Advancements in Gummies

As gummi popularity continues to grow, the adaptability of this confection encourages advancements in formulation and production methods to meet consumer demand.

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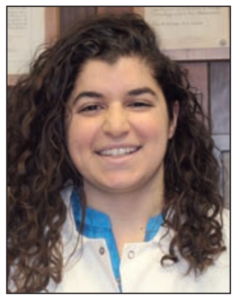

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Everyone is looking for the next big thing in confections, be it a hot new product or a unique innovation. With growth of 3 to 4 percent annually and projected retail sales of $5 billion by 2022, it can be argued that gummies *are* the next big thing. As the gummi industry continues to grow, advancements are needed to meet market demand. Fortunately, the adaptability of the gummi encourages evolving formulation and production methods. Here we review the definition of a gummi, gummi formulas and types of cookers used, starchless depositing, gelatin reduction, reduced-sugar and vegan gummies, and lastly, ways to reduce gummi production costs.

STANDARD GUMMI FORMULATION

A gummi is a gelatin confection made with bulk sweeteners, flavor, acid and colors, and typically has a rubbery texture. The gelatin not only stabilizes the product, but also creates the iconic texture that distinguishes gummies from other chewy candies such as licorice or spearmint leaves.

Gelatin is a gelling agent derived from collagen. The typical range of gelatin in a gummi is 6 to 8 percent, but more or less can be used depending on the desired texture. Gummies have a very straightforward formula—sweeteners, stabilizers, flavors and colors. However, several variations exist that create a wide range of different profiles and textures. Formulas for gummies using various levels of gelatin can be seen in Figure 1.

There are two types of gelatin: Type A and Type B. In the Figure 1 formulas, the gelatin used is Type A. The type refers to the gelatin extraction process. Type A goes through an acid extraction while Type B, an alkali extraction. Pork skin is the most common source of Type A gelatin whereas bones are the most common for Type B. The main difference between the two gelatin types is their isoelectric point; Type A is 7.0 to 9.0 and Type B is 4.7 to 5.4.

Gelatins are available in a wide range of bloom or gel strengths. The higher the bloom number, the stiffer the gelatin, which is common in more expensive gummies. The general range for gelatin is 125 to 250 bloom, but lower and higher blooms exist. Modifying bloom strength (i.e., higher to more of a lower bloom) is an easy way to reduce sugar, and optimize cost and texture without compromising product quality. If changes between different blooms of gelatin are of interest, the Figure 2 chart is a great tool for making a smooth transition in formulation. It is important to note that lower bloom strength gelatins have a ten-

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Gelatin changes are not the only factor that can contribute to texture differences in gummies. Other factors that affect texture are the percentage of corn syrup in a formula, and the dextrose equivalent (DE) of the corn syrup and its corresponding carbohydrate profile. Corn syrup is oftentimes the predominant ingredient in gummies. Corn syrup gives the gummi body and acts as an anticrystallizer. These anticrystallizing properties both prevent crystallization and increase product shelf life. In general, low DE syrups add body and strength to a gummi while higher DE syrups add sweetness, lower viscosity and improve shelf life.

Dextrose equivalent is the amount of reducing sugars (dextrose/glucose) in the product. Therefore, a 42 DE corn syrup contains 42 percent reducing sugars. The higher the DE, the thinner the corn syrup, and with thinner corn syrup, the cooked sugar slurry becomes less viscous and easier to deposit. Higher DE is also sweeter than lower DE, and slightly improves the stability of the finished product. Along with these changes is texture change. A higher DE corn syrup will produce a softer, less chewy product than its lower DE counterpart. The most common corn syrup for gummies is 42/43 DE but there are several products that use a 63 DE.

In addition to DE, changes to the carbohydrate profile can be made. A high-maltose corn syrup (65% maltose) is sweeter, less viscous and is a better humectant than the typical 42 DE corn syrup. Like the higher DE corn syrup, a high-maltose corn syrup will produce a sweeter, more stable product and will be easier to deposit. Another benefit of using high-maltose corn syrup is that the product will be less sticky.

Syrups derived from corn are not the only syrup options for gummies. Rice syrup and tapioca syrup can also be used. Just as with corn syrup, the DE and carbohydrate profiles of rice and tapioca syrups impact the gummi's texture. These syrups are natural and can be organic as well as GMO-free, which is becoming increasingly important with consumers today.

GUMMI COOKING METHODS

Gummies are traditionally cooked using coil cookers (Figure 3), where pre-dissolved slurry is pumped through stainless steel coils that are heated with indirect steam. Once heated to the correct solids, the slurry is sent through a vacuum aid for moisture removal. After heating, colors and flavors are mixed into the slurry, then transferred to the depositor. This method of cooking is well known and pretty infallible except when the operator rushes and burns product on the inside of the coil. This can result in undercooked syrups, depositing of product at the wrong solids and an engineering/maintenance cleanup mess. ➤

Gummi Formula Variations and Gelatin Levels

Ingredient	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Gelatin Type A 200 Bloom	5.0%	6.0%	8.0%	9.0%	10.0%
Water	10.0%	12.0%	16.0%	18.0%	20.0%
Granulated Sugar	37.0%	36.5%	35.5%	35.0%	34.5%
Corn Syrup 42 DE	47.0%	46.5%	45.5%	45.0%	44.5%
Water	12.0%	12.0%	12.0%	12.0%	12.0%
Citric Acid (50%)	2.0%	2.0%	2.0%	2.0%	2.0%
Flavor and Color			as desired		
Cooking Temperature	233.6°F 112.0°C	237.0°F 114.0°C	244.4°F 118.0°C	248.0°F 120.0°C	251.6°F 122.0°C

Figure 1

Bloom Conversion Chart

Percent Gelatin Requirement for Equivalent Bloom Strength

Bloom	50	75	100	125	150	175	200	225	250	275	300	325
50	**100**	81	67	60	55	51	45	43	40	37	37	33
75	125	**100**	85	75	68	66	57	53	50	46	45	41
100	146	116	**100**	88	80	73	68	63	58	54	51	47
125	164	131	114	**100**	90	84	77	71	66	62	57	54
150	180	145	125	111	**100**	92	85	78	73	70	64	59
175	195	158	136	121	108	**100**	93	86	81	76	70	65
200	208	171	147	130	117	109	**100**	92	87	82	76	71
225	222	183	158	139	125	116	108	**100**	93	88	82	77
250	236	195	169	147	133	124	116	108	**100**	94	88	81
275	250	208	180	158	141	138	125	116	107	**100**	94	88
300	263	220	190	166	148	139	132	123	113	107	**100**	84
325	277	233	201	174	156	147	140	130	120	113	105	**100**

Example: Replacing 100 parts of 175 bloom would require 108 parts of 150 bloom

Figure 2 *AOAC International*

While coil cookers remain an extremely popular method of cooking gummies, the use of jet cookers has become a viable alternative. Jet cookers are commonly used to cook starch product. These cookers, an example of which is seen on the right side of Figure 3, are a very straightforward and uncomplicated method of cooking. In addition, they are also cost-effective due to their high efficiency. Jet cookers use direct, high-pressure, super-heated, food-grade steam to cook slurries very quickly. The sensible heat and latent heat of the steam work in tandem to speed up the cooking process. Once heated, the slurry is then discharged into a flash chamber where it begins to cool and other ingredients such as acid, color and flavor are added. This fast, high-heat cooking is essential in starch cooking, especially when high-amylose starch is used.

Gelatin does not require such intense temperatures and heat for activation, which is why jet cookers had not previously been thought of as a method of choice for cooking gummies. However, jet cookers are now being retrofitted to cook gelatin gummies. Manufacturers using jet cookers for gummies are taking advantage of the rapid cooking ability of the steam for their products. An additional benefit of the jet cooker is that since the steam is direct, it requires less water in the initial syrup slurry. The drawback of jet cookers is that the steam used must be food-grade since it is in contact with the product, unlike the coil cooker, which uses indirect steam to heat the coils that contain the slurry. Coil versus jet gummi cooking formulas are compared in Figure 4.

In any cooking method, degradation of the gelatin needs to be avoided. This occurs when the gelatin is cooked to too high of temperature or held at elevated temperatures for extended periods of time. This degradation results in a loss of bloom strength, creating a less firm gel and a loss of structure.

DEPOSITING METHODS

Manufacturing efficiency is always the goal when it comes to any production process. For optimal gummi depositing efficiency, production needs to be upward of 2,000 lbs. per hour. To run at such high efficiencies, the slurry is deposited at lower solids that are less stringy into dry moulding starch and subsequently "stoved" or dried to the final solid state. For a standard gummi, the syrup will be deposited at solids around 75 to 77 percent, and dried until final solids are 78 to 82 percent, as measured by a refractometer. The moulding starch allows excess moisture to be wicked out of the pieces into

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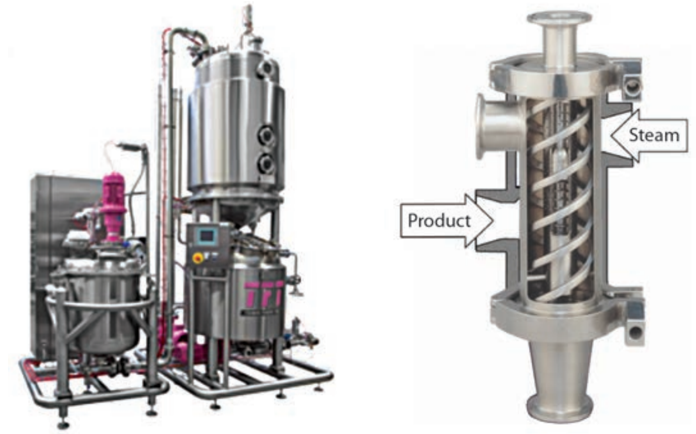
Coil and Jet Cooker Systems



Coil Cooker
- Common in industry
- Compatible with a variety of products and formulas
- Usually consists of three parts: pre-cook, coil chamber and vacuum tank

Jet Cooker
- Uses direct steam (food grade)
- High efficiency
- Cost-effective: less expensive than coil cookers
- Easy maintenance
- Capable of cooking high amylose starches

Figure 3

Gummi Cooking Formulas for Coil and Jet Cookers

Ingredient	Coil Cooker Formula	Jet Cooker Formula
Gelatin 250 bloom	5.3%	6.0%
Corn syrup 42 DE	39.5%	43.9%
Granulated sugar	32.5%	36.1%
Water (for gelatin solution)	10.6%	10.0%
Water (for sugar solution)	12.2%	4.6%
50% citric acid solution	1.0% – 2.5%	1.0% – 2.5%
Flavor	as needed	as needed
Color	as needed	as needed

Note: These formulas differ in the amount of water needed during the process. The jet-cooker formula requires about 8 percent less water.

Figure 4

Avoiding dust buildup with good housecleaning is essential with starch depositing lines to steer clear of powder explosions.

the atmosphere. Moguls, a name used for depositing lines, as shown in Figure 5, are very large production lines that require significant space for optimum efficiency. In addition, moguls can cost upwards of $10 million to $12 million and require 500,000 to 1,000,000 lbs. of dry moulding starch.

STOVING

Stoving, or drying of gummi product, is typically done in moulding starch, which is cornstarch (or similar type) with a minuscule amount of oil added to decrease dust. Avoiding dust buildup with good housecleaning is essential with starch depositing lines to steer clear of powder explosions. Stoving conditions are dependent on the product. In general, starch needs to be at temperatures between 80°F and 95°F (26.7°C and 35°C) with moisture content of 6 to 7.5 percent to prevent a "skin" from forming on the product. The temperature and moisture content of the moulding starch for gummies is a little lower than that of other jellies. Once in the starch, product is typically stoved for 4 to 36 hours before being removed and prepared for packaging.

STARCHLESS SYSTEMS

An alternative method for gummi depositing is starchless moulding, such as depositing into thermoformed plastic trays or silicon/metal moulds, generally oiled with a release agent to improve release after setting. Starchless depositing has the advantages of faster set times, low capital investment, no need for moulding starch and a reduction in product cross-contamination risk. Starch contamination is becoming an important issue with recent food safety and traceability notices. Related to this, gummies have become a great delivery system for vitamin and pharmaceutical applications, which makes contamination prevention that much more crucial. Starch contamination occurs when tailings or product residue remains in the starch. This cross-contamination can generate active ingredient problems or allergen issues.

There has been reasonable success in retrofitting moguls to run starchless by eliminating moulding starch and using plastic or rubber mould inserts in the starch boards. Success is based on the formulas used (generally pectin, a gelatin-pectin blend or another stabilizer) and the need of a mould release agent to facilitate product releasing from the moulds once set. Alternatively, specialized systems can be employed that similarly use metal, plastic or silicon moulds, and generally are much smaller in design than a typical starch-based system. These systems incorporate a mould, release agent spray, depositor, cooling or setting chamber and demoulding section. These types of systems even have the capability to run book moulds as seen in Figure 6. These book moulds are expensive but allow the ability to create three-dimensional pieces.

Although starchless depositors similar to book moulds are in use, none are currently producing a gummi with the rubbery texture attained with starch moulding. Instead, these depositors are producing product with a more jelly-type texture, despite having gelatin in the formulation. In an attempt to make a starchless-moulded gummi comparable to a starch-moulded product, a specialized European gelatin for starchless moulding was tested at 11 percent and compared to a 6.5 percent starch-moulded control piece. These results are shown in Figure 7. With almost twice the gelatin, the texture of the starchless product was similar to that of the starch-moulded ➤

Diagram of a Mogul Depositing Line

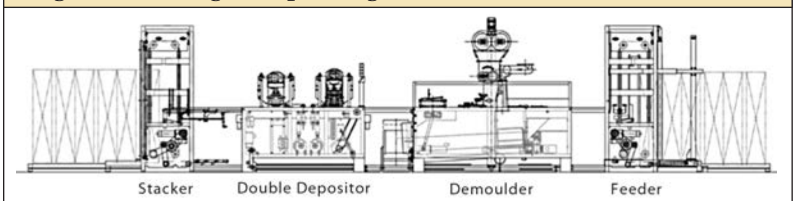


Figure 5

piece, but it was harder to chew through and was less elastic. Also, the flavor was not as strong and, quite frankly, starchless pieces can taste a little stale, even when fresh. Adding pectin or changing gelatin levels can modify texture, however, it may take extensive time and resources to achieve an identical texture to a gummi produced in a starch mogul.

FORMULA ADVANCEMENTS

As shown in the initial formulas provided in Figure 1, gummies are typically made with various levels of gelatin, but its use does bring with it some drawbacks; namely, thermos-reversibility, cost and dietary restriction (i.e., vegan, kosher, and halal). This being said, blends of stabilizers with and without gelatin continue to be evaluated and used for cost saving purposes, some more successfully than others.

The idea of using starches in gummies has been around for some time, and several companies are currently using starches for cost saving purposes. The rationale for using starches in gummies is to reduce cost and improve stability while maintaining the inherent gummi characteristics of the product. The theory behind this rationale is that the addition of starch will help gel the piece together, and the smaller portion of gelatin can then contribute to the rubbery texture. This works to some extent, however, issues are frequently seen with cloudiness, taste-masking and loss of some texture quality. Also, there is a concern that some of these starches require the use of a jet cooker to fully activate the starch.

Although quite commonly known and used today, starches causing loss of product quality continues to limit its acceptance. Most variations of thin-boiling starches will produce a cloudy-looking piece, as seen in the Figure 8 comparison. Thin-boiling starches are one of the most common modified starches in chewy confections. This hydrolyzed starch has a reduced viscosity at high temperatures, which is ideal for efficient depositing in a manufacturing setting. But to mimic and/or duplicate gelatin's texture, other types of modifications must be made to starches, such as cross-linking and heat treatment. These starch modifications do a better job at obtaining a rubbery gelatinous texture, however, many of these starches require the high heat and shear of a jet cooker for gelatinizing.

Even with all of these modifications, starch's relative stickiness, its effect on the clean bite or chew of pure gelatin, and its flavor mask (some starches, even though designated as flavorless, still leave starchy notes) on the product remain. These negatives have made it difficult to use typical corn-based starches to reduce cost for gummies since the results have often shown a change in texture, appearance, flavor and quality.

3D Book Mould Starchless Operation

Note: Line is no longer in use.

Figure 6

Starch versus Starchless Moulded Gummi Characteristics

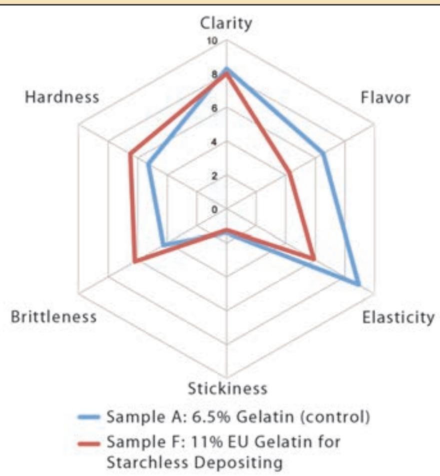


Figure 7

The idea of using starches in gummies has been around for some time, and several companies are currently using starches for cost saving purposes.

Recent research has shown significant value and benefit in using modified potato starches.

Research continues on exploring alternative options, such as carrageenans or other specialized starches designed to be gelatin replacers or extenders. The use of high-methoxyl pectin in gummies is popular for stability issues, but again, its incorporation is frequently seen as modifying the product's final chewiness and texture. Additionally, from a cost standpoint, pectin is an expensive alternative.

Recent research has shown significant value and benefit in using modified potato starches. While similar to corn-based modified starches, potato starch benefits include neutral taste, stability and no special cooking requirements, and providing the superior gelatinous texture of chew, bite and malleability. Testing on gelatin extenders or replacements has been ongoing for many years, and just recently, one has been identified for continued consideration. This is a modified potato starch from Denmark. A blend of gelatin in combination with this modified potato starch has been validated to produce a quality gummi with the added benefit of being able to be cooked with any type of cooker. It can also be cooked in an open pan cooking process.

Gummies Produced with Cornstarch versus Gelatin Showing Cloudiness

Cornstarch-based gummies are seen on the left versus gelatin-based gummies on right.
Figure 8

SAMPLE EVALUATIONS

Several samples were produced to evaluate the use of various gelling agents in addition to gelatin. The gelling agents investigated were modified corn, potato and tapioca starches, as well as pectin. These pieces were compared to a 6.5 percent gelatin control piece using a formula comparable to that of products generally available on the market.

Sample evaluation ingredients and gelling agents can be seen in Figure 9. Samples were tested using a sensory panel. While there might have been some subjectivity in their evaluation, the average of the panelists' results were both representative and consistent. Testing results were as follows:

- Sample A: A baseline control piece characterized as a typical European or American high-quality gummi containing 6.5 percent 250 bloom gelatin.
- Sample B: There were some noticeable texture differences from the control piece with the addition of thin-boiling cornstarch. Texture became shorter and stickier. Flavor also became masked and the piece looked cloudy in appearance.
- Sample C: The addition of pectin resulted in loss of some characteristic gummi bounce. The piece was rubbery, but much shorter in texture. This sample required much less chewing and almost seemed to dissolve.
- Sample D: More closely resembled Sample B with cornstarch than the gelatin control piece. This sample had less gelatin than Sample B, but would require jet cooking.
- Sample E: This sample had a core and rubbery texture similar to the gelatin control piece. There was very little impact on clarity and flavor compared to the control sample. The stickiness increased slightly but overall the piece shared several characteristics of the gelatin control piece. Since this starch is sourced only from potatoes, the gelling temperature is much lower than other starches, particularly cornstarch. This lower gelling temperature permits this starch to be used with either coil or jet cooker and also in open pan cooking.

Looking at the spider graphs in Figure 10, there is a visible difference between each of the starches and the pectin. The piece that showed the most similar characteristics to the gelatin control was Sample E using the Danish-modified potato starch. Differences remained between the two pieces, though the potato starch piece did indeed possess the iconic rubbery chew that distinguishes a gummi.

Gummi Sample Evaluation Ingredients and Gelling Agents

Ingredient	
Granulated Sugar	33% – 36%
Corn Syrup	43% – 46%
Water	12% – 18%
Citric Acid (50%)	2% – 3%
Flavor	~0.25%
Color	~0.1%
Gelling Agent*	6% – 10%

* Gelatin, starch, pectin or combination, depending on sample

Gelling Agent		
Sample A	Gelatin	6.5%
Sample B	Gelatin	5.0%
	Thin-boiling cornstarch	3.0%
Sample C	Gelatin	5.0%
	High-methoxyl pectin	0.5%
Sample D	Gelatin	3.0%
	EU-modified potato/tapioca starch	7.0%
Sample E	Gelatin	3.0%
	Danish-modified potato starch	7.0%

Figure 9

Evaluating Sample Cost Savings

Regarding cost savings, all the starch samples indicated a positive impact on cost. This is due to the replacement of gelatin at roughly $4.00/lb. with starches at $0.45 – $0.70/lb. or less (approximate 2018 price). Since Sample E had the best result texture-wise, a cost-saving exercise was performed with this sample and starch ingredient. Switching from a formula with 6.5 percent gelatin to one with 3 percent gelatin and 7 percent Danish-modified potato starch generated a more than 50 percent reduction in gelatin use equating to a more than 19 percent cost saving. This formula does not require any change to equipment since the potato starch product can be cooked with any type of cooking system. Different ratios of gelatin and starch can be used to achieve different textures and reduce cost. For instance, a formula with 5.5 percent gelatin and 3 percent Danish-modified potato starch will yield an approximate 5 percent cost saving, while the panel evaluation showed close quality parity to the 6.5 percent gelatin control piece.

Sample Stability Evaluation

In addition to sensory evaluations, stability evaluations of the pieces were performed.

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Industry Standard Gummi versus Potato Starch as Gelatin Replacement

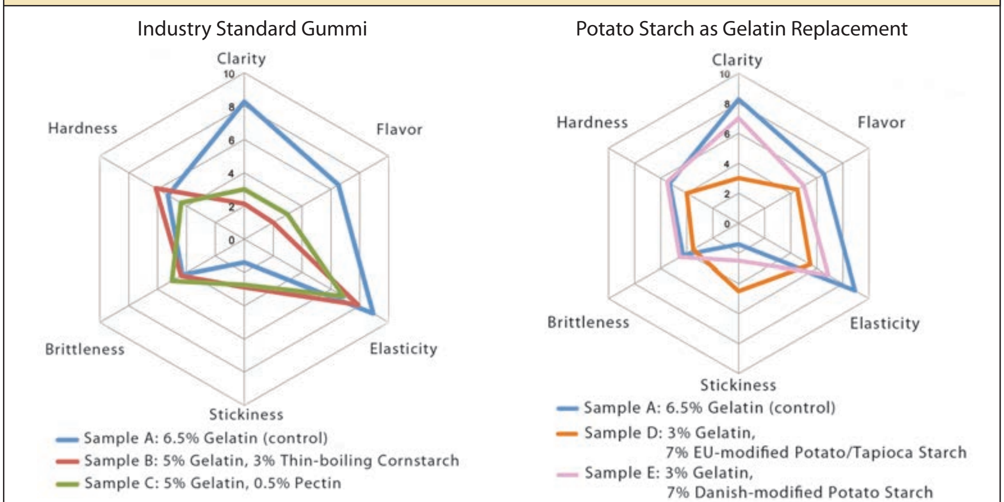

Figure 10

Another trending area in gummi formulation is reduced-sugar gummies.

Gelatin is thermo-reversible. It has the ability to melt and reset if warmed and cooled. These melting temperatures are 95°F to 100°F (35°C to 38°C). When exposed to these temperatures, a package of gummi bears, worms or rings will melt together or fluidize, and when cooled, will take on a new shape or form. The once gummi bears are now a gummi blob. The temperature range of 95°F to 100°F (35°C to 38°C) seems high, but these temperatures are frequently seen during summer months, particularly inside cars left in the sun or during shipping in closed trucks or shipping containers. To lessen damage, most gummies have to be protected during shipping in warmer months. Protected shipping typically means using temperature-controlled trucks or containers where product is held at temperatures below 85°F (30.5°C), which is expensive.

For stability testing, various gummi pieces were placed in a vacuum oven set to 110°F (43.3°C) and checked every few hours. It only took two hours at this temperature for the pure gelatin pieces to begin to melt, and at four hours the pieces had completely melted together. The other samples formulated with either pectin or one of the starches showed improved stability with no melting or sticking.

NEW FORMULATION POSSIBILITIES

Natural Colors and Flavors

Today, removing artificial ingredients is becoming commonplace across all food product categories, and gummies are no exception. There has been quite a bit of industry discussion regarding natural ingredients, particularly colors. To reiterate, several natural colors are heat and pH sensitive. The pH of the final product can and will affect the color and its stability over time. Color suppliers are very knowledgeable in this regard and should be consulted on color use considerations.

Reduced-sugar Gummies

Another trending area in gummi formulation is reduced-sugar gummies. These formulas have ranged from basic reduced-sugar to sugarfree using polyols and lately, no sugar added/no polyol gummies. A few companies have made a big splash in the market with no sugar added/no polyol gummies and it is possible that more products such as these will appear in the future. Advancements in fibers, gums and resilient starches (bulking agents) have made it viable to formulate and produce these types of products. However, formulating is not easy because just as with starch, not all fiber is equal. These functional fibers are derived from a variety of sources such as corn, tapioca and chicory root. Some are available in liquid form while others are powdered. The functionality of these fibers differs as well. Some can be used for gummies or other confections such as hard candy or chews, while others are more suited to granola bars or beverages.

Vegan Gummies

Yet another area of increased interest with gummies is vegan alternatives. With the advancements in starches and fibers, do possibilities exist for vegan gummies? Yes and no. Vegan products are possible, however, depending on the texture of the piece, these products may be perceived more as licorice than gummies since replacing all the gelatin with starch will result in loss of some, if not all of the product's characteristic bounce or texture. In research into vegan alternatives performed on some of these starches, one was determined to have similar characteristics to a gelatin piece. This starch is another variety of a Danish-modified potato starch, and the formula and its characteristics can be seen in Figure 11. As seen in the graph, the piece is not exactly a German-style gummi, but it is both vegan and a high-quality product. Compared to some of the other vegan ➤

gummies currently being produced with pectin or cornstarch, the texture is much more gelatinous in nature, resulting in what many would consider a superior product.

Another vegan option not currently available, but may be sooner rather than later, is vegan gelatin. A San Francisco Bay area company has successfully engineered a vegan gelatin that is free from hooves, hides and bones from pigs, cows and fish. This company's production method involves DNA sequencing using the protein and collagen sequences of animals, and converting these microbes into gelatin. To prove that no animals were harmed in their process, the company opted to use the DNA sequence of a mastodon, a prehistoric ancestor of the elephant. They were successful in creating a gelatin, but it was not comparable to the current existing product from animals. The company is still working to find the correct sequencing that will not only produce a stiff gelatin comparable to the current animal-sourced versions, but also be considered generally recognized as safe (GRAS) according to FDA standards. Mimicking nature is an area of great concern that receives tight scrutiny from the FDA, however, a DNA-sequenced microbe would not be the first genetically-modified microbe that is GRAS if approved. Similar GRAS success has been seen with engineered oils and proteins.

Another vegan option not currently available, but may be sooner rather than later, is vegan gelatin.

CONCLUSION

Gummies continue to grow as a confection category. They also continue to grow in the supplement market as a delivery system for active ingredients. Gummies are formulation-versatile. They can be stiff, soft or rubbery, all by using differing levels and strengths of gelatin. Gummies can also be natural, organic, sugarfree or vegan.

In our study, potato starches yielded the best results, reducing the use of gelatin while maintaining product integrity at a reduced cost. Additional advantages of potato starch are improved heat stability and ability to be cooked using any type of cooker. A quality vegan gummi can be made by replacing gelatin with potato starch.

While this article focuses specifically on gummies, many of the points stated herein can also relate to other confections. Hopefully, this information has shed some light on gummies and their advancements today, and can assist others in their efforts to create the next generation of gummies. □

Vegan Gummi Formulation and Standard versus Vegan Gummi Characteristics

Vegan Gummi Formulation

Ingredient	
Corn Syrup 42 DE	36%
Granulated Sugar	34%
Water	19%
Danish-modified Potato Starch 2	11%
50% Citric Acid Solution	1.0% – 2.5%
Flavor	as needed
Color	as needed

Standard versus Vegan Gummi Characteristics

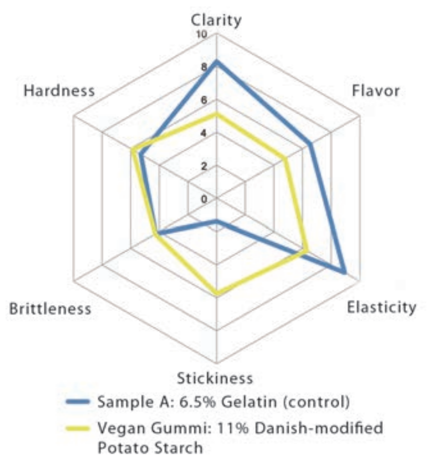

Figure 11

Presented at the PMCA Production Conference