

Overview

The objective of this bulletin is to provide information on maple marshmallows for commercial production. This document includes an overview of marshmallow composition, a recipe, regulation requirements, information on packaging and food additives, market projections, and pricing information. Further, this article is the first in a subset of the “Marshmallow Series”, which also includes Dehydrated Maple Marshmallows, and Maple Marshmallow Spread.

The name marshmallow comes from the mallow plant (*Althaea officinalis*), the root of which was historically used to soothe coughs (Mahboubi, 2020). Today’s marshmallows do not contain mallow root, but instead use either gelatin or egg whites for their thickening properties, and are enjoyed as confections. This simple recipe is made up of five ingredients – gelatin, sugar, syrup, water, and air – and is packed with maple flavor.

The Science of Marshmallows



Gelatin

Gelatin is derived from **collagen proteins** and it provides stability and elasticity in food products. It is sold in two forms: dehydrated sheets (Fig. 1a) and powder (Fig. 1b). Gelatin sheets are the standard in professional kitchens because they contribute less odor, flavor, and color to the final product than gelatin powder. Additionally, sheets are graded for “Bloom strength”, also known as “gel strength”, which corresponds to the elasticity of the final product (Harris et al., 2003). The grades for sheet gelatin from lowest to highest Bloom strength, are titanium, bronze, silver, gold, and platinum. This recipe requires a moderate gel strength and thus uses silver gelatin sheets. Bloom strength for gelatin powder varies by manufacturer; conversion rates are provided in the “Recipe” section.

Figure 1 (a) Silver gelatin sheets with inset showing 170 Bloom strength. (b) Powdered gelatin. (c) Rehydrated gelatin sheets. (d) Rehydrated powdered gelatin. Photos by Ailis Clyne.

Gelatin proteins are stiff when dehydrated. For proper use, sheet gelatin must be rehydrated in cold water until it reaches a softened, gelled state after about 15 min (Fig. 1c and 1d). Then it must be heated in a double boiler to 77 - 104 °F until it reaches a liquid state (Fig. 2c) (Burton, 2014). Overheating gelatin causes the proteins to become inactive (≥ 140 °F) or to denature (≥ 200 °F). The appearance of gelatin sheets in dehydrated, gelled, and liquid states is shown in Figure 2.

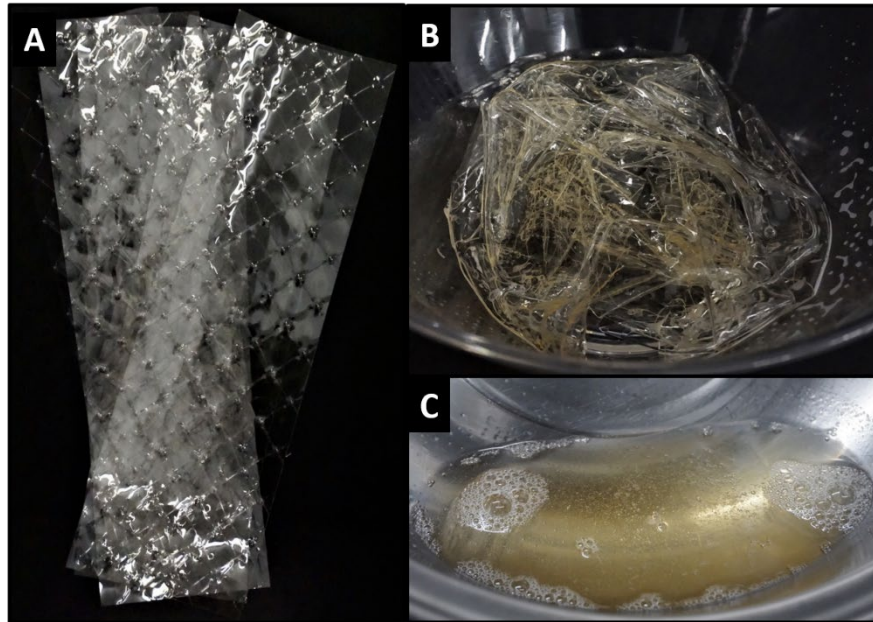


Figure 2 Silver gelatin sheets pictured in (a) dehydrated state, (b) gelled state, and (c) liquid state. Photos by Ailis Clyne.

After softening, the gelatin is then whipped with a heated sugar mixture to form a marshmallow. Because gelatin proteins denature at 200 °F, the sugar solution must be cooled to below this threshold before combining with the gelatin. This cooling step will ensure a stable, springy texture and prevent an overly dense marshmallow.

Sugars

Three types of sugars are used in marshmallows: granulated sugar (**sucrose**) and invert sugars (**glucose** and **fructose**). The granulated sugar contributes to structure, while the invert sugars prevent sucrose from forming large crystals, thus providing smooth mouthfeel. Invert sugars also act as humectants, meaning, they attract water. This property prevents marshmallows from drying and stiffening.

The ratio of these sugars impacts the texture and shelf-life of the product. Recipes commonly recommend either a 3:2 or 1:1 ratio of granulated sugar to invert sugar. Marshmallows made with a **3:2 ratio** have a springy texture and can maintain quality for 3 or more weeks. These are referred to as “grained” marshmallows and are recommended for production when humidity is higher (>60 %). A **1:1 ratio** results in a stickier marshmallow that pulls in more moisture due to the higher invert levels. These are referred to as “ungrained” marshmallows and are ideal for production when humidity is lower (<60 %) and marshmallows are more prone to drying out (Hartel et al., 2018).

For enhanced maple flavor, it is recommended to use Dark syrup for inverting and use any grade of maple sugar. The inverted syrup will impact the marshmallow’s flavor more

than the granulated sugar. Inverted Golden syrup will result in a delicate flavor, and inverted Very Dark may impart undesirable flavors.

To prevent finished marshmallows from sticking to each other, they are coated with **powdered sugar** (confectioner's sugar), which consists of finely ground sucrose crystals (approximately 50 microns) and 2 – 5 % of an anti-caking agent, such as cornstarch. The anti-caking agent reduces moisture loss and prevents sugar from clumping. For maple marshmallows, powdered maple sugar can be substituted for powdered cane sugar and will provide a maple-like color, enhanced maple flavor, and a higher marketing value because the product is made with 100% maple sugar. Basic instructions for making small batches are provided in the "Recipe" section.

It is important to note that large-scale production of powdered sugar can be hazardous due to the combustible nature of sugar dust. This is a concern in industrial sugar processing and packing facilities but is of little concern in small operations. Check with your food safety inspector to determine appropriate hazard analysis.



Necessary Equipment & Supplies

You will need:

- Stand mixer with whisk attachment
- Two 8" x 8" baking pans
- Rubber spatula
- Saucepan
- Double boiler
- Invertase
- Plastic wrap (cling wrap)
- Neutral flavored oil (e.g., canola vegetable, corn, safflower)
- Sharp knife
- Cutting board
- Appropriate PPE, including: gloves, apron, close-toed shoes

Recipe

Maple Marshmallow (3:2 Ratio¹)

Ingredients

12 (30 g) Silver Gelatin Sheets²

330 g Granulated Maple Sugar

328 g Inverted Dark Maple Syrup³

118 g (½ cup) Water

Pinch of salt (optional)

Powdered Maple Sugar⁴

¹For a **1:1 ratio**, use 273 g granulated maple sugar, and 408 g inverted maple syrup.

²To substitute powdered gelatin, use 1 packet for every 5 gelatin sheets. Knox brand powdered gelatin has an approximate Bloom strength of 225 and contains about 7 g of gelatin per packet (Knox, n.d.). Bloom strength and g per packet vary by manufacturer.

³To fully invert maple syrup, add 1 tsp of invertase per gallon of syrup. For rapid conversion, hold maple syrup with invertase at 120 – 150 °F for 24 hours. Where time is not a factor, stir the solution thoroughly and store at room temperature for 3 - 5 days.

⁴Basic instructions for Powdered Maple Sugar are provided at the end of this recipe.



Directions

1. Submerge gelatin sheets in cold water until softened (10 - 15 minutes).
2. While gelatin is rehydrating, use a neutral-flavored oil to lightly coat two 8" x 8" baking pans, plastic wrap to cover the marshmallows while they set, and a rubber spatula. Remove excess oil with a paper towel.
3. Squeeze rehydrated gelatin sheets to remove excess water, and place them into a double boiler. Heat on low until the gelatin is liquid (2 - 3 minutes), taking care not to overheat.
4. Transfer liquid gelatin into a stand mixer with whisk attachment. Gelatin will gel as it cools and liquefy again as the hot syrup is added to the stand mixer.
5. In a medium saucepan, add the granulated maple sugar, inverted maple syrup, water, and salt. Heat to 245 °F. Immediately remove from heat and allow to cool to <200 °F.
6. Once the syrup has cooled, turn the stand mixer on low. Slowly add the cooled syrup to the gelatin by pouring it down the side of the mixing bowl. Be careful not to allow hot syrup to hit the moving whisk attachment as it can spatter and cause burns.
7. Increase stand mixer speed to high and continue to mix for 10 – 12 minutes.

8. Working quickly, use the rubber spatula to deposit the marshmallow mixture into the baking pans and spread evenly. Gently cover and press the oiled plastic wrap onto the exposed surface of the marshmallow to avoid formation of a crust. Allow the marshmallows to set at room temperature for 6 – 24 hours.

9. Coat a cutting board with Powdered Maple Sugar. Use lightly oiled hands to release the edges of the marshmallow from the baking pan onto the cutting board. Using a lightly oiled knife, cut the marshmallows into squares.

10. As each marshmallow is cut, coat completely with Powdered Maple Sugar. Shake excess powdered sugar off of the marshmallows using sifter.

11. Store marshmallows in an air-tight container for up to 3 weeks.

Recipe makes approximately 725 g.

Basic Instructions for Powdered Maple Sugar

To make 1 cup of powdered maple sugar with 3 % cornstarch, combine 194 g (~1 cup) finely ground maple sugar with 6 g (~1 tbsp) cornstarch in a bowl. Mix thoroughly with a whisk. To grind sugar, use a coffee or spice grinder, blender, or melanger. A melanger is a stone grinder that can uniformly grind particles to 10 - 20 microns. It is most often used for chocolate and nut butter production. More information on equipment and techniques for grinding sugar can be found in the Powdered Maple Sugar fact sheet. Sugar crystals should be ground until the powdered sugar dissolves readily on the tongue with no detectable crystals. To quickly discern how much cornstarch to add for a 3 % cornstarch powdered sugar, weigh the powdered maple sugar in grams and multiply the value by 0.03. The resulting value is the grams of cornstarch to add to the sugar. This method for calculating cornstarch addition rates is accurate for small batches of powdered sugar.

To comply with the physical granulation size requirements set by the United States Department of Agriculture (USDA), powdered sugar must be sifted through No. 100 or No. 200 U.S. Standard No. sieve sizes (USDA, 2015). Store the sieved powdered sugar in a glass jar or other high moisture barrier container.

Large-scale production of powdered sugar can be hazardous due to the combustible nature of sugar dust. These instructions are only intended for production of small batches of powdered sugar. Promptly clean any surfaces that may become coated with sugar dust.



Granulated maple sugar before (left) and after (right) grinding to a powder using a melanger.

Regulations

Regulation Requirements

To produce this product commercially in New York State, a process approval from a processing authority and either a Home Processor Exemption or a 20-C Food Processing Establishment License from New York State Agriculture and Markets must be acquired.

Process approvals are required for any food or beverage product manufactured in New York State for which a critical control point (CCP) is necessary to address any or all health hazards. The Cornell Food Venture Center offers process approval services which provide information on procedures to ensure a safe product, record keeping requirements, and information on licenses and registrations required to produce said product. The “Food Additives” section below is for general informational purposes only. All recipes must be reviewed by a processing authority before commercial production.

Individuals with a Home Processor Exemption are permitted to prepare fresh marshmallows in a home kitchen for wholesale and retail sale within New York State. For further information, please visit the New York State Department of Agriculture and Markets website, Home Processing page.

Individuals interested in sales outside of New York State must acquire a 20-C Food Processing Establishment License from New York State Agriculture and Markets. For further information, please visit the New York State Department of Agriculture and Markets website, Food Business Licensing page.

Food Additives

A food additive is any substance that becomes a component of or otherwise affects the characteristics of any food. Food additives must be “generally recognized as safe” (GRAS) or approved for use by the FDA; these include preservatives, stabilizers, anti-caking agents, among many others (FDA, 2018). Three food additives common in marshmallow production are tetrasodium pyrophosphate, sodium hexametaphosphate, and potassium sorbate.

Tetrasodium pyrophosphate is a synthetic food additive used to improve the gel strength and stability of foods (Tetrasodium pyrophosphate, 2022). In marshmallows, this additive helps stabilize gelatin, which is sensitive to elevated temperatures and elevation changes during transportation. In addition to marshmallows, this food additive is commonly used as a stabilizer in cottage cheese and a thickener in instant puddings (USDA-ARS, 2022). The FDA has labeled tetrasodium pyrophosphate as a GRAS food substance. There are no limitations on the amount added to food products (Tetrasodium pyrophosphate, 2022). Recommendations for use of tetrasodium pyrophosphate are unclear. O’Donnel and Wirebaugh (1996) patented a marshmallow using 0.05 – 0.15 % of tetrasodium pyrophosphate. These values are similar to those recommended by Hartel et al. (2018) for the general use of stabilizers: 0.1 – 0.2 %.

Sodium hexametaphosphate is a salt that acts as a sequestrant to improve quality and stability of food products (Sodium hexametaphosphate, 2022), possibly at high temperatures (Hartel, 2018). In marshmallows, it acts as a gelatin aid by increasing the rate at which marshmallows set. This is useful for shaped or extruded marshmallows that need to set quickly. Grettie (1940) reported that 1 – 2 % sodium hexametaphosphate per dry weight of gelatin resulted in a lighter, firmer marshmallow that set more quickly than marshmallows without the food additive. It is commonly used in pasteurized cheese, flavored beverages, and imitation syrups (USDA-ARS, 2022) and is considered a GRAS food substance. There are no limitations set by the FDA on the amount added to food products (Sodium hexametaphosphate, 2022).

Potassium sorbate is a salt of sorbic acid, which occurs naturally in some berries, particularly mountain ash tree berries (Alrabadi et al., 2013). The commercially available potassium sorbate is synthetically produced and acts as a preservative by preventing mold growth. Mold growth can occur in foods with high water activity (a_w). However, mold growth is unlikely in marshmallows (Hartel, 2018). Potassium sorbate can be added to help maintain quality by slowing color, flavor, and textural changes in food products. Potassium sorbate is also considered a GRAS food substance with no limitations on the amount added to food products (Potassium Sorbate, 2022).

Packaging and Shipping

Store marshmallows at room temperature in an air-tight container with a high moisture barrier. High moisture barrier packaging will prevent moisture migration and includes linear low-density polyethylene (LLDPE), polyethylene terephthalate (PETE or PET), and glass (Fig. 3).



Figure 3. Packaging examples for fresh maple marshmallows.

Marshmallows are prone to deformation when transported in reduced atmospheric pressure environments, such as over mountains, or when stored at elevated temperatures (95 – 104 °F). Food additives such as tetrasodium pyrophosphate can reduce deformation due to atmospheric pressure changes, while sodium hexametaphosphate may improve heat stability (Hartel, 2018). If no stabilizers are used, it is recommended to inform customers of potential changes during transportation and storage.



Maple marshmallows make decadent upgrades to s'mores and hot cocoa. Photos by Ailis Clyne.

Market projections

The marshmallow market in the United States has a value of \$342 million and is projected to grow to \$535 million by 2028 according to Fortune Business Insights (2021). This growth can be attributed to an increased demand for premium and artisanal confectionery products (Fortune Business Insights, 2021). Up-and-coming brands are dedicating their businesses to large scale production of “premium” marshmallows. These premium marshmallows that are contributing to market growth are employing marketing strategies such as printing “all-natural” on their labels, using organic cane sugar, and diversifying their product portfolios with a wide range of unique flavors to draw both adventurous and health-conscious consumers. Despite regional trends in American consumers restricting their sugar intake (Fortune Business Insights, 2021), health-conscious consumers are still in the market for sweet treats, and maple sugar can help fill that market niche for “all-natural” confections.

Forty-seven percent of consumers are purchasing confections that they consider “healthier” or “better-for-you”, according to the National Confectioners Association (NCA) (2022). Further, 9 of 10 consumers are interested in environmental commitments and social responsibility practices, all of which can be or are already met by maple producers.

While supermarkets are the current leaders in marshmallow sales, the rapidly growing online sales market can be a good avenue for marketing marshmallows as well. According to their 2021 state-of-the-industry report, the NCA saw online sales of non-chocolate confections nearly double between 2017 and 2019, increasing from \$366.9 million to \$655.2 million. They projected online sales to continue to increase in upcoming years.

Cost and Pricing

As described in the NY State Maple Confections Notebook (www.cornellmaple.com), determining a price for a value-added product entails adding up all the costs that go into production and choosing a margin of profit. These costs include: ingredients, packaging, capital investment (e.g., equipment), labor, and energy use. Labor costs vary from business to business, and energy costs vary according to equipment, among other things. These two variables will not be addressed here.

Additionally, marketing labor, shipping/delivery costs, product loss, and samples used for promotion should ultimately be taken into account and covered by your margins, but these variables can be difficult to measure directly, particularly prior to inclusion of a new product in your business model.

Equipment

The necessary equipment for a small scale operation is a stand mixer. Standard KitchenAid Stand Mixers range from \$400-\$700 depending on size. Assuming it will create 10,000 batches over the course of its lifetime, you can figure in \$0.04-\$0.07 per batch. This is a crude estimate.

Cost of ingredients

Costs shown are specific to the brands used during the development of this product (in italics); these ingredients were not sourced for competitive pricing.

| Ingredient | Cost per 725 g batch |
|---|----------------------|
| Silver Gelatin Sheets from <i>PerfectaGel</i> | \$1.77 |
| <i>Cornell</i> Maple Syrup ¹ | \$7.19 |
| Invertase from <i>LorAnn Oils</i> | \$0.03 |
| Salt (negligible) | \$0.00 |
| Total cost per 725 g batch: | \$8.99 |

¹Includes syrup used to make granulated sugar and inverted syrup, using Cornell Maple Program's current wholesale price. Does not include the cost of converting syrup to sugar.

Premium (luxury, gourmet) marshmallows are most commonly sold in 4 oz (113 g) retail units. One batch of this Maple Marshmallow recipe would make over 6 retail units. The ingredients alone, when sourced as they were for the development of this product, contribute \$1.41 to the cost of production. This cost is expected to decrease with bulk purchasing and sourcing for competitive prices. For reference, the average current retail price across the top seven premium marshmallow brands is \$7.14.

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Citations

- Alrabadi, N.I., M. Al-Massad, and A.A. Gharaibeh. 2013. The antifungal effect of potassium sorbate on *Penicillium* sp in Labaneh. *Amer.-Eurasian J. Agr. Environ. Sci.* 13(11): 1497-1502. <https://doi.org/10.5829/idosi.aejaes.2013.13.11.81265>
- Boerner, L.K. 2021. What's in marshmallows, and how do the ingredients work together to make ooey-goey treats? *Chemical and Engineering News*. <<https://cen.acs.org/food/food-science/s-marshmallows-ingredients-work-together/99/web/2021/04>>.
- Burton, J. 2014. Guide to Gelatin. *Stella Culinary*. <<https://stellaculinary.com/cooking-videos/food-science-101/fs-003-guide-gelatin>>.
- Fortune Business Insights. 2022. Marshmallow Market Size, Share and Industry Analysis, By Type (Flavoured Marshmallow, Unflavoured White Marshmallow), By Distribution Channel (Supermarkets/Hypermarkets, Specialty Stores, Convenience Stores, Online Retail) and Regional Forecast 2022 – 2029. <https://www.fortunebusinessinsights.com/marshmallow-market-103832>
- Grettie, D.P. 1940. Gelatin. U.S. Patent No. 2,196,300. U.S. Patent and Trademark Office. <https://rb.gy/ik0fb0>
- Harris, P., Normand V., and Norton, I. T. 2003. Gelatin. In B. Caballero, L. C. Trugo, & P. M. Finglas (Eds.), *Encyclopedia of Food Sciences and Nutrition* 2nd edition (pp. 2865–2871), Elsevier.
- Hartel, R.W., von Elbe, J.H., and R. Hofberger. 2018. Ch. 11. Aerated Confections. In R.W. Hartel, J.H. von Elbe, and R. Hofberger (Eds), *Confectionery Science and Technology* (p. 301-328). Springer Nature. DOI: 10.1007/978-3-319-61742-8
- Knox. (n.d.). Knox Basics. Knox Unflavoured Gelatine - The Basics. Retrieved March 2, 2023, from <https://www.knoxgelatine.com/basics.htm>
- Mahboubi, M. 2020. Marsh Mallow (*Althaea officinalis* L.) and Its Potency in the Treatment of Cough. *Complementary medicine research*, 27(3), 174-183.
- National Confectioners Association. 2022, 13 March. Sweet Insights: State of Treating 2022. <https://candyusa.com/sweet-insights-state-of-treating-2022/>
- O'Donnel, L.T. and R.S. Wirebaugh. 1996. Melt Restricted Marshmallow U.S. Patent No. 5,532,017). U.S. Patent and Trademark Office. <https://rb.gy/ik0fb0>
- Potassium sorbate, 21 C.F.R. § 182.3640, 2022.
- Sodium hexametaphosphate, 21 C.F.R. § 182.6760, 2022.
- Tetrasodium pyrophosphate, 21 C.F.R. § 182.6789, 2022.
- United States Department of Agriculture (USDA). 2015. Commercial Item Description. Sugar, white, refined, and sugar, brown. www.ams.usda.gov/sites/default/files/media/CID%20Sugar%20Refined%20White%20and%20Sugar%20Brown.pdf

United States Department of Agriculture, Agricultural Research Service (USDA-ARS).
FoodData Central, 2022. fdc.nal.usda.gov

U.S. Food and Drug Administration (FDA). 2018. Overview of Food Ingredients, Additives & Colors.
<https://www.fda.gov/food/food-ingredients-packaging/overview-food-ingredients-additives-colors#foodadd>

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Cornell University
College of Agriculture and Life Sciences
Department of Natural Resources