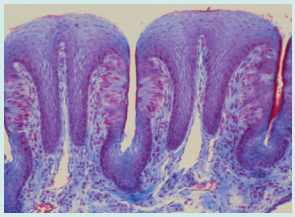
■ Online Exclusive Article

Pilot Study of "Miracle Fruit" to Improve Food Palatability for Patients Receiving Chemotherapy

Marlene K. Wilken, RN, MN, PhD, and Bernadette A. Satiroff, MSN, APRN, ANPc, CHTP, RN



Taste changes in patients undergoing chemotherapy are common and can be of long duration, are associated with poor nutrition, and can reduce quality of life. A pilot study of the fruit *Synsepalum dulcificum*—known as "miracle fruit"—as a novel supportive intervention was conducted with eight patients with cancer who were being treated with chemotherapy and reporting taste changes. Miraculin, a naturally occurring protein in miracle fruit, has the unusual ability to transduce a sweet signal in an acidic environment, profoundly changing food taste profiles for a short duration, masking unpleasant tastes, and increasing the palatability of certain foods. This pilot study was designed to determine whether consumption of the Miracle Fruit™ supplement would improve chemotherapy-associated taste changes, thereby improving the taste of food and ultimately leading to better nutrition. Four of the participants were given a two-week supply of the supplement and the other four were given a two-week supply of a placebo. After two weeks, the supplement group received a two-week supply of the placebo and the placebo group received a two-week supply of the supplement. Participants recorded food and drink intake in daily food dairies and rated taste changes with each food as better, worse, or no change. All study participants reported positive taste changes with the supplement.

Marlene K. Wilken, RN, MN, PhD, is an associate professor in the School of Nursing at Creighton University in Omaha, NE, and Bernadette A. Satiroff, MSN, APRN, ANPc, CHTP, RN, was, at the time of this writing, an assistant professor in the School of Nursing at Creighton University and an adult nurse practitioner in the Hematology/Oncology department at Creighton University Medical Center. The authors take full responsibility for the content of the article. The authors did not receive honoraria for this work. The content of this article has been reviewed by independent peer reviewers to ensure that it is balanced, objective, and free from commercial bias. No financial relationships relevant to the content of this article have been disclosed by the authors, planners, independent peer reviewers, or editorial staff. Mention of specific products and opinions related to those products do not indicate or imply endorsement by the *Clinical Journal of Oncology Nursing* or the Oncology Nursing Society. Wilken can be reached at mwilken@creighton.edu, with copy to editor at CJONEditor@ons.org. (First submission December 2011. Revision submitted February 2012. Accepted for publication February 22, 2012.)

Digital Object Identifier:10.1188/12.CJON.E173-E177

Taste changes are common in patients with cancer; however, they are understudied, likely underestimated, and frequently impact quality of life (Comeau, Epstein, & Migas, 2001). Treatment with chemotherapy has been documented to affect alterations in taste (dysgeusia) for which no conventional therapy exists (Soares et al., 2010). Taste changes, including bitter and metallic tastes, can lead to loss of appetite, compromised nutrition, and malnutrition (Comeau et al., 2001). Taste changes from chemotherapy treatment may last a few hours or several days (Comeau et al., 2001).

Food provides comfort and flavors are one of the few constants in our lives. Research indicates that the psychological effect of altered taste in patients with cancer may be significant (Berteretche et al., 2004). These abnormal tastes can result in food aversions that, in turn, may lead to negative outcomes such as poor nutrition, a decreased response to treatment, decreased morale, depression, and an altered quality of life (Berteretche et al., 2004).

Synsepalum dulcificum, also known as "miracle fruit," is native to West Africa and is currently being developed in the United States as a sweetness enhancer (Wong & Kern, 2011). Miraculin, a naturally occurring protein in the fruit, has the ability to mask certain unpleasant tastes for a short duration, making some foods more palatable (i.e., acidic citrus fruit such as raw lemon) (Wong & Kern, 2011). Miraculin adheres to the taste receptors, not the food; therefore, the sweetness-enhancing effect is uniform throughout the food (Wong & Kern, 2011).

A pilot study was designed to assess whether miraculin use improves taste changes (dysgeusia). The study consisted of a convenience sample of eight participants (see Table 1), recruited from an oncology clinic in the midwestern United States, who had received three or more cycles of chemotherapy and reported taste changes to the clinic nurse. None of

TABLE 1. Participant Characteristics

Participant	Age (Years)	Type of Cancer	Chemotherapy Type and Duration
1	69	Breast	Four cycles of doxorubicin and cyclophosphamide
2	59	Ovarian	Four cycles of topotecan and bevacizumab
3	65	Pancreatic	Four cycles of gemcitabine
4	76	Lymphoma	Six cycles of CHOP and rituximab
5	56	Endometrial	Five cycles of carboplatin and paclitaxel
6	56	Breast	Four cycles of paclitaxel and trastuzumab
7	59	Carcinamatosis of unknown origin	Twelve cycles of 5-FU, bevacizumab, folinic acid, and oxaliplatin
8	47	Sarcoma of the thigh	Four cycles of doxorubicin, ifosfamide, and mesna

CHOP—cyclophosphamide, doxorubicin, vincristine, and prednisone; 5-FU—5-fluorouracil

the participants received radiation therapy during the time they were enrolled in the study. Protection of human subjects' protocols and institutional review board procedures were followed. Signed, informed consents were obtained for all study participants.

Methods

Participants were assigned to either the experimental or control group (non-randomized). Each participant received either a 14-day supply (six fruits per day for a total of 84 fruits per participant) of the Miracle Fruit™ supplement or placebo fruit (dried cranberries). The control group (n = 4) was given the supplement for two weeks and the experimental group (n = 4) was given the placebo for two weeks. Instructions for the two groups were identical. The supplier shipped the fruit in pharmacy-type medication dispensers. The placebo (a commercially sold dried cranberry product) was packaged by the investigators using the same pharmacy-type medication dispenser as the Miracle Fruit supplement. Both the supplement and the placebo were stored and dispensed from a secure location.

Exploration on the Go

An article in *The New York Times* reviews the *Synsepalum dulcificum* fruit and the effect it has on taste. To access the article, open a barcode scanner on your smartphone, take a photo of the code at right, and your phone will link automatically. Or, visit www.nytimes.com/2008/05/28/dining/28flavor.html.

Participants were weighed during their initial study visit and a research investigator inquired about eating habits, including which foods tasted different and/or unpalatable since chemotherapy treatment began. The investigator gave instructions for using the provided fruit (either the supplement or the placebo). The fruit was to be consumed immediately prior to meals.

In addition, each participant was given a 28-day food diary form (see Figure 1) and asked to list the foods and portion size eaten immediately following ingestion of the fruit. The participants also were asked to note the taste associated with the food, including whether the food tasted the same, worse, or better than expected based on their previous experience. The start and ending times of each meal were self-recorded. Because the effects of the miraculin are temporary, participants were asked to note whether the changes in food taste lasted throughout the meal. In addition to foods that participants chose on their own, they also were asked to try common foods that are noted for having sour or bitter taste, such as lemons and grapefruit.

The investigator contacted each participant by telephone between days 5–8 of the study to ask about food intake and the food diary. At the end of two weeks, each participant brought his or her food diary to the clinic and met with the investigator. At this meeting, the investigator weighed the study participant and went over the information from the food diary and any other subjective data that the participant wanted to discuss. The investigator kept from influencing participants by asking the same questions regardless of whether the participant was in the experimental or placebo group. Participants in the experimental group were then given a two-week supply of the placebo and the participants in the control group were given a two-week supply of the supplement.

Findings

Participants

Ten individuals originally consented to take part in the study; however, one withdrew after two days because she did not like the taste of the Miracle Fruit supplement and one was removed because of hospitalization. After the initial meeting to obtain consent, one participant refused to record information in the food diary because it "was too cumbersome." One of the eight did not return her diary, but did give verbal input. Eight participants completed the study, seven women and one man. The sample size was too small to report statistical significance, but the qualitative data is supportive of the hypothesis. All participants reported positive taste changes with the supplement compared to the placebo.

Participant 1: The patient reported that chemotherapy treatment made water, yogurt, and mashed potatoes taste spoiled. She was started in the experimental group (receiving miraculin for two weeks) and reported that meat and water tasted better and toast with jelly as well as chili tasted very sweet. During her two weeks in the control group (receiving placebo), her taste alterations reverted to their presupplement state on the first day. All four food groups (meat, dairy, vegetables and fruits, and grains) tasted the same as presupplement, and water tasted bad. She reported she ate less during this time because food did not taste good.

Instructions: You will be given a 14-day supply of a dried fruit product. You are to chew completely and swallow this substance. Wait five minutes and then eat your meal. In the diary provided, please list the foods and fluids you consume. Please note the time you started eating, stopped eating, and did it taste the same, worse, or better than you remember from previous sampling. Did the effects of the fruit last throughout the meal? Please try sour and/or bitter foods and other foods that have not tasted good to you.

If at any time you have questions or if you have any problems, contact _____ (phone: _____) or _____ (phone: _____). Please leave a message and phone number where you can be reached. Please remember to bring this diary with you to your two- and four-week appointments.

Date and time for meeting #1: _____ 2 weeks: _____ 4 weeks: _____

Please make note of any questions you might have on the lines below so that when one of the healthcare professionals calls you, you will remember your questions.

_____

_____

Remember: Before eating any meal or snack, place one fruit in your mouth, chew completely, swallow and wait five minutes before eating your food. If you noticed any taste changes with this meal or snack, how many minutes did the changes last?

Day 1. Date _____	**Better**	**Same**	**Worse**	**Comments**
Meal: Time you started to eat this meal: 8 am Time you stopped eating this meal: 8:30 am				
Food item: White toast with grape jam	✔			Sweet, usually bitter: 30 minutes
Food item: Bacon		✔		
Food item: Eggs over easy		✔		
Food item: Orange juice	✔			Sweet, was metallic: 30 minutes
Food item: Skim milk			✔	Tasted really sweet; don't like sweet milk
Other: _____				
Snack: Time you started eating this snack: 10 am Time you stopped eating this snack: 10:15 am				
Food item: Yogurt		✔		
Food item: Blueberries	✔			Tasted sweeter than usual
Food item: Caffeinated green tea		✔		
Meal: Time you started to eat this meal: Noon Time you stopped eating this meal: 12:45 pm				
Food item: Chicken enchilada with ranchero sauce	✔			Sweeter, milder: 30 minutes
Food item: Mexican beans		✔		
Food item: Mexican rice	✔			More flavor, sweeter: 30 minutes
Food item: Diet soda	✔			Metallic taste gone: 20 minutes
Food item: Water		✔		
Other: Lemon wedges	✔			Sweet, not bitter: 20 minutes
Snack: Time you started to eat this snack: 2 pm Time you stopped eating this snack: 2:30 pm				
Food item: White toast		✔		
Food item: Peanut butter	✔			Sweeter than usual: 25 minutes
Food item: Decaffeinated coffee	✔			Usually bitter, now sweeter: 20 minutes
Meal: Time you started to eat this meal: 6 pm Time you stopped eating this meal: 6:30 pm				
Food item: Mashed potatoes with butter		✔		
Food item: Turkey breast		✔		
Food item: Green beans with almonds and mushrooms	✔			Sweeter, did not add sugar: 20 minutes
Food item: Cranberries	✔			Not as bitter: 30 minutes
Food item: Blueberry muffins	✔			More flavor than usual: 30 minutes
Food item: Skim milk			✔	Sweeter than I like it: 30 minutes
Snack: Time you started to eat this snack: 8:30 pm Time you stopped eating this snack: 8:45 pm				
Food item: 2% milk			✔	Still sweeter than I like: 30 minutes
Food item: Chocolate chip cookies	✔			Sweeter than usual: 20 minutes
Food item: Water		✔		

FIGURE 1. Sample Food Diary of a Patient Using the Miracle Fruit™ Supplement for Taste Changes

Note. Courtesy of Creighton University. Used with permission. This food diary may be reprinted or reproduced for noncommercial use.

Participant 2: This person did not submit a food diary but did report to the investigator that "all food prior to starting the study tasted like cardboard and, with miraculin, everything tasted better. I can't believe how good it is that foods taste good again."

Participant 3: The participant stated that, prior to inclusion in the study, food tasted metallic. He started in the experimental group and reported that the metallic taste went away with the supplement and, in addition, beans, tomatoes, and citrus fruit juices tasted sweeter. When switched to the control group, the man reported that foods tasted terrible; however, he continued to experience no metallic taste.

Participant 4: The participant said that, prior to the study, "all foods taste like lard." She reported that the seeds in the supplement caused heartburn but that foods no longer tasted like lard. Investigators advised her to just eat the outside of the supplement and that seemed to alleviate the heartburn. Entries in her diary indicated that all food groups tasted better. While in the control group, she wrote that foods tasted good or better.

Participant 5: The participant reported that "all foods tasted off, metallic, and greasy . . . even water" prior to the study. She was started in the control group and indicated in her food diary that foods tasted the same, better, or sweeter. When switched to the experimental group, she reported that the metallic and greasy tastes were gone, and that grapefruit tasted good. Her diary entries reflected this.

Participant 6: The participant reported, prior to the study, that "all foods tasted metallic" and that she had to force herself to eat. She was started in the control group and said that raw fruits tasted better, a little sweeter, and sour and salty tasted a little better. When switched to the experimental group, she said fruit tasted "sweeter than before, and the sour foods less sour than the first two weeks." Her diary was consistent with her verbal reports.

Participant 7: Prior to study inclusion, the participant described food as "tasting metallic," like cardboard, felt like her tongue was coated, and "had to force [herself] to eat." She was started in the control group but the investigator was unable to reach her by telephone during this time. However, the participant did respond via e-mail that food was "maybe a little sweeter, but no dramatic differences" and "not sure the fruit does a lot for daily foods, but I will keep trying." When switched to the experimental group, she wrote in the first week that "foods taste sweeter and better all the time, but meat is the one thing that still tastes bad most of the time." During her time in the experimental group, she wrote in her diary that "fish tasted much better than usual and everything is a sweeter taste, sometimes too sweet; overall a better taste in my mouth." She reported "no metallic, bitter taste" three or four days after starting the miraculin.

Participant 8: Prior to the study, the participant said, "No foods taste good. Salty foods help with bad taste and Gatorade™ is revolting, and citrus foods really bad." During the first two weeks in the control group, her diary indicated she still experienced metallic taste, some foods tasted worse, others no change. During that time, she marked the category "same" for taste changes; however, in her comment section she wrote "usual and good" and "metallic taste often noted with different foods." After switching to the experimental group, she stated on a telephone follow-up call that "foods were very sweet, even the salad. Water tasted better. Foods were less sweet after a few days . . . now can eat salty foods, they taste usual." She wrote in her diary that "tea and water tasted sweet but better." After the first four days she indicated that all foods groups tasted the same but the sweet taste was not as strong anymore.

Implications for Practice

- In the pilot study, all of the negative changes from treatment reported by the study participants improved with the ingestion of the Miracle Fruit™ supplement prior to eating.
- The Miracle Fruit supplement increased food intake for some of the participants.
- Healthcare professionals should be informed of how the use of the Miracle Fruit supplement may improve outcomes for patients with taste changes resulting from chemotherapy.

Discussion

In this pilot study, all the negative taste changes reported by the eight study participants improved with ingestion of the Miracle Fruit supplement. A metallic taste was reported by five of the eight participants, and all five reported that the metallic taste disappeared with the supplement. The participants reported that the supplement affected the level of sweetness in several different food groups. The supplement improved taste for all participants and increased food intake for some. Of the four participants who started in the experimental group, all reported positive taste changes. When those four switched to control, one reported a "bad" taste, one described it as "terrible but still no return of the metallic taste," one stated "better/good," and the fourth person did not report any data. Participants who started in the control group all reported a metallic taste when eating. Comments included "same, better, or sweeter," "no change," and "same." When the four were switched to the supplement, all four stated "better," and two of the four specifically said "no metallic taste." No significant changes in weight were noted with the participants. The response to the Miracle Fruit supplement appears encouraging and bears further exploration.

Conclusion

Taste changes in patients with cancer undergoing chemotherapy are common but understudied. Abnormal or bad tastes as a result of treatment can result in negative outcomes that affect nutrition, response to treatment, and quality of life. Good nutrition has a direct relationship to immune health. Chemotherapy suppresses the immune system, making individuals more prone to infection, the number one killer of patients of cancer (American Cancer Society, 2012). Patients may experience more positive outcomes if nutritional intake can be improved through the use of a Miracle Fruit supplement. This pilot study demonstrated that all the negative taste changes improved with the ingestion of the Miracle Fruit supplement. Given the responses from the study participants, healthcare

providers should consider offering a Miracle Fruit supplement to patients experiencing taste changes as a result of chemotherapy. Larger studies should be conducted given the encouraging results from the current study.

References

American Cancer Society. (2012). *Cancer facts and figures, 2012.* Atlanta, GA: Author.

Berteretche, M.V., Dalix, A.M., Cesar d'Ornano, A.M., Bellisle, F., Khayat, D., & Faurion, A. (2004). Decreased taste sensitivity in cancer patients undergoing chemotherapy. *Supportive Care in Cancer, 12,* 571–576. doi:10.1007/s00520-004-0589-2

Comeau, T.B., Epstein, J.B., & Migas, C. (2001). Taste and smell dysfunction in patients receiving chemotherapy: A review of current knowledge. *Supportive Care in Cancer, 9,* 575–580. doi:10.1007/s005200100279

Soares, H.P., Cusnir, M., Schwartz, M.A., Pizzolato, J., Lutzky, R.J., Campbell, J.L., . . . Lilenbaum, R. (2010). Treatment of taste alterations in chemotherapy patients using the "miracle fruit:" Preliminary analysis of a pilot study [Abstract]. *Journal of Clinical Oncology, 28*(15, Suppl.), e19523.

Wong, J., & Kern, M. (2011). Miracle fruit improves sweetness of a low-calorie dessert without promoting subsequent energy compensation. *Appetite, 56,* 163–166. doi:10.1016/j.appet.2010.10.005