

Iron Supplement Taste Acceptance in Orange Juice

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HMD 461

Embry

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## I. Introduction

Iron-deficiency is the most prevalent micronutrient deficiency in the world. (Miller, 2013). This can be caused by severe blood loss, low iron intake, and/or malabsorption of iron within the body. A severe deficiency of iron can lead to decreased hemoglobin synthesis, which is a main component of red blood cells. This lack of hemoglobin can cause a decrease in the size of red blood cells also known as microcytic anemia, which can lead to several adverse health effects. At-risk populations for iron deficiency anemia include infants, children, child-bearing aged women, pregnant women, and the elderly. (McLean et al., 2007).

Some of the causes of iron deficiency anemia are preventable, including low iron intake, and to some extent, the malabsorption of iron. Many individuals diagnosed with iron-deficiency anemia should be educated on different food sources of iron, but in some cases are prescribed an iron supplement. The most commonly available form of iron supplementation prescribed by practitioners is ferrous sulfate pills (SABM, 2020). The pill form of iron supplementation has a bitter and metallic taste that most people find unpleasant. Research has shown that ascorbic acid, also known as Vitamin C, can help increase the absorption of iron through foods or through supplementation. One research study found that sources of iron containing ascorbic acid have a significant increase in ferritin formation in the body (Lei, 2008).

Great sources of Vitamin C are citrus fruit juices, including orange juice. The purpose of this research study is to investigate if participants can detect liquid iron supplementation within orange juice and perceived sensory differences between standard orange juice and iron fortified orange juice.

## II. Literature Review

Iron-deficiency anemia is defined as a condition in which the hemoglobin content of the blood is lower than normal. There are many different causes of iron deficiency anemia including severe blood loss, low iron intake, or the malabsorption of iron by the body. Most of the preventable causes of low iron can be treated by incorporating more iron into a daily diet or by taking an iron supplement. The most common iron supplement is in the form of ferrous sulfate pills.

Iron absorption amongst at-risk groups seems to be an issue, as research has found that Vitamin C helps with both the absorption of iron and its stability (Berk, 2016). Unfortunately, two problems with iron supplements are the unacceptable taste and the GI side effects. This form of supplementation has a bitter and metallic taste that most people find unpleasant. (Forbes et al., 1989). Another issue with the absorption of iron through food is other food sources that inhibit iron absorption. One research study found that certain food fortifications can negatively affect iron absorption such as dietary fiber, phytic acid, and tannic acid (Cook, 2001). These certain elements in food can inhibit iron absorption, so it is generally recommended to take iron supplements on an empty stomach.

Research study completed in Brazil found that the use of iron-fortified orange juice was evident to reduce the prevalence of anemia, without side effects or acceptance problems of the product, this study included 50 preschool aged children (Almeida et al., 2002). Shah (2003) conducted a study that included 25 children between the ages of 3-6 years old, in which

participants were given orange juice and apple juice that had been supplemented with an iron during their breakfast. The study found that there was an evident increase in iron absorption with both the apple and orange juice. Median iron absorption from the meal ingested with apple juice was 7.17%. While median iron absorption from the meal ingested with orange juice was 7.78%. However, there was no documentation regarding the taste acceptance of the supplement drink by the participants within the study. (Shah, 2003).

### III. Methods

Research participants were recruited from Western Kentucky University's Hospitality Management Nutrition and Dietetics courses. Participants were offered a range of 3-10 extra credit points toward their semester grade upon completion of the study. Overall, 14 HMD students participated in the study, one of which whose research data was completed incorrectly and could not be recorded. Participants were asked to first complete a duo-trio test, then were asked to complete two likert scales: first the variable sample of orange juice with the iron supplement, then the control sample of just orange juice. Before beginning the experiment, participants were asked to read and sign a WKU Institutional Review Board approved informed consent document (See Appendix B).

This research experiment consisted of duo-trio testing to determine if liquid iron supplementation within orange juice could be accurately detected. The Duo-Trio method is particularly useful in determining whether product differences result from a change in ingredients, processing, packaging, or storage. It is also useful to determine whether an overall difference exists, where no specific attributes can be identified as having been affected (Meilgaard et al., 2006).

Within the Duo-Trio test participants were asked to try and match one of the two variables (Variable A and B) to the control sample orange juice (Appendix C). Variable B contained 3 ounces of orange juice with 1 teaspoon of liquid iron supplement dissolved in the orange juice, while variable A contained 3 ounces of orange juice. Participants were then asked to circle the variable that they believed matched the control. The participants were given a palate cleanser of saltine crackers and water as needed, in between the tastings in order for the data to be correctly represented (Singh-Ackbarali, et al, 2014).

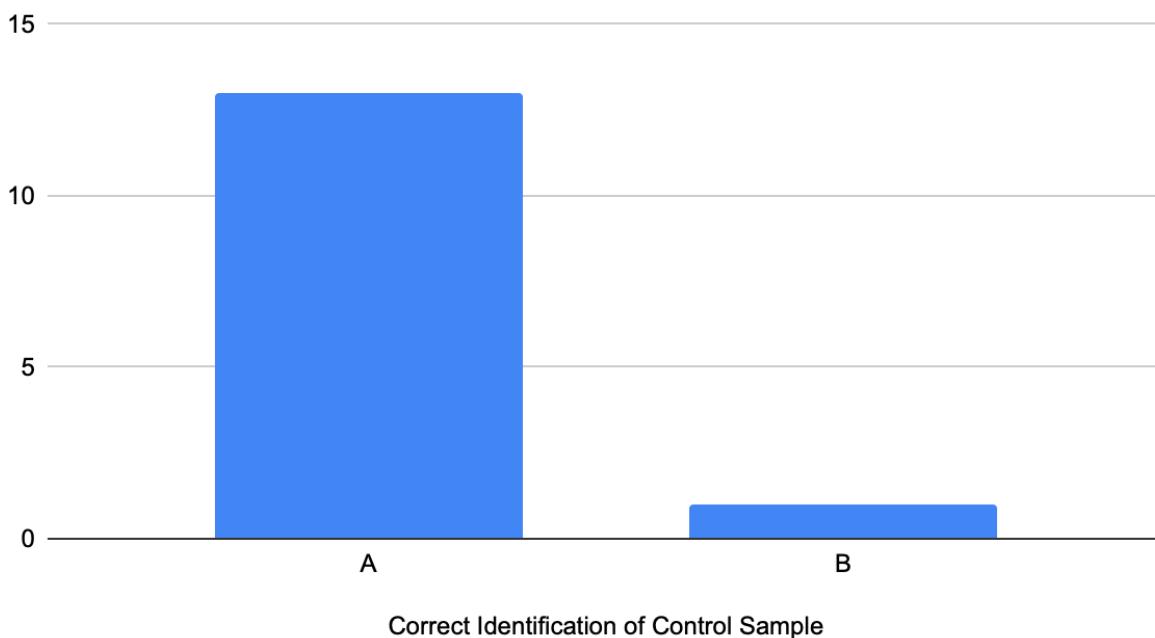
Participants then proceeded to the second part of the experiment. Participants were asked to complete a taste test of two different samples, then complete two separate likert scales (Appendix D). There were two separate likert scales for the participants to fill out. The first was for Sample #23, while the other was for Sample #27. Sample #23 contained the variable with the iron supplement and Sample #27 was the control which only contained orange juice. The findings from the two different scales demonstrated the participants' perception of both sample's appearance, aroma, taste, sweetness, and mouthfeel. The participants also had the opportunity to leave comments at the bottom of each scale. This research and its methods were evaluated and approved by the Institutional Review Board at Western Kentucky University. (See Appendix A).

#### IV. Results

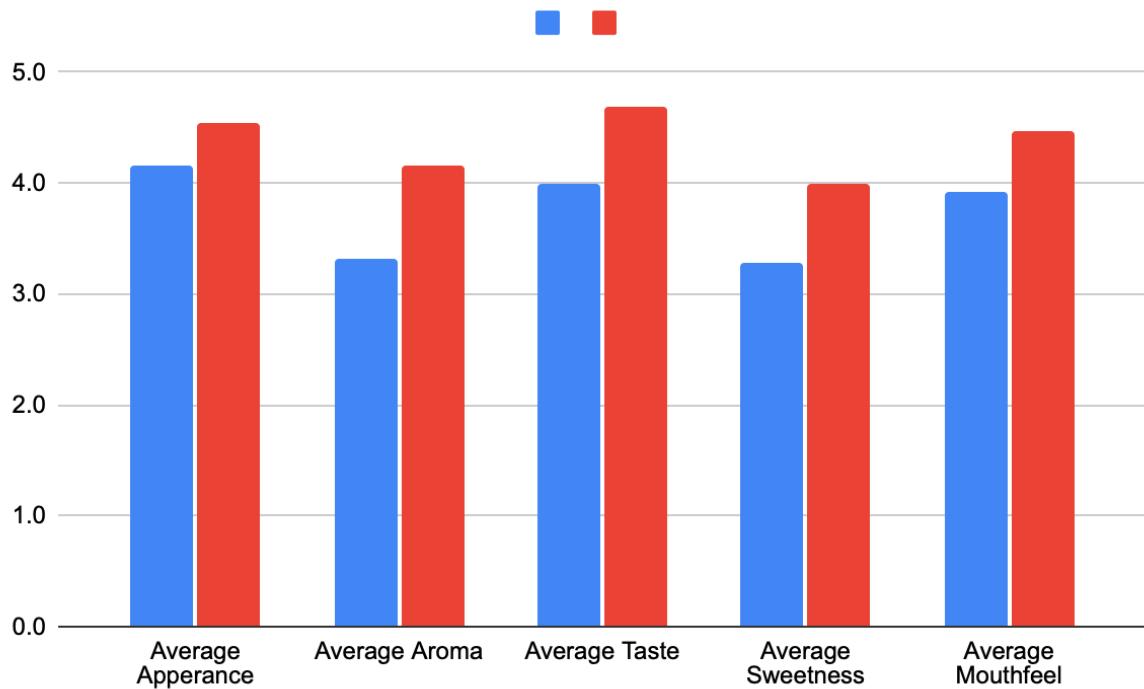
The results from the Duo-Trio testing were all around compelling. There were 14 participants within this experiment and out of the 14 participants, 13 participants were able to match the correct variable to the control. The control was unsupplemented orange juice, and the correct variable match was variable A. 13 participants chose Variable A to correspond with the control. This research found that there was a distinct flavor difference between Variable A and

Variable B. 93% of research participants were able to accurately detect the liquid iron supplement within the orange juice in a duo-trio test.

## Duo-Trio Test



The results from the two likert scales within the experiment were entered into a data sheet with a number scale. This scale ranges from 1 to 5, 5 corresponding to “Extremely Liked” and 1 being “Extremely Disliked”. Samples #23 and #27 were represented identically within the experiment. The participants were to evaluate the appearance, aroma, sweetness, and mouthfeel. #23 contained the orange juice with the supplemented iron, while #27 contained the regular orange juice. The average appearance of #23 was 4.2. The average aroma for #23 was 3.3. The average taste of #23 was 4.0. The average sweetness of #23 was 3.3. And finally, the average mouthfeel for #23 was 3.9. To compare to #27, the average appearance of #27 was 4.5. The average aroma was 4.2. The average taste of #27 was 4.7. The average sweetness of #27 was 4.0. The average mouthfeel of #27 was 4.5.



Comparing the data of Sample #23 and Sample #27 show that overall, Sample #27 ranked higher in appearance, aroma, taste, sweetness and mouthfeel. One unsuccesspecting confounding variable indicated by research participants was the noticeable aroma difference between the two samples. Although this research was focused on taste acceptance/detection, participants average ranking of Sample #23's aroma was almost an entire point lower than of Sample #27.

Some things that may have had an effect on research was that participants were not asked if they had ever been diagnosed with COVID-19 and had symptoms such as loss of taste and/or smell that could have had an effect on their sensory perceptions. If this had been included within the informed consent document, research participants who did not have taste or smell could have been excused from the study.

Also, if this research study had been conducted for longer and included more participants, a more well rounded and conclusive study could have been done on the taste acceptance/detection of liquid iron supplementation within orange juice.

In conclusion, research participants were able to perceive significant sensory differences between the standard orange juice sample and the iron fortified orange juice sample, as evidenced by the overall averages of Sample #27 being several points higher in the Hedonic Rating Scale/likert scales. This may or may not be indicative of the success of this form of supplementation acceptance in the future, as this is a limited study with few participants. The benefits of iron supplementation when paired with Vitamin C outweigh possible discomforts of sensory perception, but would only be more so if this were not the case. Therefore, there is a call for more research to be done in order to fill the knowledge deficit of iron supplementation acceptance when paired with Vitamin C.

## Appendix A



INSTITUTIONAL REVIEW BOARD  
OFFICE OF RESEARCH INTEGRITY

DATE: March 24, 2022  
TO: Autumn Evans  
FROM: Western Kentucky University (WKU) IRB  
PROJECT TITLE: [1872940-1] Iron Supplement Taste Acceptance in Orange Juice  
REFERENCE #: IRB# 22-230  
SUBMISSION TYPE: New Project  
ACTION: APPROVED  
APPROVAL DATE: March 23, 2022  
EXPIRATION DATE: May 29, 2022  
REVIEW TYPE: Expedited Review

Thank you for your submission of New Project materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a *signed* consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a MINIMAL RISK project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and

procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of May 29, 2022.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Robin Pyles at (270) 745-3360 or Robin.Pyles@wku.edu. Please include your project title and reference number in all correspondence with this committee.

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Generated on IRBNet

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Western Kentucky University (WKU) IRB's records.

## Appendix B

**INFORMED CONSENT DOCUMENT**

**Project Title:** Taste Acceptance of a Liquid Iron Supplement Within Orange Juice

**Investigators:** Allison Cook: [Allison.cook803@topper.wku.edu](mailto:Allison.cook803@topper.wku.edu); Haven Pitts:

[haven.pitts920@topper.wku.edu](mailto:haven.pitts920@topper.wku.edu); Autumn Evans:

[autumn.evans752@topper.wku.edu](mailto:autumn.evans752@topper.wku.edu); Dr. Ann Embry: [ann.embry@wku.edu](mailto:ann.embry@wku.edu)

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

**You must be 18 years old or older to participate in this research study.**

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** The purpose of this research is to gain a better understanding of the taste acceptance/rejection of a liquid iron supplement within a sample of orange juice.

2. **Explanation of Procedures:** You will be asked to participate in a duo-trio taste testing of 3 samples of orange juice.

Step #1: You are being asked to try 3 different samples of orange juice. After each individual tasting, you will be asked to eat a saltine cracker to cleanse your palate, and continue the taste test.

Step #3: After all three samples have been tried, you are to try and identify which sample is the same as the control, and which sample is the variable.

Step #4: After completion of the Duo-Trio Test, you will receive another saltine cracker.

Step #5: You are to then evaluate another sample of orange juice and rank the sample on aroma, appearance, taste, sweetness and mouthfeel. Participants can give the sample scores ranging from like a lot = 5, like a little = 4, neither like nor dislike = 3, dislike a little = 2, dislike a lot = 1.

Step #6: After completing the taste test please turn in all documentation to researchers. You



Witness

Date

- I agree to the audio/video recording of the research. *(Initial here)* \_\_\_\_\_

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES  
THAT THIS PROJECT HAS BEEN REVIEWED AND APPROVED  
BY  
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD  
Robin Pyles, Human Protections  
Administrator TELEPHONE: (270) 745-3360



WKU IRB# 22-230  
Approved: 3/23/2022  
End Date: 5/29/2022  
EXPEDITED  
Original: 3/23/2022

will receive conformation of their completion to receive extra credit for HMD 151.

3. **Discomfort and Risks:** Any known/unknown allergies to orange juice, or liquid iron supplement, saltine crackers.

4. **Benefits:** A better understanding of the taste acceptance of an iron supplement within orange juice, and extra credit for participants from HMD 151.

WKU IRB# 22-230
Approved: 3/23/2022
End Date: 5/29/2022
EXPEDITED
Original: 3/23/2022

5. **Confidentiality:** All electronic data collected will be kept on a password protected computer that only researchers have access to, and all physical copies of data will be kept in a locked filing cabinet in Dr. Ann Embry's office for 3 years following the completion of our project. No names/identifying information of participants will be linked to specific data. Only researchers will have direct access to individual data collected.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

*You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.*

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Signature of Participant

---

Date

## Appendix C

**Duo Trio Test****Name:** \_\_\_\_\_**Date:** \_\_\_\_\_

Please taste the CONTROL sample glass. Taste and evaluate the flavors. A saltine cracker and water will be provided in between tastings. Repeat this step for variable A & B. Circle the letter that is the same as the control.

**CIRCLE THE SAMPLE THAT IS THE SAME AS THE CONTROL**

If no difference is perceived, you must guess.

**Control**

Variable A      Variable B

## Appendix D

**Scorecard - Hedonic Rating Scale****Name:** \_\_\_\_\_**Date:** \_\_\_\_\_

**In front of you is one sample. Taste the sample and check ✓ how much you like or dislike each of the characteristics compared to the control. You can taste the sample more than once.**

Sample 23:

	Appearance	Aroma	Taste	Sweetness	Mouth feel
Extremely liked					

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Liked					
Neither liked nor disliked					
Disliked					
Extremely disliked					

Comments:

Sample 27:

	Appearance	Aroma	Taste	Sweetness	Mouth feel
Extremely liked					
Liked					
Neither liked nor disliked					
Disliked					
Extremely disliked					

Comments:

## References

*Citrus juice*. Citrus Juice - an overview | ScienceDirect Topics. (n.d.). Retrieved April 13, 2022, from <https://www.sciencedirect.com/topics/food-science/citrus-juice>.

Cook, J. D., & Reddy, M. B. (2001). Effect of ascorbic acid intake on nonheme-iron absorption from a complete diet. *The American Journal of Clinical Nutrition*, 73(1), 93–98. <https://doi.org/10.1093/ajcn/73.1.93>.

de Almeida, C. A., Crott, G. C., Ricco, R. G., Del Ciampo, L. A., Dutra-de-Oliveira, J. E., & Cantolini, A. (2003). Control of iron-deficiency anaemia in Brazilian preschool children using iron-fortified orange juice. *Nutrition Research*, 23(1), 27–33. [https://doi.org/10.1016/s0271-5317\(02\)00487-6](https://doi.org/10.1016/s0271-5317(02)00487-6).

E. McLean, I. Egli, B. de Benoist, and D. Wojdyla, “Worldwide prevalence of anemia in preschool aged children, pregnant women and non-pregnant women of reproductive age,” in *Nutritional Anemia*, K. Kraemer and M. B. Zimmermann, Eds., pp. 1–12, Sight and Life Press, Basel, Switzerland, 2007.

Forbes, A. L., Arnaud, M. J., Chichester, C. O., Cook, J. D., Harrison, B. N., Hurrell, R. F.,

Kahn, S. G., Morris, E. R., Tanner, J. T., & Whittaker, P. (1989). Comparison of in vitro, animal, and clinical determinations of iron bioavailability: International Nutritional Anemia Consultative Group task force report on Iron Bioavailability. *The American Journal of Clinical Nutrition*, 49(2), 225–238. <https://doi.org/10.1093/ajcn/49.2.225>

Lei J; Zhang MQ;Huang CY; Bai L; He ZH; (n.d.). *[effects of ascorbic acid and citric acid on iron bioavailability in an in vitro digestion/ Caco-2 cell culture model]*. Nan fang yi ke da xue xue bao = Journal of Southern Medical University. Retrieved April 26, 2022, from <https://pubmed.ncbi.nlm.nih.gov/18971162/>.

Meilgard, M.; Civille, G. V.; Carr, B. T. Sensory evaluation techniques. 4. ed. Boca Raton: Taylor & Francis, 2006.

Miller, J. L. (2013). Iron deficiency anemia: A common and curable disease. *Cold Spring Harbor Perspectives in Medicine*, 3(7). <https://doi.org/10.1101/cshperspect.a011866>.

Physician's Guide to Oral Iron: Iron Corner. SABM. (2020, December 29). Retrieved March 1, 2022, from <https://sabm.org/physician-guide-to-oral-iron/>.

Shah M, Griffin IJ, Lifschitz CH, Abrams SA. Effect of Orange and Apple Juices on Iron Absorption in Children. *Arch Pediatr Adolesc Med*. 2003;157(12):1232–1236. doi:10.1001/archpedi.157.12.1232.

Singh-Ackbarali, D., & Maharaj, R. (2014). Sensory evaluation as a tool in determining

acceptability of innovative products developed by undergraduate students in Food Science and Technology at the University of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3(1). <https://doi.org/10.5430/jct.v3n1p10>.