PLANT VERSUS ANIMAL

Plant-Based Alternatives to Gelatin: Hydrocolloids in Confectionery

Gelatin is compared to plant-based replacement hydrocolloids used in gummies and marshmallows.

by Nesha Zalesny

A vast array of confectionery textures are possible using hydrocolloids, but what it generally boils down to is engineering. Reformulating confectionery products to be vegetarian or vegan is a massive undertaking that not only involves the formulation, but can also involve capital investment for new processing equipment.

This article will compare and contrast gelatin with replacement hydrocolloids in chewy or aerated confections. Note that chocolate for enrobing or consumption in bar form contains little to no water, and hydrocolloids are not generally used in chocolate. This article will focus on confectionery products that contain hydrocolloids to derive their texture.

Gelatin: The Gold Standard

When developing a new confection, one of the first ingredients confectioners reach for to provide texture is gelatin. The texture, clarity, and flavor release of gelatin-based products is the gold standard. Gelatin also has ideal processing properties; it has a very low hot viscosity, a low setting temperature, and a slow set. It is also the only protein among the most common hydrocolloids, which are generally carbohydrates. Gelatin has a unique blend of amino acids, the most important of which are proline and hydroxyproline.

It is these amino acids, along with production methods, that determine the gel strength. Gel strength is measured using standardized tests and is expressed in units of "bloom." Most producers offer low (<125 bloom), medium (150-200 bloom), and high (>220 bloom) grades. Each range has a confectionery category as noted in the following table.

Gummy confections rely on gelatin's low hot viscosity and low set temperature. Gummy bears are made by pre-hydrating the gelatin in as little water as possible, then combining with combinations of sucrose and corn syrup in jet cookers. Colors and flavors are added, and the warm solution is deposited into starch molds. These are trays filled with 5-7 cm of starch that have the desired shape indented into the surface of the starch. The candy is then cooled and dehydrated to the desired finished solids or percentage of sugar. This can run from 75% to 85% for most confections. The gelatin sets fully during the dehydration/cooling step.

In reality, the process is more complex than this simple description. Water use must be minimized. Any water added needs to be cooked off, and additional cook time reduces plant through-put. The hot viscosity of the corn syrup/sugar/stabilizer blend needs to be consistent; low enough to flow properly into the starch molds, but high enough that it doesn't flow freely through the depositor, and not so high that it tails between deposits. The starch molds have to have the right density of starch to hold the shape when the hot liquid is deposited. These are just a fraction of the things that can go wrong. Next time you consume a gummy bear, take a moment to appreciate the engineering and food science miracle that it is.

For aerated confections such as marshmallows, low levels of high bloom strength gelatin (>220 bloom) gives a soft creamy textured marshmallow. Higher concentrations of low bloom gelatin (<200 bloom) will give a chewier, more cohesive texture. Hydration of gelatin is similar to processes used for gummy manufacture, but where the hot solution is simply deposited for gummies, marshmallows are made by whipping, then either depositing into starch at 50°C–60°C or extruded at 35°C–45°C. Gelatin works well in aerated confections because it stabilizes the foam and reduces the surface tension of the water phase, making air incorporation possible.

Switching to Plant-Based

One of the major trends within the food industry has been the plant-based movement. Consumers concerned with health and the environment have focused on plant-centered diets. This has pushed plant-based meat and dairy products into double-digit growth for several years. This

› *Gelidium type agar is based on red seaweed that grows off the coast of Morocco, France, and Spain.*

trend has made its way into the confectionery world, with major grocery chains in Germany announcing late 2020 that they are replacing gelatin-based gummies with vegan options. Similarly, Nestlé brand Rowntree (UK) reformulated its Fruit Pastilles to be vegan-friendly.

Making the switch to a plant-based hydrocolloid is a weighty undertaking. The ideal gelatin replacement must be easy to hydrate at high concentrations, have a low hot viscosity, a low set temperature or a set that is easily controlled. It should also have good clarity, texture, and flavor release.

These properties would essentially allow formulators to "drop in" a different hydrocolloid and use the same production lines and processes they use with gelatin-based products. Unfortunately, drop-in solutions don't really exist. Of the nearly twenty hydrocolloids that are commercially available, only five or six form a gel and can be used in confectionery applications. Agar, carrageenan, gellan, pectin, and starches are all possible replacements, but all require a bit of re-engineering to do the job.

Agar's Performance

Agar is one of the oldest hydrocolloids known to man. There are three commercially available types based on red seaweed. The seaweed grows in the warm waters off the coast of Morocco, France, and Spain (gelidium), or Indonesia and China (gracilaria), or the cold water off the coast of Chile (agarophyton).

Gelidium is primarily used in bacterial plates as it is non-ionic and resistant to enzymatic breakdown. It can be used in food applications as well, but it tends to be pricier than the agarophyton or gracilaria types.

Agar is the least soluble of the gelling hydrocolloids. In its native form, it is virtually insoluble in cold or warm water. It requires a lot of time and plenty of water to hydrate, a ratio of 30 parts water to 1 part gum is recommended. It is more readily soluble in boiling water, but still requires time to completely hydrate. This makes agar difficult to use in continuous or automated plants. There are treated agars that solubilize at significantly lower temperatures, but these have higher hot viscosity, which changes pumpability, flow, and depositing significantly.

› *Marshmallows with carrageenan have less overrun and thus a firmer texture than gelatin, making it less ideal to be pressed between two graham crackers and a piece of chocolate for a s'more.*

Agar has a large gap between its melting temperature (85°C) and its set temperature (35°C–40°C). It is the set temperature that makes agar one of the better plant-based options for gelled and aerated confectionery. It is possible to deposit the hot solutions into starch molds prior to set. The viscosity of the hot solution is higher than gelatin, so the detailed shapes that are possible with a gelatin-based system are more difficult to achieve with agar.

The texture of agar is more brittle than a gelatin confection. The brittleness of gelidium type agar can be modified with the addition of locust bean gum for a chewier texture. The low set temperature also makes it possible to be used in aerated confections or marshmallows, but the overrun possible is lower than gelatin as agar does not lower the surface tension of the water phase by much.

Table 1: Gel Strength Measured in Bloom

Confectionery Type	Gelatin Concentration	Bloom Strength
Gummy Bears	7%-9%	200-250
Marshmallows	1.7%-2.5%	225-275
Circus Peanuts	2%-2.5%	200-225

Agar's Positives

On the plus side, however, the high melt temperature makes agar stable in warmer climates, not to mention being vegan and available in kosher and halal types. If accommodation can be made for the hydration, agar is a good option for both gummy and aerated type confections. Use levels are 0.5%–0.9% for gummies, with a similar range for aerated confections. Gelidium type agar will fall on the lower concentration range, agarophyton in the middle range, and gracilaria at the upper range.

Carrageenan Properties

There are three commercially available gelling types of carrageenan: kappa, kappa II, or iota types. Kappa and kappa II type gel with monovalent ions such as potassium. Kappa has a firm, brittle texture, while kappa II has a firm, but more elastic texture. Iota type gels require divalent ions such as calcium and have a much more elastic, wobbly texture. Kappa types are readily soluble in higher sugar concentrations, but iota is less so. The key to working with carrageenan in high solids systems is to ensure hydration and be aware of mono and divalent ions coming from other ingredients.

There is a variety of textures using blends of each type and varying levels of ions. Carrageenan gummies have good clarity and flavor release. However, carrageenans are difficult to incorporate into existing starch mold confectionery lines due to significantly higher set temperatures and a more rapid set. They are also prone to acid hydrolysis in their liquid form (dissolved, but prior to the set of the gel), so acidification for carrageenan type confectionery should be one of the last steps prior to deposit. The hot viscosity is high, which makes tailing between deposits an issue. Carrageenan type gummies are more suitable to silicone molds than starch molds and better still may be candies formed in slabs then cut and sugared. Use levels will range from 0.4%–0.9% for gummies and 0.6%–1% for aerated confections.

Carrageenan in Marshmallows

Blends of kappa and iota can also be used successfully for aerated confections such as marshmallows. Here, the iota type is particularly useful. As with agar, the overrun possible with carrageenan is significantly lower than the overrun possible with gelatin. Whipping proteins are also necessary for forming a good foam; these can be egg whites or soy protein. Marshmallows made with carrageenan have a good, if chewier, texture. The melting properties are different as well. Making s'mores with carrageenan marshmallows is a bit different as the melt temperature is much higher as compared to a gelatin marshmallow.

Gellan Gum for Intricate Shapes

Gellan gum is another option for gummy candies. There are two forms: high or low acyl gellan. The low acyl form is the preferred form for gummy candy as it is usually clarified and has a very low hot viscosity. It is very calcium and pH sensitive. It has very low use levels and good flavor release. In high solids gummies, the texture of low acyl gellan gum is soft and elastic. The texture is influenced more by pH than by calcium. Buffering high solids systems with SHMP (sodium hexametaphosphate) is recommended to bind up calcium. Low acyl gellan gum hydrates best in low ionic or buffered environments and it has a high set temperature. Gellan gum has a snap set and will set between 38°C–45°C depending on the ions present. Deposit should be done hot. The low hot viscosity makes it flow well into intricate gummy shapes, but because the set temperature is high, pre-gelation is a risk. These properties also make it difficult to drop into a typical confectionery line. The high set temperature also makes the incorporation of gellan into marshmallows difficult. Typical use levels can be as low as 0.2%–0.8%.

› *The low acyl form of gellan gum is preferred over the high acyl form for gummy candy as it is usually clarified and has a very low hot viscosity.*

Pectin for Simple Molds

The high solids and low pH of fruit-flavored jellies make high methoxyl (HM) pectin a good choice. HM pectin jellies have good clarity and a soft gummy texture. HM pectin comes in a range of methoxylation ranges from 55%–75% that dictate the set. This range is referred to as the degree of methoxylation (DM). In most cases, the higher the DM, the more rapid the set. Much care needs to be taken to select the cor-

› Gum acacia can be used to modify texture, reduce sugar, and stabilize foams within gummy and aerated confectionery applications.

rect pectin. High solids and low pH are ideal conditions for pectin to set, meaning pre-gelation can be a problem. Pre-gelation occurs when the pectin sets prior to deposit, but the set gel gets broken up creating microgels or gel bits within the matrix, which is then deposited. This results in a soft, mushy, or grainy texture. Many pectin suppliers offer pre-blended pectins that contain buffers to control pre-gelation. Pectin use levels will range from 1.2%–1.5%.

Pectin confections are generally soft and less cohesive than what is possible with other hydrocolloids. Hot pectin solutions have a higher hot viscosity than the other hydrocolloids which also makes the flow properties less ideal for detailed starch molds. It is good for simple starch mold shapes, silicone molds, or slab type confectionery. It is not commonly used for aerated type confections.

Starch: An Essential Ingredient

Last but certainly not least, starches are very commonly used for confections. There are a vast amount of starches available for use in confectionery applications ranging from the simple inert starch used for starch molds to highly substituted or modified starches that can give a nearly gelatin-like chew. Starches are essential to the plant-based confectioner. Use levels of starches tend to be significantly higher than other hydrocolloids, so flavor release may be muted. Use levels can range from 2%–7% in gummy confections.

High amylose corn starch is one of the most common starches used within the industry, but rice, tapioca, and potato starch can all be used to achieve different textures. These different varieties have different granular sizes, waxy maize starch being on the lower end of granulation and potato on the high end of the spectrum. Unmodified starches tend to have a higher hot viscosity which makes using them in starch molds a bit more problematic. High hot viscosity starches can be cut with acid-thinned starches, which have a lower hot viscosity. Blending the two types can help confectioners achieve various textures. Starches do not have a snap set. Depending on the starch, they can take anywhere from 16 to 72 hours after depositing to set, depending on the starch type.

Textures Unlimited

Hydrocolloids offer a world of different textures to consumers within the confectionery world. The gelling hydrocolloids can be blended with one another to create even more unique textures. A common blend is gelatin and pectin for softer and more heat-stable gummy bears. Gum acacia can also be used to modify texture, reduce sugar, and stabilize foams within gummy and aerated confectionery applications. All the options discussed are not drop-in solutions, however. Some adjustments to processing will be necessary to account for differences in hydration, hot viscosity, and set characteristics.▼

Nesha Zalesny is co-author of ***The Quarterly Review of Food Hydrocolloids***, an in-depth analysis on hydrocolloids, produced by IMR International since 1991.