Susanna Kaiser

Individual Project Report

The Effect of Soy Protein Isolates on the Nutritional, Physical and Sensory Attributes of Marshmallows

F&N 453

November 21, 2005
Title:

The Effect of Soy Protein Isolates on the Nutritional, Physical and Sensory Attributes of Marshmallows

Abstract:

Soy protein isolates are dietary constituents that have positive health benefits. This is important in the American society today because over 60 million adults are obese. In this study, soy protein isolates were added in different proportions to marshmallows to observe the effects of sensory and objective qualities. There were three variations of marshmallows with the soy protein isolates, but the control marshmallows were given the highest ratings by the panelists on the sensory test. The marshmallows that had additional soy protein isolates added to them needed a greater amount of force from the texture analyzer in order to penetrate the marshmallows. The results of the Hunter Colorimeter test were inconsistent because there was not a significant decrease in the L values as the amount of soy protein isolates increased in the three variables. Additional research will need to be conducted in order for soy protein isolates to be used successfully in all products, and this will positively improve the nutritive value of foods.

Introduction:

The Food and Drug Administration (FDA) recognized soy protein for its health benefits, and in 1999, the FDA allowed the use of a health claim on food labels. The claim states that “consuming 25 grams of soy protein per day as part of a diet low in saturated fat
and cholesterol may reduce the risk of coronary heart disease” (ADM-Health). Soy protein provides many health benefits that may improve a person’s well-being. Soy protein decreases the risk of coronary heart disease, lowers blood serum cholesterol, decreases the incidences of prostate and breast cancer and inhibits bone resorption (Lee and Brennand 2005). Because of these health benefits, soy protein has been incorporated into food products such as snack foods, dairy products, bread, meat substitutes and cereal.

Besides all of the health benefits, soy protein provides many functionalities as well. These include binding, water-holding and emulsifying properties (Lee and Brennand 2005). These functionalities would be beneficial in the production of marshmallows. In the marshmallow recipe, 400 g of white sugar and 295 ml of water are used. Adding soy protein to the recipe would be beneficial in order to improve the water-holding capacity of the marshmallows.

Soy flour, concentrates and isolates represent the three categories of processed soy protein products. In this experiment, soy protein isolates are added to the marshmallow recipe because soy protein isolates contain 90% protein. This represents the greatest amount of protein for all soy products (Soy Protein). Soy protein isolates also have a bland flavor and can be safely added to food products without influencing the flavor or characteristics of the food products. The protein quality of soy protein is outstanding, even though it is a plant protein (Slavin 1991). Adding soy protein isolates to a marshmallow recipe would improve the protein content and add numerous health benefits and functionalities. Even though early attempts to supplement soy into products met with limited success, new processing methods have enhanced soy protein isolates with an improved functionality, mild flavors and aromas.
(Klein and others 1995). With these new processing methods, soy protein isolates could be added into marshmallows to positively increase their nutritive value.

Studies have not been conducted that have added soy protein isolates to marshmallows or other products with a similar consistency. One research study evaluated the textural and sensory properties of a fried cookie (called a Yackwa) containing soy protein isolates (Lee and Brennard 2005). The Yackwa was made by partially replacing wheat flour with soy protein isolates. This resulted in an increase in moisture and protein content and a decrease in fat content in the Yackwa. It was also noted that the increase in protein content might cause Maillard browning. Normal dehydration decreased and dough consistency increased with the addition of soy protein isolates. Sensory panelists did not feel the soy flavor influenced overall acceptability of the product. The positive sensory and physical attributes of the Yackwa product, made with soy protein isolates, provides evidence that products can be enhanced in a constructive way.

Marshmallows are a relatively common food, and it would be beneficial to increase their nutrient content. Thus, it was important to perform the experiment (using an experimental design) to see if a successful product could be concocted. The experimenter believed the dependent variables (sensory and physical qualities) in the marshmallows containing soy protein isolates would not negatively differ with regard to the control marshmallows. Therefore, a more nutritional and functional product can be produced without negative changes in quality.
Methods:

Objective Tests

The Stable Micro Systems Texture Analyzer and the Hunter Colorimeter were utilized in order to objectively measure the marshmallows. In order to properly use the texture analyzer, the experimenter had to utilize the appropriate probe type. The cone probe was chosen because it analyzes hardness, penetration and spreadability of soft samples. Using the computer, the experimenter chose to use the gelatin setting because the settings are consistent with the characteristics of the marshmallows. These are the parameters used for the gelatin setting: Pre-test speed-1 mm/s

Test speed-1 mm/s

Post-test speed-1 mm/s

Rupture test distance-1.0 mm

Distance-4 mm

Force-2,000 g

Time-5 seconds

Count-5

Once the computer was ready, the marshmallow was placed under the probe and a quick test run was conducted. After the test was performed, the experimenter viewed the graphs to analyze the marshmallow and recorded the grams of force needed to penetrate the marshmallow. The experimenter performed the procedure on the other three variables after the data was collected from the control marshmallow. The experimenter practiced this procedure and collected data for all three trials.
The other objective test performed involved the Hunter Colorimeter. The experimenter standardized the instrument, and then placed the control sample from trial 1 into a Petri dish on the measuring port. The experimenter performed the test, and then observed the data in the Master Color Data Window. The experimenter recorded the L Hunter Parameter values because the L Hunter Parameter records the lightness or darkness of a sample. This is a direct measure of appearance and color. This test was performed for the rest of the variables in trial 1 and for the two remaining trials of the control and each variable.

**Sensory Test**

The consumer preference and hedonic ranking was used for the sensory test. Essentially, this provided information about how much a panelist liked the sample. Here is an example of the hedonic ranking:

- Like extremely (9)
- Like very much (8)
- Like moderately (7)
- Like slightly (6)
- Neither like nor dislike (5)
- Dislike slightly (4)
- Dislike moderately (3)
- Dislike very much (2)
- Dislike extremely (1)

The scale ranges from the values 9 to 1. The like extremely preference has a value of nine, and the dislike extremely preference has a value of one. The other preferences take the appropriate values between nine and one. Six panelists tasted the control marshmallows and the three variables. The same six panelists were recruited to taste the marshmallows in all
three trials in order to reduce any unnecessary variability or bias. For each trial, the experimenter randomized the order in which the four samples of marshmallows were tasted in order to reduce any bias. In trial 1, sample #1 was the control marshmallow, sample #2 was the marshmallow with 2 tablespoons of soy protein isolates, sample #3 contained the marshmallows with 3 tablespoons of soy protein isolates, and sample #4 contained the marshmallows without any gelatin. Likewise, in trial 3, sample #1 represented the marshmallows without gelatin, sample #2 contained the marshmallows with 2 tablespoons of soy protein isolates, sample #3 contained the marshmallows with 3 tablespoons of soy protein isolates, and sample #4 was the control marshmallows. This is an example of how the variations were randomized in the experiment. If the marshmallows are tasted in the same order each time, then the panelists will begin to realize that they are tasting the different variables in the same exact order for each trial. This will cause them to figure out which variables they like and do not like, and this would produce bias in the results.

The experimenter controlled any lurking or unwanted variables by planning in advance for any changes or discrepancies. When making the marshmallows, temperature is an independent variable that must be controlled. The experimenter used a thermometer to accurately measure this variable. The recipe yields 18 servings, and this controls the amount of the marshmallow sample. Variation within a food sample was controlled by precisely following the recipe for the control marshmallows and the experimental marshmallows. By being careful and precise, the experimenter did not anticipate any unnecessary variables to interfere with the results. Also, the experiment was replicated three times for the control marshmallows and the three variations of marshmallows in order to properly measure precision and accuracy to report precise results.
Recipe

Emily’s Famous Marshmallows is the recipe that was followed to make the marshmallows.

Ingredients:

- 120 g confectioners' sugar for dusting
- 400 g white sugar
- 15 ml light corn syrup
- 295 ml water, divided
- 25 g unflavored gelatin
- 2 egg whites
- 5 ml vanilla extract

First, the experimenter dusted a 9x9 inch square dish generously with confectioners' sugar. Then in a small saucepan over medium-high heat, the experimenter stirred together the white sugar, corn syrup and 295 ml of water. The contents were heated to between 250 to 265 degrees F (121 to 129 degrees C). While the syrup was heating to the appropriate temperature, the experimenter placed the remaining water in a metal bowl and sprinkled gelatin over the surface. Then the experimenter placed the bowl in the microwave until the gelatin completely dissolved. The bowl was kept in a warm place until the syrup arrived at the proper temperature. After the optimum temperature was obtained, the experimenter removed the syrup from the heat and whisked the gelatin mixture into the hot syrup and set it aside. Then in a separate bowl, the experimenter whipped the egg whites to soft peaks. The experimenter continued to beat, pouring the syrup mixture in a thin stream
into the egg whites, until the egg whites were very stiff. Next, the experimenter stirred in the
vanilla, and then spread the contents evenly into the prepared pan and let the marshmallows
set up overnight before cutting. The experimenter performed this procedure for the other
three variables as well. In one variable, the experimenter added 12.5 grams of soy protein
isolates to the gelatin after the gelatin had been completely dissolved in the water. In another
variable, the experimenter added 18.75 grams of soy protein isolates to the gelatin after the
gelatin had been completely dissolved in the water. For the last variable, the experimenter
completely omitted the gelatin from the recipe and substituted 25 grams of soy protein
isolates to the water in place of the 25 grams of gelatin. Each pan of marshmallows set up
overnight before the sensory test was performed the following day by the six panelists. The
experimenter made the control marshmallows and the variable marshmallows three times in
order to perform three trials for proper analysis. After the sensory test was performed, the
experimenter used the remaining marshmallow samples to conduct the two objective tests.

Discussion:

Soy protein isolates provide numerous functions in products such as binding, water-
holding and emulsifying properties (Lee and Brennard 2005). Soy protein affects the
qualities of foods. Soy protein isolates have the mildest flavor and the highest protein
content of any soy protein products. The sensory test results of all three trials are shown in
the results section in tables 1, 2 and 3. Table 1 displays the results from trial 1. Table 2
displays the results from trail 2, and Table 3 displays the results from trial 3. Table 1 shows
that the control marshmallows had the highest average rating in trial 1. Table 2 shows that
during trial 2, the marshmallows with 2 tablespoons of added soy protein isolates received
the highest average rating. The results in Table 3 show that the control marshmallows received the highest average rating during trial 3. Figure 1 displays the mean sum of the sensory tests for the control and each variable for all three trials combined. The panelists liked the control sample the best. The second favorite was the marshmallows with 2 tablespoons of added soy protein isolates, and they were followed by the marshmallows that contained 3 tablespoons of additional soy protein isolates. The marshmallows that contained 4 tablespoons of soy protein isolates in place of the gelatin received the lowest sensory rating. The experimenter was hoping the panelists would not be able to noticeably taste a difference between the control marshmallows and the marshmallows with added soy protein isolates, but the results show that the panelists could detect a difference. Even though research indicates that soy protein isolates have the mildest flavor, it appears that the flavor cannot be disguised in the marshmallows. This may be due to the fact that there are not many ingredients in a recipe of marshmallows to mask the flavor of the soy protein isolates.

Several researchers have reported the high water holding and binding capacity of soy protein isolates (Lee and Brennard 2005). As the amount of soy protein isolates increased in the various samples, the marshmallows became more spongy and gooey in consistency. The marshmallows that contained 4 tablespoons of soy protein isolates in place of the gelatin were extremely gooey. The marshmallows could barely hold their shape, and they were noticeably less springy than the control marshmallows. Likewise, the control marshmallows had an excellent consistency and were not abnormally sticky or gooey.

A study was conducted to observe the effects of soy protein isolates in a Korean fried cookie, and the soy protein isolates made the external color of the cookie more dark (Lee and Brennard 2005). Figure 3 shows the recorded L values of the Hunter Colorimeter for the
variables in trials 1, 2 and 3. The marshmallows that contained an additional 2 tablespoons of soy protein isolates appeared to be darker in color than the control marshmallows. This figure shows that the marshmallows that had 4 tablespoons of soy protein isolates substituted for the gelatin had the highest L values. This means that these marshmallows had a lighter color than the control marshmallows and the other variables of marshmallows. This seems to contradict research because the increase in protein content with the addition of soy protein isolates could increase the effects of Maillard browning (Lee and Brennard 2005). Therefore, a source of error may have occurred when the marshmallows were being tested with the Hunter Colorimeter. If any food fell into the Lab Scan XE, then this could have affected the results. In addition, storing the marshmallows overnight before performing this objective test could have possibly induced unwanted color changes.

In this study, the control marshmallows were the most fluffy and had the highest volume. The volume decreased in the marshmallows as the amount of soy protein isolates increased. This was to be expected, and in a particular study researchers found that soy protein decreased the volume of bread (Lee and Brennard 2005). The marshmallows that contained 4 tablespoons of soy protein isolates in place of the gelatin could not hold their shape. They were extremely runny, and this effect may have been increased since the gelatin was not present in the particular variation. The soy protein isolates may not have been a good substitute for gelatin because Junction zones were not able to form because there was no gelatin present for the gelation process to occur.

Figure 2 displays the objective analysis results from the texture analyzer. The amount of force needed to penetrate the marshmallows appeared to increase with the addition of soy protein isolates. Based on former research, as soy protein isolates increase up to 15%,
springiness decreases and hardness increases (Lee and Brennard 2005). The marshmallows that contained varying amounts of soy protein isolates appeared to lose their springiness as the amount of soy protein isolates increased. The marshmallows that did not contain gelatin required relatively high amounts of force to penetrate them compared with the control and the other two variables of marshmallows. Although soy protein isolates provide relative binding capacities, it would appear that the force required to penetrate these marshmallows would drastically decrease without the additional aid of the gelatin. In trial 2 with this variable, the texture analyzer could not calculate a reading because the marshmallow was too sticky, and the probe became stuck in the marshmallow. The results for this variable required varying amounts of force in each trial. The marshmallows in trial 1 used 14.3 g of force. The marshmallows in trial 2 could not utilize a reading from the texture analyzer, and the marshmallows in trial 3 required 21.9 g of force. A source of error must account for these discrepancies. This could have occurred if the beating time was not consistent for all three trials when the syrup mixture was gradually being poured into the egg whites. Overbeating could have destroyed the ability of the marshmallows to set up if the air seeped out of the egg whites.

The results of this research project show that soy protein isolates influenced the characteristics of marshmallows in a more negative direction than in a positive direction. The marshmallows with soy protein isolates did not possess the ideal characteristics of a normal marshmallow based on the sensory and objective analyses performed. Therefore, people may not desire to purchase marshmallows with soy protein isolates (even though the nutritive value has improved) if they do not approve of the sensory qualities the soy protein isolates produce. Processing methods have improved the incorporation of soy protein
isolates into food products by improving the flavor, aroma, and functionality of the soy protein isolates, but more work and research will need to be conducted in order for soy protein isolates to be used successfully in all products (Klein and others 1995). For future proceedings, researchers may want to use soy protein isolates in other foods that have a similar consistency of a marshmallow in order to see if the sensory and physical qualities of the substance can be improved. Different ratios of soy protein isolates should be added to the recipes to see if there is an optimum amount that can be added to foods.

Thus, it is important to continue this research because findings have shown that soy protein isolates can serve as the sole source of protein intake because their protein value is comparable to the food proteins that are of animal origin (Young 1991). The most recent data from the National Center for Health Statistics show that 30% of U.S. adults 20 years of age and older (over 60 million people) are obese. This has been a substantial increase in obesity over the past twenty years (Overweight and Obesity: Home). Soy proteins can be important components of hypocaloric diets to be used for weight reduction in obese people (Young 1991). Therefore, it is vital that the sensory characteristics of soy protein isolates should continue to be improved in all foods in order to improve health conditions for Americans.
Results:

Table 1. Trial 1 Results of the Sensory Test

<table>
<thead>
<tr>
<th></th>
<th>Sample 1 (Control)</th>
<th>Sample 2 (2 T Soy Protein Isolates)</th>
<th>Sample 3 (3 T Soy Protein Isolates)</th>
<th>Sample 4 (No Gelatin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like Extremely: 9</td>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like Very Much: 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like Moderately: 7</td>
<td>III</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Like Slightly: 6</td>
<td>I</td>
<td>II</td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td>Neither Like nor</td>
<td></td>
<td></td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Dislike: 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike Slightly: 4</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike Moderately: 3</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike Very Much: 2</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike Extremely: 1</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE Total</td>
<td>7.5</td>
<td>4.7</td>
<td>4.5</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Table 2. Trial 2 Results of the Sensory Test

<table>
<thead>
<tr>
<th></th>
<th>Sample 1 (2 T Soy Protein Isolates)</th>
<th>Sample 2 (3 T Soy Protein Isolates)</th>
<th>Sample 3 (Control)</th>
<th>Sample 4 (No Gelatin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like Extremely: 9</td>
<td>I</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Like Very Much: 8</td>
<td>I</td>
<td></td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td>Like Moderately: 7</td>
<td>II</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Like Slightly: 6</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Neither Like nor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike: 5</td>
<td></td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Slightly: 4</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Moderately: 3</td>
<td>II</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Very Much: 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislike Extremely: 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE Total</td>
<td>6.8</td>
<td>4.0</td>
<td>6.7</td>
<td>3.5</td>
</tr>
</tbody>
</table>
### Table 3. Trial 3 Results of the Sensory Test

<table>
<thead>
<tr>
<th></th>
<th>Sample 1 (No Gelatin)</th>
<th>Sample 2 (2 T Soy Protein Isolates)</th>
<th>Sample 3 (3 T Soy Protein Isolates)</th>
<th>Sample 4 (Control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like Extremely: 9</td>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like Very Much: 8</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like Moderately: 7</td>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like Slightly: 6</td>
<td>I</td>
<td>I</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>Neither Like nor Dislike: 5</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Dislike Slightly: 4</td>
<td>I</td>
<td>III</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Moderately: 3</td>
<td>I</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Very Much: 2</td>
<td>III</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dislike Extremely: 1</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE Total</td>
<td>2.3</td>
<td>4.7</td>
<td>5.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

### Collaborative Average of the Hedonic Scale Ratings for Each Variable and for all 3 Trials

![Collaborative Average of the Hedonic Scale Ratings](chart.png)

**Figure 1.** The Mean Sum of Each Variable of Marshmallow for all 3 Trials Combined
Figure 2. Amount of Force Used to Penetrate the Various Types of Marshmallows in Trials 1, 2 and 3

Figure 3. Color Values of the Various Types of Marshmallows in Trials 1, 2 and 3
References:


