LIBERTY UNIVERSITY

Time to Tickle the Taste Buds

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Abstract

The CHEM 497 Special Topics in Chemistry: ***Kitchen Chemistry*** (Kitchen Chemistry) course was designed for students to learn, engage, reason with, and practice foundational scientific principles in a familiar setting – food in the kitchen. The process of cooking involves transforming the qualities of ingredients and how they combine to form new textures, flavors, and tastes.

According to our survey, taste is the most important factor when determining how appealing a certain food product is. Thus, finding a compound to alter the taste and perception of food could prove very useful. The Miracle Fruit Berry (MFB) is not sweet in and of itself, but it contains miraculin, which is a glycoprotein that changes how our taste bud receptors perceive ordinarily sour (i.e., acidic, pH < 7) foods as sweet for up to 2 hours afterward, whereas salty, sweet, and bitter foods resulted in minimal to no change in taste.

The goal of this research was to have CHEM 497 and other students participate in ranking their taste-testing perceptions of various sour, salty, bitter, and sweet foods before and after exposing their tongues to the MFB. A drastic increase in the perception of sweetness in typically sour foods was reported, whereas little to no differences in bitter, sweet, or salty foods were reported. This supports our hypothesis that our taste perception of foods of low pH are more affected by presence of miraculin than food items at higher pH. Additionally, the results of our research will be implemented into future course offerings.

Background

Regarding the Miracle Fruit Berry:

Taste is a critical aspect of the enjoyment of food and drink. Many studies have discovered numerous types of taste-modifying proteins found in nature that are categorized as having sweet, antisweat, and sweetness-inducing abilities (1). Miracle fruit (*Synsepalum dulcificum*) is a plant native to Western and Central Africa that has historically been used to modify the taste of several foods, specifically, the ingestion of this fruit has resulted in altered perception of previously sour foods, making them appear sweeter for up to 2 hours (2). Miraculin, a glycoprotein found in miracle fruit, has been identified as the compound that stimulates this taste-altering response (3). The suggested mechanism by which the miraculin works is related to the presence of protons in acidic (sour) foods (2) interacting with the tongue taste cells by the sweet receptors (2). Recent work suggests that these taste-modifying effects are more pronounced at lower pH values, specifically below 6.5 (4).

The effects of miraculin at varying pHs indicated a flat taste at neutral pH because of the inhibition of sweet receptor activation by aspartame, sucrose, and other molecules (5). At pH levels of 6.7 or higher, the miraculin protein seems to slightly shift shape, blocking the sweet sensors but not activating them (4). However, the receptors' response to sweeteners are increased in mildly acidic conditions (pH 6-7), and the receptors are activated solely by the miraculin at even lower pH values (5). For example, sweet-tasting cells respond twice as vigorously to miraculin at a pH of 4.8 than at 5.7, explaining the difference in sweetness rating across various foods (4).

Miraculin may have potential health benefits (6), which include antioxidant properties, antidiabetic activity, anticancer activity, anti-hyperuricaemic activity, anticonvulsant activity, and more (6). Some of these are likely due to the presence of many vitamins such as A, C, K, E, and both essential and non-essential amino acids (6).

Although the effects of the miracle fruit have the potential to linger for 30 min to 2 hours, this does not pose much of a problem as this would allow the patients to enjoy a meal without rushing (7). This could be added as a disclaimer when pursuing product development and would be left up to the discretion of the user. However, it is likely that the pros outweigh the cons, especially for those suffering from type II diabetes or cancer treatments. Miraculin has been shown to lose its effects when subjected to high temperature or boiling due to the denaturation of the protein (7). This would limit its ability to be consumed as part of a baked good. However, there are recipes that cut sugar content with the intent of ingesting a miracle pill tablet before consumption, thus allowing for the preservation of its effects. Scientists have attempted to produce miraculin in bacteria, yeast, and other plants, but it was difficult to extract and purify and, in some cases, didn't have the same taste-modifying effect (8).

Regarding the Kitchen Chemistry Course:

CHEM 497 is currently available to students as a science elective. The students are taught practical and simple cooking techniques that can be easily implemented into their daily lives. The goal of this course is to teach the chemistry background of these techniques while focusing on the biblical integration of the various food items or ingredients as well. The integration of the science of foods with the Bible is critical to this course, because all throughout scripture, we see that Jesus used meals as a way of fellowshipping with and teaching others. Even in the Old Testament, meals were sacred and used as a way for God to represent Himself and communicate with His people.

Methods

Students tested the before- and after-effects of miraculin (in MFB tablet) by tasting and scoring on a 0-10 scale their perception of sweetness, bitterness, sourness, and saltiness of various food items including granny smith apple, Goldfish®, cranberry, lemon, cocoa powder, jellybeans. This student project and tastings were exempt from IRB review, per section 46.104 in 45 Code of Federal Regulations. The pH values of the different food items were tested to determine if there was a correlation between the pH and effect of the miraculin.

Miracle Fruit should be consumed with some caution. This fruit, if eaten regularly, may cause elevated levels of acidity in the blood and may also lead to heartburn, digestion issues and other gut related problems (9). People with fruit or berry allergies should not consume.

Figure 1. pH measurements of jellybean, lemon, and cocoa, respectively.

Figure 2. Miraculin chemical structure. (*Synsepalum dulcificum*)

Figure 3. Miracle fruit.

Figure 4. Miracle fruit experiment

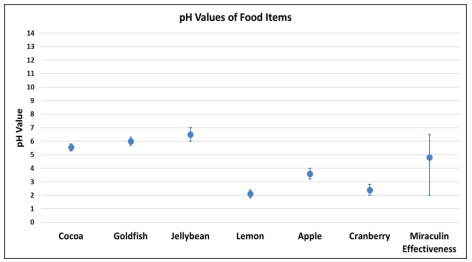

Figure 5. pH values of each food product.

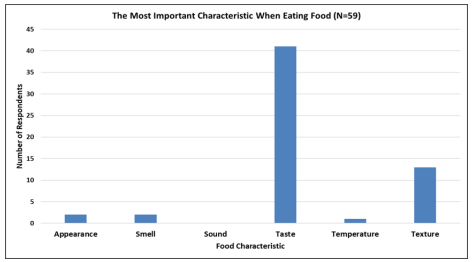

Figure 6. Most important Characteristics of Food

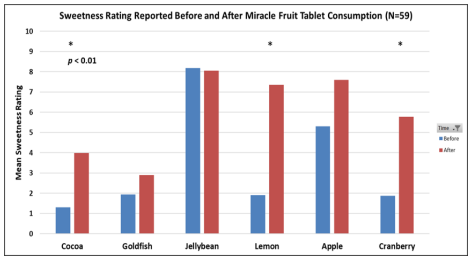

Figure 7. Changes in sweetness perception following the ingestion of miracle fruit.

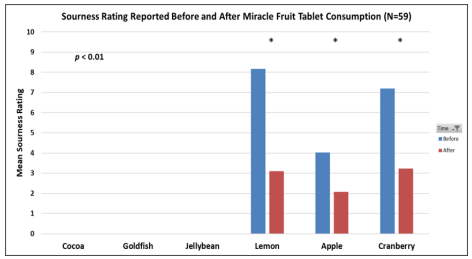

Figure 8. Changes in the sourness perception following the ingestion of miracle fruit

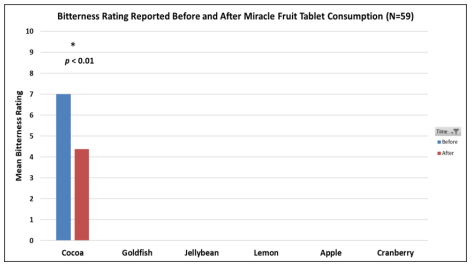

Figure 9: Changes to the bitterness perception following the ingestion of miracle fruit

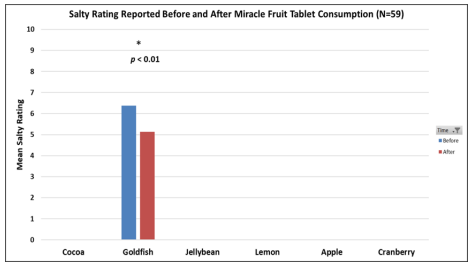

Figure 10: Changes to the salty perception following the ingestion of miracle fruit

Kitchen Chemistry Survey

		Lemon Sweet	Lemon Sour	Cocoa Sweet	Cocoa Bitter	Goldfish Sweet	Goldfish Salty	Jellybean Sweet	Apple Sweet	Apple Sour	Cranberry Sweet	Cranberry Sour
	p-value (<0.01 is stat signif) for 2T t-test of Before/After, equal var	1.8E-29	7.3E-26	1.3E-07	1.9E-07	0.016	2.3E-04	0.610	0.010	2.4E-05	8.0E-08	6.4E-06
Before	avg	1.9	8.2	1.4	7.1	1.9	6.4	8.2	5.3	4.0	1.9	7.2
	stdev	1.7	1.8	1.7	2.3	1.9	1.6	1.2	2.9	2.7	1.8	3.8
	N	59	58	57	58	59	59	59	42	42	42	42
After	avg	7.5	3.1	4.0	4.4	2.9	5.1	8.2	7.6	1.6	5.8	3.2
	stdev	2.1	2.1	3.0	2.8	2.2	1.9	2.2	3.8	1.4	3.4	2.4
	N	58	59	58	59	58	59	58	42	42	43	43

Table 1. Grubbs' Test was used to statistically identify and remove a single outlier prior to calculating p-values from t-tests comparing the means of the "before" and "after" ranking data, which were normally distributed and exhibited equal variances.

Miracle Fruit Survey

Results

Miracle Fruit Taste Test:

- Participants ranked "taste" as the most important food characteristic that influences their choice of foods to eat.
- Miracle fruit is a taste-modifying berry that causes sour (i.e., acidic) foods to be perceived as sweet.
- Sampled foods focused on four different types of tastes: sweet, sour, bitter, and salty.
- Participants ranked their perception of taste intensity for each food item, both before and after consuming a miracle fruit berry tablet.
- As expected, sour foods were perceived as sweeter after the miracle fruit berry tablet was consumed. Additionally, the perception of sourness, saltiness, and bitterness in intensity, whereas the perception of jellybean sweetness remain unchanged.
- The change in sweetness of more acidic foods (pH 2-4) was more pronounced than that of slightly acidic (pH 5-7) foods that were categorized as bitter, salty, or sweet.

Future Work

Regarding the Kitchen Chemistry Course:

- Incorporation of these research results into the course curriculum.
- Conversion of the Chem 497 course into 100-200 level General Education course for piloting in upcoming semesters.
- Development of additional taste testing experiments involving Miracle Fruit by reducing the sugar content in recipes of sour foods.

Regarding the Miracle Fruit Berry:

- Additional research is needed to investigate the effectiveness of using Miracle Fruit for individuals suffering from type II diabetes (9,10) and from metallic tastes resulting from chemotherapy treatment (11).

Biblical Integration

Regarding the Kitchen Chemistry Course:

The Bible begins and ends with meals. The first words of God to Adam and Eve were an invitation to eat; the first conflict in the Bible was over a forbidden fruit; the last act of Jesus before his death was to share a supper with his disciples; and the final vision of the new world is of a massive, joyful banquet. God uses meals as a way to have fellowship with us and as an example of our need for Him (Matt 4:4). The Kitchen Chemistry topics covered in the CHEM 497 course illustrate the importance of food in the Bible, how it relates to us now and provide simple methods of cooking to make this process easier and more attainable, especially for college hungry students. The biblical importance of eating meals together and of the familial ties it creates is emphasized and students are encouraged to pursue this in their daily lives.

Regarding the Miracle Fruit Berry:

The Garden of Eden was filled with plants that were pleasing to the eye and good for food (Gen 2:9, 3:6). Miracle fruit is yet another example of the creation with which God has so abundantly blessed us. Miracle fruit is good for food, and in a way that many of us would not have expected. Its potential benefits are limitless and show that the Lord can take the bitter and sour things of life and make them sweet (Psalm 119:103).

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