

BEVERAGE FORMULATION

The Changing Face of Beverage Processing

Three processing methods – thermal, pressure, and chemical – offer almost unlimited options for meeting the demands of today’s beverage trends and nutritional choices.

by Rachel Zemser

Beverage processing’s primary goal is to ensure a safe product and shelf stability. That of course means eliminating pathogens and greatly reducing or eliminating spoilage bacteria. Three processing methods – thermal, pressure, and chemical – offer almost unlimited options for meeting the demands of today’s beverage trends and nutritional choices.

From creamy high-protein smoothies to vitamin-infused energy drinks, beverage creators can “pick their poison.” It might be

a fresh-tasting refrigerated beverage that costs both creator and consumer a premium or a retorted, overcooked tasting juice that is economical to make and can last for years on the shelf. The beverage creator’s choice of trend will dictate the optimal processing method, packaging material, storage conditions, and final price for the product.

An Array of Options

Beverage makers should consider all three major processing options when creating a product.



› Juice and smoothie producer Fruitapeel has opened a new HPP facility, which it claims will make it the only UK manufacturer able to extract juice directly from the citrus fruit, bottle it and apply the HPP process from a single site.

The Chemical Appeal: As clean label products become the norm, a beverage brand may want to avoid ingredients like potassium sorbate or sodium benzoate on the ingredient label. However, significant cost benefits of this shelf-stable process sometimes make it a viable option to consider. Products that are high in acid and sugar (like soda) or that “contain less than 10%” juice are prime candidates for chemical preservation methods. The low nutrient environment, sugar, acidity, and preservatives are enough to ensure shelf stability for up to one year. Chemically processed beverages are inexpensive to manufacture, because they can be made on production lines that are not set up for thermal processing. Chemical processing should be considered by manufacturers of inexpensive products that are marketed to consumers who are not as concerned with nutrition, clean labels and sugar content.

The Thermal Approach: All beverage products are made with ingredients – like fruits, vegetables, nuts, and seeds – that can support both spoilage and pathogenic bacteria. Bacteria growth is influenced by

the amount of available water in a given system (known as water activity or “Aw”), the pH of that system, and the temperature. By controlling those parameters in a closed system, we can create safer, longer-lasting beverages.

Temperature is the most common bacteria-control method, and a variety of time/temperature combinations are used. Pasteurization, the gentlest heat process, greatly reduces microbial loads and must be combined with refrigeration to extend shelf life.

The FDA requirement for pasteurization is at least 160°F (71°C) for 6 seconds. Hot-filling and retorting a beverage sterilizes the product and allows it to be shelf-stable for a year or more at room temperature. Other levels of heat treatment include aseptic, ultra-high temperature (UHT), and extended shelf life (ESL). The longer and hotter the treatment is, the more shelf-stable the final beverage product becomes.

The specific time and temperature required to ensure commercial sterility and stability are directly related to the pH of that product. If a product is above pH 4.6, it must be retorted for shelf stability; with a pH below 4.6, a hot fill is enough. Water activity – controlled products, usually very high in sugar and brix, have minimal water available for bacteria to grow. If a beverage has a water activity below 0.85 and a high pH, it may not need any thermal processing, just some preservatives – that’s the scenario for beverage concentrates with a high sugar content.

Even so, spoilage can occur depending on the water activity. Most beverage creators seek the lowest time and temperature process possible as they aim to retain flavor, color and vitamins. They often must compromise some of the product’s attributes, however, to achieve shelf stability.

The FDA requires that a “processing authority” make decisions about time and temperature for beverage processing. Chapter 21 of the Code of Federal Regulation (CFR) 113.83 defines the authority as having “expert knowledge of thermal processing requirements for low-acid and acidified foods in hermetically sealed containers.”

High-Pressure Processing (HPP): HPP, otherwise known as non-thermal pasteurization, is the latest and fastest-growing beverage category. It’s not just a trend but a “new product segment,” according to Avure Technologies, a leading manufacturer of HPP products. The non-thermal process complements current consumer tastes for juice smoothies, detox beverages, coconut water, and functional beverages – all

of which rely on great flavor, clean labels, and nutrient retention to encourage sales.

The HPP process applies high pressure of 400 to 600 mPA for 1 to 10 minutes, thereby reducing several log cycles of spoilage microorganisms and pathogens. Hiperbaric, another leading manufacturer of HPP products, explains the science: "HPP is able to break, or create, weak bonds (hydrophobic and electrostatic interactions), only present on macromolecules. It allows microorganism inactivation without modifying the food nutritional quality and without significantly reducing the enzymatic activity."

HPP produces safer products with a longer shelf life because it inactivates vegetative microorganisms while retaining flavor and nutrients.

Thermal pasteurization degrades vitamins, antioxidants, and polyphenols, but the HPP process retains them at levels almost as high as that of the fresh, unprocessed juice.

It's All in the Package: The most common packaging options in today's beverage market are glass and plastic bottles, metal cans, flexible pouches, and coated cartons. Pasteurized, ESL-, and UHT-processed beverages are usually filled into cans, pouches, glass bottles, or cartons. Aseptic prod-

ucts often come in cartons, and the retort works well with special foil pouches, glass, and metal cans.

The HPP process can be used only with plastic containers because in order to create 87,000 psi of water pressure, the HPP equipment must also compress the water by 15%. That means the packaging material also must have a minimum of 15% flexibility. Glass has no flexibility - it breaks. If a plastic container is too rigid, it too can crack or at least be stressed, thereby changing the appearance of the package.

The choice of processing does dictate packaging to some extent, but a company's design and marketing plan also play a big role.

Many artisan start-up companies want to give the impression that they have a low carbon footprint and prefer to use lightweight recyclable plastics and cans rather than heavier glass bottles. Foil pouches, such as those often used for baby food, are not recyclable but are very lightweight and, therefore, consume less energy related to shipping.

Entrepreneurial Trends

With the array of options for creating either shelf-stable or refrigerated products, beverage makers have to consider the cost of making the product, the consumer's

willingness to pay, and the ultimate goals for the deliverable product.

The Fruits of High Pressure: Fresh fruit and vegetable smoothies are showing up under the HPP process because it delivers the best flavor and nutrient value that consumers are willing to pay for. However, energy drinks (with vitamins and caffeine) are often made via hot-fill or pasteurization because consumers of those products generally focus less on fresh taste and flavor than on the stimulating effects. Smoothies are most flavorful when delivered via HPP, but the cost is prohibitive and if protein is the main attraction, then developers don't mind cutting costs and opting for a more shelf-stable retorted product. Probiotic beverages that involve dairy and yogurt are typically pre-pasteurized to eliminate pathogens and then re-inoculated with the beneficial bacteria. Those products cannot be post-pasteurized (because that would kill the probiotics) and must be refrigerated to ensure that the good bacteria thrive for the entire shelf life.

In the HPP category, the most common offerings are functional smoothie blends, detox drinks, and fresh fruit-plus-vegetables combinations. The HPP process is crucial when marketing drinks that include heat-sensitive ingredients like vitamins

Table 1: Processing Options For Beverages*

**time, temperature, storage and time may vary and depend on product solids, pH and content and environmental conditions*

Process	Types	Bacterial Inactivation Method	Time	Storage	Approximate Shelf Life	Packaging Options	Applications
Thermal	Pasteurization (HTST)	Thermal 160-175°F	Seconds	Refrigerated	10 days	Glass, Cartons, Plastic	High and low acid beverages
	Extended Shelf Life (ESL)	Thermal 255-265°F	Seconds	Refrigerated	21 days	Glass, Cartons, Plastic	High and low acid beverages
	Ultra High Temperature (UHT)	Thermal 280-302°F	Seconds	Shelf stable	18 months	Glass, Cartons, Plastic	High and low acid beverages
	Hot Fill	Thermal 170-195°F	Minutes	Shelf stable	1 year	Glass, Cartons, Plastic	High and low acid beverages, thicker smoothies, salsa, tomato sauce
	Retort	Thermal 250-280°F	Hours	Shelf stable	2 years	Cartons, Metal	Viscous, chunky and particulated products
	Aseptic	Thermal 195-295°F	Minutes	Shelf stable	Years	Cartons, Metal, Glass	High and low acid beverages
Chemical	Sodium Benzoate, Potassium Sorbate, Velcorin	Preservative	None	Shelf stable	6-12 months	Glass, Plastic	High acid, low nutrient beverages
High Pressure Processing	Pressure	Pressure (400-600 MPa)	1-10 minutes	Refrigerated	30 days	Plastic only	Typically for high acid, also low acid
Other Emerging Technologies	Pulsed Electric Fields (PEF)	Electroporation	< 1 second	Refrigerated	10 days	Glass	Heat sensitive liquid foods, both high and low acid
	Ohmic Heating (OH)	Thermal, Electroporation	Minutes	Shelf stable	1 year	Glass	High and low acid beverages

and enzymes. Even more important, HPP retains fresh flavors and creates a fresh-tasting juice experience.

Fermented Kombucha Drinks: Kombucha, a probiotic-fermented tea beverage, combines tea, water, sugar and kombucha bacteria cultures (or “scooby,” a mixture of bacteria and yeast). The bacteria and yeast ferment the sugar, yielding an effervescent drink that is low in sugar. The beverages often incorporate herb and fruit flavors to

provide consumers with a variety of tastes.

Most kombucha products are fermented in glass bottles, which several manufacturers tout as a benefit (contending that fermentation in plastic bottles makes chemicals leach out of the plastic and into the drink). It is a subject of debate whether all the probiotic organisms can truly survive the bottling process and maintain the claimed health properties, which include greater vitality, digestion detox, immunity protection, and weight-loss potential. Most

of the mainstream kombucha brands add strong flavors like grape, ginger, vanilla, and apple to appeal to the masses.

Herbs and Spices: The beverage market has begun to tap the known medicinal and antimicrobial properties of herbs and spices. Several HPP detox blends, such as Suja and Blueprint, include cayenne, mint, cinnamon, ginger, and red chili peppers. TumericALIVE has a line of HPP-processed sport beverages that contain turmeric in combination with other fruit and vegetable purees. Popular vegetables in detox smoothies include kale, spinach, cucumber and celery. Lemons, limes, and ginger are used to sweeten the beverages naturally and to improve overall flavor and palatability.

Vinegar Drinks: For more than 50 years, Patricia and Paul Braggs have been promoting the health attributes of raw vinegar and encouraging their customers to drink their 5% acid apple cider vinegar as a beverage. Vinegar drinks are now becoming more widely accepted as other companies begin to market similar drinks. PokPok, based in Portland, Oregon, sells its vinegar drink as a concentrate that can be added to water or club soda. Another beverage company, Gravity, has a more mainstream approach of combining a small amount of apple cider vinegar with regular apple cider. The drink is sweetened with honey and xylitol to make it more palatable. Consumers who favor the harsh vinegar acidity may prefer drinks like Braggs or Kevita, which has 30 grams of apple cider vinegar per bottle.

Hand-Crafted Coffee and Tea Brews: Bottled coffee beverages have been around for a while, particularly the creamy sweetened kind that is retorted and sold in glass bottles. They now are competing with artisanal brands that use either cold-brew or proprietary custom-brewing processes to make bottled black coffee and tea. The cold-extraction process takes longer but draws significantly fewer of the bitter acids from the beans than hot coffee does.

Grady’s Cold Brew uses the cold process to make its concentrated New Orleans-style coffee blend of roasted coffee and chicory. Tea, also in this category, has taken on a simpler approach. Products like Oak Reserve Tea (AriZona Beverages) use an oak-barrel aging process of steeping the tea in American oak chips. Harmless Harvest has introduced its HPP-processed 100% raw tea made with frozen and ground-up raw tea leaves that are cold-brewed in water. The HPP process improves safety by reducing the microbial load and also ruptures the plant-cell mem-

Table 2: Up and Coming Ingredients for Beverages

Ingredient	Types	Claims
Herbs and Spices	Cinnamon	Lowers blood sugar, fiber source
	Turmeric	Anti-inflammatory
	Mint	Helps digestion and irritable bowel syndrome
	Ginger	Nausea remedy for pregnant women
Insects	Ground-Up Cricket Flour	Sustainable protein source
Cannabis	Hemp Protein	Vegan and allergen free protein with all 9 essential amino acids
	Hemp Oil	Omega 3 and omega 6
Tea	Black Tea	Energy, antioxidants
	Matcha Green Tea Powder	High in fiber, antioxidants, fat burner
Vinegar	Apple Cider Vinegar	Energy, vitality, digestion, well being
Plant Waters	Maple	Phytonutrients
	Barley	Digestion, well being
	Artichoke	Vitamins, potassium

› Unprocessed Juices May Carry Dangers

A small segment of the consumer population prefers juices with no thermal or HPP process at all. Believing that a thermal process kills all the nutrients and that HPP destroys the enzymes, they want their fruits, vegetables, and nuts pressed into a glass without heat or pressure before consumption. However, scientific evidence does not fully support this view and furthermore, even the combining of low and high acid fruits plus the grinding of fruit against metal during the press process can alter the so-called “enzyme activity.”

According to other unproven theories, unprocessed juices help cure cancer and other ailments. The fresh press (cold press) method works well if the beverage is made and sold in a juice shop where the time between pressing and consuming is minimal. However, as these juice shops grow, they may seek to make more profit and creatively devise ways to prepare their beverages in advance (in a central location) and deliver them to local purchasing shops. Some even ship their raw uncooked beverages on ice to consumers in other parts of the US.

The FDA is concerned about these activities because raw fruits and vegetables contain high levels of both pathogenic and spoilage bacteria that can grow to dangerous levels if the product is not properly refrigerated and stored at all times. The deadly pathogen *Clostridium botulinum*, for example, can thrive and produce toxins in a sealed bottle of temperature-abused carrot juice. The FDA is keeping an eye on these operations and encouraging the use of HPP as an alternative. Unfortunately, HPP is not an option for many small producers because of its cost. ▼

branes, releasing extra tea oils and extracts.

Mixology Retail: The 1980s and '90s were known for super-sweet, artificially flavored cocktail mixes. Today, more authentic and sophisticated concentrated syrups allow retail consumers to recreate classics by adding these fruit, bitters, and herb mixtures to their alcohol at home. The category includes tea concentrates like Finest Kind and The Owls Brew, as well as Morris Kitchen's line of grapefruit, rhubarb, and preserved lemon syrups.

A more creative approach for the now grown-up college crowd are Ludlow's Jelly shots, whose impressive ingredient lineup includes barrel-aged bourbons, Meyer lemon juice, 100% Agave Blanco tequila, and dark Caribbean rum. The mixers and concentrates are mainly marketed to create alcoholic drinks, but the companies all recommend using the alcohol-free syrups in natural sodas and as a dessert topping.

Natural and organic cocktail concentrates should be made via hot-fill to ensure safety and product stability without diminishing the finished product's flavor. Natural flavors can be added back in to restore what may be lost during the thermal process.

Plant Waters: Coconut water has been on the scene for a while, but newer plant-based waters each have their own marketing opportunities:

- Watermelon water has anti-inflammatory and antioxidant health benefits.
- Water extracted from California artichokes (Arty Water) retains the vegetable's nutrients, but the nutritional panel reflects a low delivery potassium, vitamin A, E, B, and C per 8-oz serving size. The product, whose patent is pending, is also sweetened with agave and monk fruit.
- Clear maple water (Vertical Water) is made from the sap of sugar maple trees.
- A maker of barley water (Deo

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Barley Water) says that its beverage is connected to "digestion, complexion, and well-being." The idea of drinking a boiled grain comes from ancient times and has now been reinvented in a hot-filled bottle.

Plant waters are marketed as a source of electrolytes, minerals, vitamins, and antioxidants, but most of the claims are not

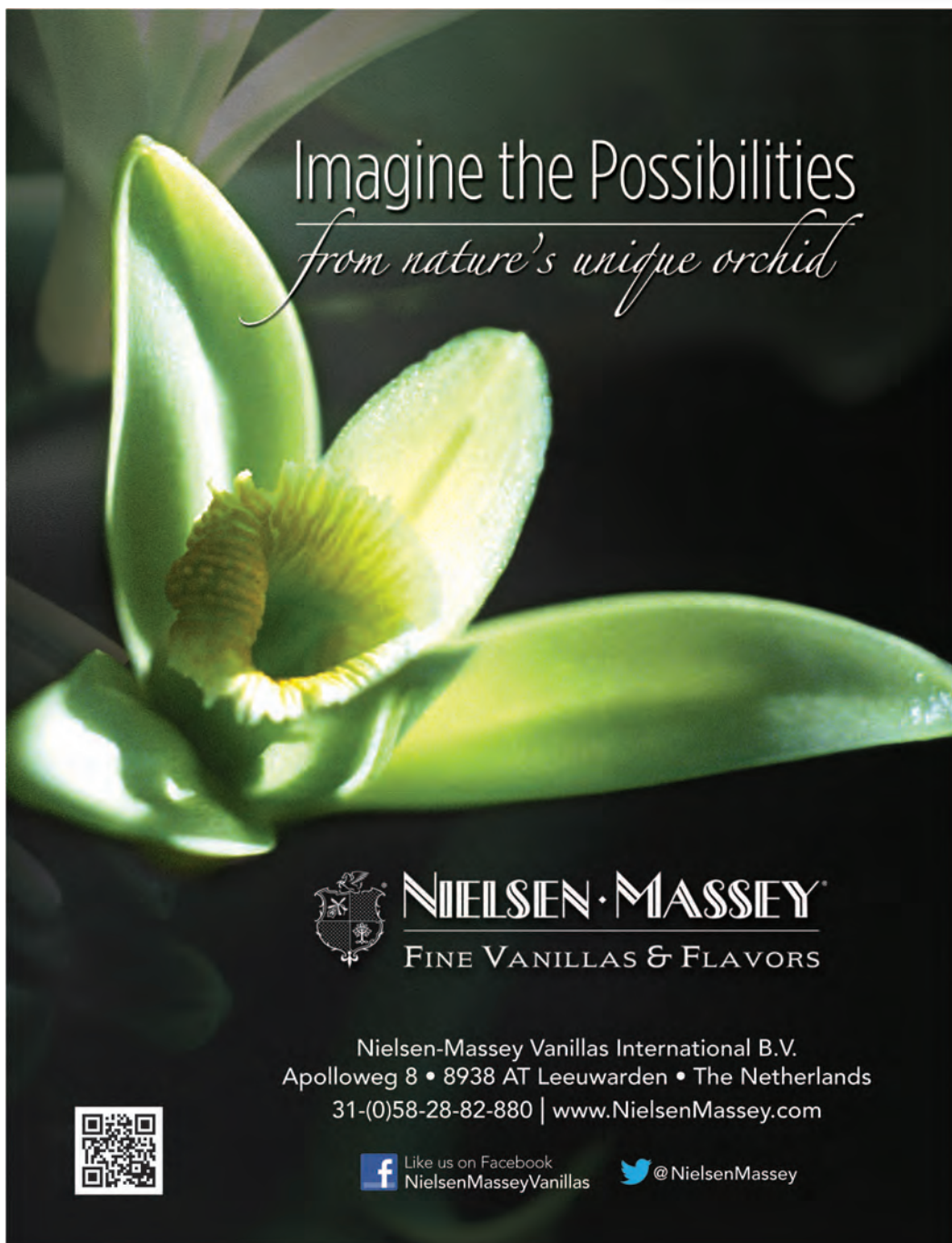
backed by scientific analysis of the fully processed finished product. Nevertheless, plant waters taste refreshing and can be a delicious alternative to plain water.

Processing the Future

The fast-growing beverage market offers multiple processing options to achieve optimal

quality and safety for both refrigerated and shelf-stable products. High-cost beverages are usually refrigerated or made via HPP. Lower-cost drinks are hot-filled and re-torted, and they can last for years on the shelf. Each developer should choose a process according to its target market, desired flavor profile, and nutrient-delivery expectations. ▼

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