk Separator	29.28	14.15
40	58.96		Tails	Eggshell	15.13	
37	59	7	Heads	Yolk Separator	22.48	-1.17
38	59		Tails	Eggshell	23.65	
47	59.25	8	Tails	Eggshell	21.38	-0.63
27	59.28		Heads	Yolk Separator	20.75	
43	59.44	9	Tails	Eggshell	21.67	4.35
42	60		Heads	Yolk Separator	26.02	
55	60	10	Heads	Yolk Separator	36.66	23.77
34	60.04		Tails	Eggshell	12.89	

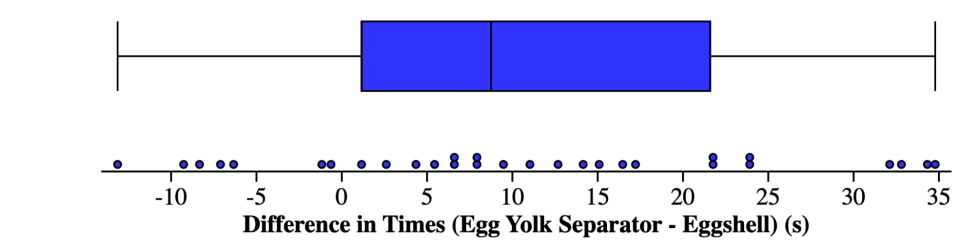
Figure 5. A snippet of our spreadsheet, showing the first 10 smallest pairs of eggs with their assigned numbers, recorded weights, random assignment of treatments, and recorded times.

4. Data Display

Egg Pair Number	Egg Yolk Separator Time (seconds)	Eggshells Time (seconds)	Difference (Egg Yolk Separator - Eggshells)
1	35.47	28.96	6.51
2	24.91	33.25	-8.34
3	33.79	46.93	-13.14
4	26.53	25.37	1.16
5	25.47	31.81	-6.34
6	29.28	15.13	14.15
7	22.48	23.65	-1.17
8	20.75	21.38	-0.63
9	26.02	21.67	4.35
10	36.66	12.89	23.77
11	37.89	13.83	24.06
12	46.66	12.33	34.33
13	25.72	23.11	2.61
14	53.31	40.63	12.68
15	21.28	20.44	5.44
16	32.22	41.34	17.22
17	32.96	49.79	34.79
18	36.93	43.63	21.93
19	18.83	11.00	7.83
20	34.73	28.04	6.69
21	24.37	13.34	11.03
22	35.54	19.07	16.47

23	13.30	20.41	-7.11
24	26.77	17.29	9.48
25	20.43	29.70	-9.27
26	28.76	20.74	8.02
27	45.89	13.08	32.81
28	32.90	11.30	21.6
29	31.63	16.54	15.09
30	47.54	15.42	32.12

Figure 6. A table with the data we collected.



Summary Statistics

n	mean	SD	min	Q_1	med	Q_3	max
30	10.605	13.484	-13.14	1.16	8.75	21.6	34.79

Figure 7. A box plot and dot plot illustrating the distribution of our data, as well as some summary statistics of the data.

5. Data Analysis

We will conduct a matched pairs t-test for a mean difference (μ_d) at a 0.05 significance level, if all conditions for inference are met:

1. *Random*: Each egg in a pair was randomly assigned to one of the two treatment groups with a coin flip.

2. *Independence*: Every pair of eggs is independent from another pair and has no effect on the separation of yolks and whites in another egg pair. We conducted an experiment, so we do not need to check the 10% condition.
3. *Normal/Large Sample Size*: Each treatment had a sample size of 30 eggs. Due to the Central Limit Theorem (CLT), sample sizes of 30 or greater can be assumed to have an approximately normal distribution. Because 30 eggs is greater than or equal to 30, our sample sizes are large enough to satisfy CLT and it is appropriate to carry out the inference procedure.

All conditions were met, so we conducted the t-test and obtained the following results:

$t = 4.308$

$p = 0.000172$

$df = 30 - 1 = 29$

6. Conclusion

Because our p-value of 0.000172 is less than the alpha level of 0.05, we reject the null hypothesis. We do have convincing evidence that the true mean difference in time, in seconds, it takes to separate egg yolks from egg whites (egg yolk separator - eggshells) is not 0. In other words, there is statistically significant evidence that there is a difference in the time it takes to separate egg yolks from whites when using an egg separator tool compared to the traditional method of using eggshells.

7. Reflection

Our experiment compared the efficiency between one type of egg yolk separator gadget and the traditional method of using eggshells. After cracking and separating 60 eggs with 30 in each treatment, we were able to conclude a difference in the time it took to separate the eggs when using the egg yolk separator compared to using eggshells. We did not run into any major issues during data collection and all eggs were later consumed. In order to reduce confounding, we conducted a matched pairs test to balance out the effects of variables like default skill, egg sizes, and natural improvement. We realize that although the matched pairs design reduced many potential confounding variables, there are still flaws in our experiment.

Based on our conclusion, there is a chance that we made a Type I error, in which we would conclude that there is a difference in the separating times when there actually is not. We could reduce the probability of making a Type I error by lowering the significance level.

We recognize that the results of our study are only applicable to the specific egg separator brand that we used, and that a different kind may yield a different outcome. If we were to further pursue this study in the future, we could test out other brands and perhaps perform a one-sided test instead, where we test the alternative hypothesis that the separator is faster than the eggshell method. Our experiment also only applies to the specific size and brand of eggs we used. While we only used large eggs in the study, we could experiment with small, medium, or extra large sized eggs to determine if one treatment is faster than the other for certain sized eggs by comparing p-values between identical experiments with different egg sizes.

In addition, during the data collection, we noticed that using the separator includes the time it takes to place the eggshells aside after cracking. However, this increase in time would only be around two seconds at most and thus, not large enough to affect the outcome of our

results, although our p-value would be slightly larger. In fact, if it were calculated, even a five second discrepancy would still result in a significant outcome.

Because we found convincing evidence of a difference, we can perform a follow up to estimate the actual time itself using a one-sample t-interval for μ_d at 95% confidence. The conditions are all met because they are the same as the t-test, so we went ahead with the inference procedure to obtain an interval of (5.57, 15.64). We are 95% confident that this interval captures the true mean difference in time it takes to separate egg yolks from whites when using the separator versus eggshells. If we were to draw a conclusion about the efficiency of the separator compared to eggshells, we can observe that since all the values in our interval are positive, there is convincing evidence that the separator takes a longer time than eggshells, and is thus, not as efficient. All in all, for greater efficiency, we would recommend saving money and using the trusty eggshell method.