A Comparative Analysis on the Effectiveness and Cost of Homemade Calamansi (Citrofortunella microcarpa)-Vinegar Solution and Commercially-Known Fabric Softener

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Abstract

Most of the time, customers look for alternative solutions or home trends to lower their weekly costs. Some people switch to natural methods of reducing environmental chemical exposure. This study compared commercial fabric softener pods with a homemade calamansi (Citrofortunella microcarpa) -vinegar solution to determine whether the product was more effective and cost-efficient in the long run. The experiment was carried out by comparing the odor and cloth softness of the two solutions. The effectiveness and cost-efficiency of each were determined by the researchers. The commercially available and homemade fabric softeners were compared using a Likert scale in survey form. Additionally, SPSS was utilized to examine the outcomes. According to the study, the do-it-yourself solution is a less expensive option for fabric softeners than commercially available ones, providing similar results. However, additional research and modifications are required to make the homemade remedy effective. At par with the readily available commercial fabric softener, if not superior. The collected information and study findings would aid consumers in determining whether to use fabric softeners that are still being used or use the Calamansi-Vinegar solution that is commercially available and would enable additional studies to be done by other academics.

Keywords
Calamansi-Vinegar Solution, Cost-Efficient, SPSS, and Likert scale.

1. Introduction
Fabric Softeners are one of the things that users usually use in doing laundry, not only does it make the clothes smell good and remove odors, but it also makes clothes wrinkle-free and smooth. Currently, there are three types of fabric softeners - liquid, dryer sheets, and dryer balls. Liquid fabric softeners are much more expensive than sheets and balls. According to (Stessman 2019), a downside to that is that it contains a lot of chemicals. There is no study done yet on whether calamansi-vinegar solution as fabric softeners are an effective alternative to commercial softeners but as two separate subjects, it is already proven.

According to an article by Nunez, K. (2020), vinegar kills bacteria and prevents yeast from growing in fabric. Not only that, but it also removes stains and softens the fabric's texture and scent that does not stick when used in the fabric. Meanwhile, calamansi helps remove stains as well and can be used for its scent. Therefore, it is possible to

conduct this experiment. There is also an existing study about the citrus-vinegar solution as a disinfectant cleaner, specifically orange peel-vinegar solution entitled "Feasibility of Vinegar and Orange Peel to produce organic cleaner" by Magbuhat, A. et al. (2019).

Users and customers nowadays switch to greener alternatives in using products in order to save and take care of the environment. In an article by Kantar World Panel (2021). 75% of Filipinos are actively looking for products that might help them reduce their environmental effect. More than half of Filipinos find it difficult to be environmentally conscious since alternatives are either harder to come by or more expensive. Despite these obstacles, many Filipinos claim to have noticed a change in their family and friends' behavior in this area. Fabric softeners are no different, and the best way to solve the problem is to create a green alternative for fabric softeners, especially because it contains harmful chemicals that may not only affect people but also the environment.

The study was motivated by a make-or-buy analysis between a commercially-known fabric softener and the calamansi-vinegar solution. On whether it is cheaper to make a fabric softener solution rather than buying what is already available and also to give consumers another option, especially those who want to be eco-friendly.

1.1 Objectives
The following are the objectives of the study:
1. To formulate the proportion of ingredients for the homemade solution.
2. To come up with an actual mixture of the solution.
3. To provide the solution to the respondents for them to use the same.
4. To let respondents answer the survey questionnaire and compare the solution and the commercially available fabric softener.
5. To statistically analyze data from the survey questionnaire.
6. To make conclusions and recommendations based on the analysis of data.

2. Literature Review
According to Fremer, E. (2020), many traditional cleaning products can be replaced with white vinegar as a cleaning agent. It's less expensive, creates less waste, and is better for the environment because, unlike dangerous chemicals, vinegar is non-toxic and has no long-term contaminating effects in water or the air. However, white vinegar may be used for more than just unclogging drains and cleaning windows. It can also be used to wash clothes. Using vinegar to wash clothes, results in softer-feeling laundry, eliminating the need for costly and environmentally problematic fabric softener. Because vinegar's modest acidity removes the residue left behind by alkaline soap, it has a similar effect when added to the laundry.

The odor that is detected may affect the consumer's perspective towards the product and the process so a fresh and non-toxic smell is a must. According to R. McQueen et al. (2020), the odor of clothes may influence how they are cleaned, forcing users to choose less environmentally friendly solutions than those for non-odorous apparel. To decrease odor, the user must employ tactics such as using varying temperatures of water and utilizing various household treatments.

According to an article by Lim, X. (2020) entitled "Do we know enough about the safety of quats?", quats or quaternary ammonium compounds are widely used in a lot of solutions that are mass produced (ex. disinfectants, cleaners, fabric softeners) but some scientists think that further research should be done and gather more data to determine how safe it is to use and what effects it has on the safety of the people.

According to TURI (2021), quats are a broad class of several hundred chemicals. It acts as an active ingredient in mouthwashes, disinfectants, wood preservatives, herbicides, eye drops, nasal sprays, detergents, shampoos, and fabric softeners. Ready-to-use products contain 0.8%-20% active QAC and industrial concentrates can contain 20-80% QAC. Fabric softeners contain no less than 50% of active QAC for them to be effective.

3. Methods
The research design that was used in this study is the comparative design. This design is going to determine the perception of the respondents to the important criteria for this study. The comparative research design aims to compare

the variables between the homemade solution and the commercially available softener and if it is going to have statistically significant differences between the criteria. The fabric softener was made by the researchers using calamansi peels and white distilled vinegar. The researchers then compare the homemade fabric softener to the commercially available softener through a series of tests to discover if the homemade softener can compete with the superior competition. The researchers assess the softness using a Likert scale, with 1 being the least soft and 7 being the softest. The same approach was utilized for the odor following the application of the calamansi-vinegar solution, with 1 being the "bad odor" and 7 being the "pleasant odor."
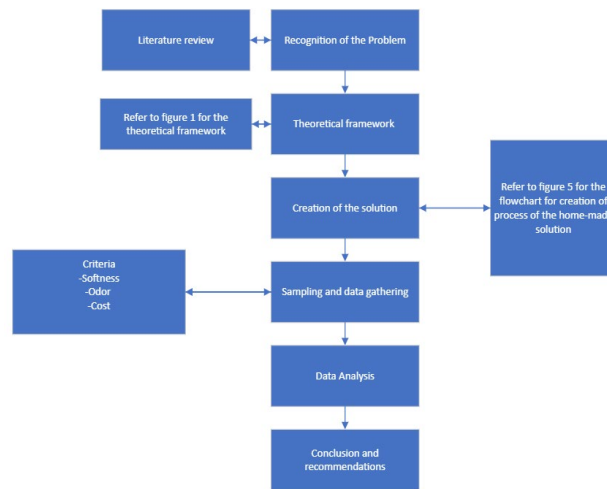

Figure 1. Research Design

The first step is to recognize the problem of the current use of commercially available fabric softeners, which is the negative effects of the production of these on health and its environmental effects. By recognizing the problems with the currently available fabric softeners the researchers can identify the issues that need to be addressed. With knowing the issues, the researchers can proceed with theoretical research that can create an alternative solution as a fabric softener.

For creating the homemade solution, a step-by-step process is provided. Meanwhile, for the data sampling and gathering of data, the researchers compute the sample size needed for the comparative analysis. After data sampling, the researchers start gathering data with the use of survey questionnaires that were answered after testing the homemade solution against the commercially available fabric softener. For the data analysis, the collected data from the respondents about their perception of the homemade solution and commercially available fabric softener gave the researchers the data needed if there are significant differences between the homemade solution and commercially available fabric softener about their effect on odor and softness of the fabric with the use of a statistical analysis technique called Wilcoxon rank-sign test.

Table 1. Data Measures of the Calamansi-Vinegar Fabric Softener

Variables	**Unit Of Measurement**	**Measuring Tool**
Softness	Scale (Likert)	Survey form
Odor	Scale (Likert)	Survey form

4. Data Collection

The process of gathering data involves looking for qualified respondents, ages between 18 to 60 years old that can wash their clothes or others' clothes once, twice, or thrice a week, washing clothes manually, and those who use fabric

softeners. that are currently residing in the Philippines. This is to assert the respondent's perception of the softness of the homemade solution and commercially available brand, as well as their preference for the odor. The questions are answered using a Likert scale. The respondents' perceptions were rated on a scale of 1 to 7, with 7 being the best perception and 1 being the lowest. The information would be contrasted with a brand of commercially accessible goods, Product Y. (Del). SPSS would be used to analyze the results using the Wilcoxon-Signed rank. The figure below shows the distribution process of the experiment.

Figure 2. Distribution Process
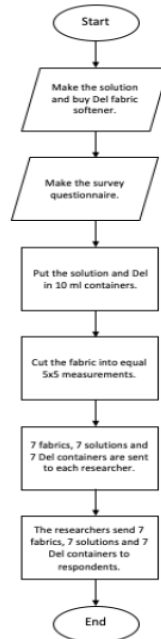
5. Results and Discussion

The results of the Wilcoxon-Signed Rank test show that the odor and softness data are statistically significant and based on the results, respondents gave Product Y higher rates compared to Product X, which means respondents prefer Product Y better. In the end, respondents were asked if Product X can be an alternative as a fabric softener, 91.2% of the respondents answered "yes" that this solution can be an alternative as a fabric softener. In addition to the results, it shows that respondents still gave a high rating for the effect of Product X on the fabric.
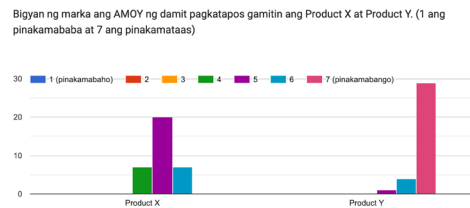
5.1 Numerical Results

Figure 3. Odor of the fabric upon using Product X vs Product Y

Using the Likert scale the perception of the respondents was determined by the odor of the fabric. From the raw results and after being analyzed, it is clear that the respondents found Product Y to be more fragrant than Product X.

Bigyan ng marka ang kalambutan ng damit pagkatapos gamitin ang Homemade
Calamansi-Vinegar Solution at ng commercial fabric softener. (1 ang pinakamababa at
7 ang pinakamataas)

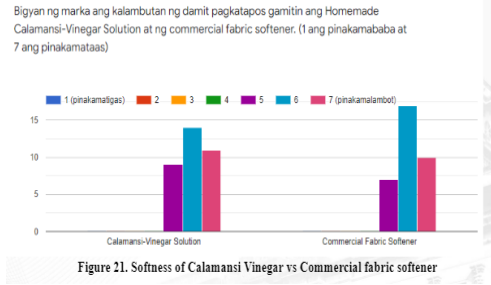**Figure 21. Softness of Calamansi Vinegar vs Commercial fabric softener**

Figure 4. Softness of the fabric upon using Product X vs Product Y

Using the Likert scale the perception of the respondents was determined by the softness of the fabric. Upon analyzing the raw data, more respondents answered that they found that Product Y was more effective than Product X based on the softness of the fabrics.
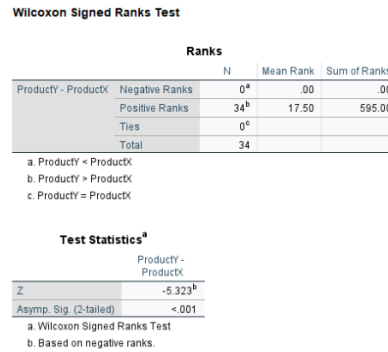
5.2 Graphical Results

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
ProductY - ProductX	Negative Ranks	0[a]	.00	.00
	Positive Ranks	34[b]	17.50	595.00
	Ties	0[c]		
	Total	34		

a. ProductY < ProductX
b. ProductY > ProductX
c. ProductY = ProductX

Test Statistics[a]

	ProductY - ProductX
Z	-5.323[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Figure 20. Wilcoxon-Sign rank test for Odor

Figure 5. Wilcoxon-Sign Rank test for Odor

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
ProductY - ProductX	Negative Ranks	0[a]	.00	.00
	Positive Ranks	14[b]	7.50	105.00
	Ties	20[c]		
	Total	34		

a. ProductY < ProductX
b. ProductY > ProductX
c. ProductY = ProductX

Test Statistics[a]

	ProductY - ProductX
Z	-3.742[b]
Asymp. Sig. (2-tailed)	<.001

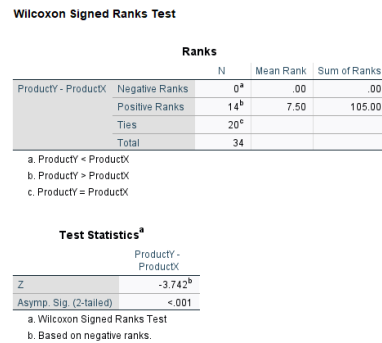a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Figure 6. Wilcoxon-Sign Rank test for Softness

Through survey form, the researchers gathered data from respondents about their perception of the odor of the homemade solution and the commercial brand. Through the use of the Wilcoxon-Signed rank test, the researchers determined that Product Y leads on the softness and odor test, and the computed results were statistically significant.

5.3 Proposed Improvements

The only components of the fabric softener considered in this investigation were calamansi and vinegar. Homestratosphere's Editorial Staff & Writers (2020) list baking soda as one of the ingredients that can be used in place of fabric softener since it may absorb odors and get rid of lingering scents from clothing. Epsom salt is another simple and potential money-saving option. Essential oils are a great alternative to traditional fabric softeners because of their all-natural makeup and lack of chemicals. After they use the homemade calamansi-vinegar solution, a follow-up survey or in-person interview may be undertaken to see if the researcher's solution has any implications. Add proposed improvements written here including additional numerical and graphical results.

5.4 Validation

Due to the limited studies that compare homemade fabric softeners and commercially available fabric softeners, it was difficult for the researchers to validate the results. However, this study has a goal to statistically compare the variables between the homemade softener and the commercially available fabric softener in their effect on the odor and the softness of the fabric through a Likert scale based on the perception and preference of respondents.

6. Conclusion

This study identifies the difference between the commercially available fabric softener to a homemade fabric softener to allow consumers and users of a fabric softener to choose either to make or buy. The results showed that the test on the odor and softness were statistically significant, which means the commercially available brand in these 2 criteria is more likely to be chosen by the consumers but based on the numbers that they gave in the Product X are also high which means it could still can be an alternative for a fabric softener.

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Biography

Renz Barrozo, Andrea Mendoza, Vinz Oliveros, Josiah Ramos, and Maximillian Yañez are 4th year students taking up BS in Industrial Engineering in the University of Santo Tomas.

Bionote

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Carlos Ignacio P. Lugay, Jr. is a tenured faculty member in the Department of Industrial Engineering, at the University of Santo Tomas. He has been with the University since November 1992. He earned his BSIE degree from the University of Santo Tomas in 1992. After this, he went to the University of the Philippines-Diliman and earned his MS IE Degree in 1999. While teaching and holding academic/administrative positions, he earned his Ph.D. Commerce degree from the University of Santo Tomas in 2015. He is a Professional Industrial Engineer and an ASEAN Engineer. His areas of specialization are Ergonomics and Operations Management. He has published and presented papers at local and international conferences/symposia.