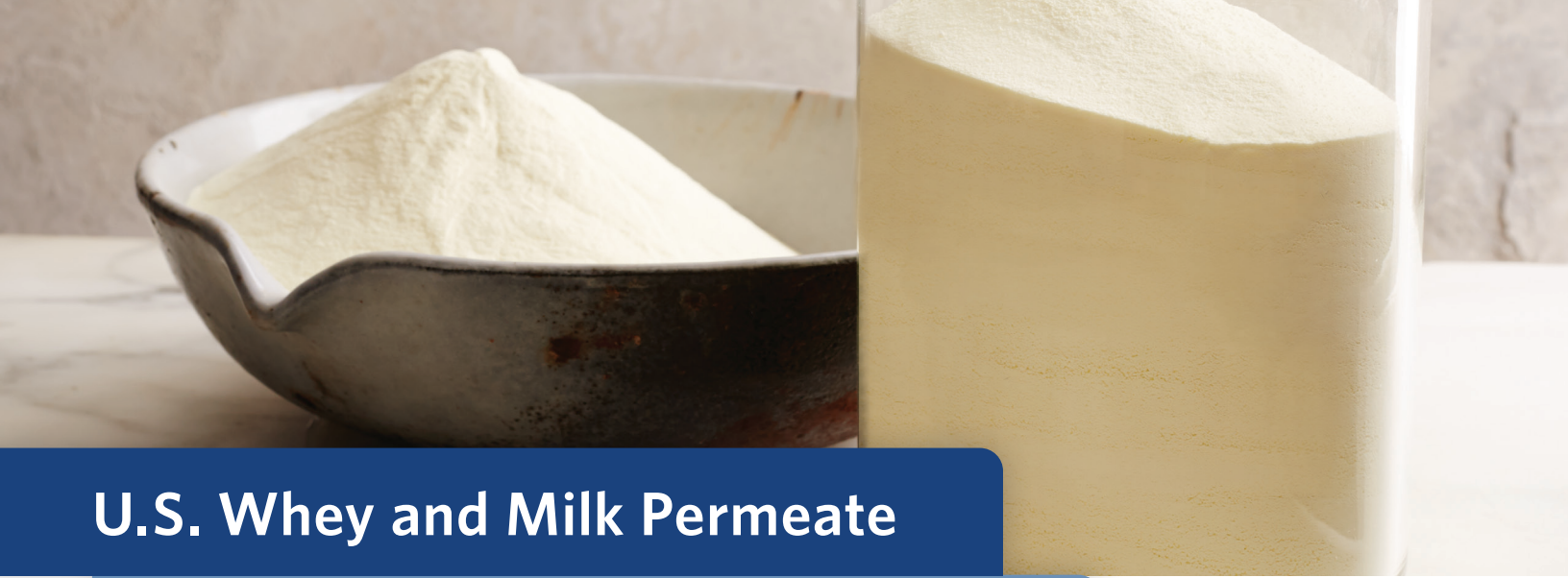




U.S. Whey and Milk Permeate

✓ Cost Saving, Flavor Enhancing Ingredient

Dairy (whey and milk) permeate powders are attracting the global food and beverage industry spotlight as multifunctional and advantageous ingredient and innovation solutions with bright usage potential. U.S. production of dairy permeates continues to climb, ensuring ample supply capacity for global dairy customers to utilize these versatile ingredients across wide-ranging applications that consumers regularly purchase.

What is Permeate?

Dairy permeate, which includes whey permeate powder and milk permeate powder, is a high-lactose ingredient produced through the removal of protein and other solids from milk or whey via physical separation techniques. Sometimes also called dairy products solids, dairy permeates have a minimum of 76 percent lactose, a maximum of 14 percent ash and typically between 2-7% protein (nonprotein nitrogen).

Permeate composition may vary depending on the original material used. Sweet whey and milk are common starting materials for permeate production in the United States.

Whey permeate (also referred to as deproteinized whey or modified whey) is a coproduct of the production of whey protein concentrate and whey protein isolate. Good solubility and a pleasant dairy flavor make whey permeate formulator-friendly.

Milk permeate is a coproduct of the production of milk protein concentrate, milk protein isolate and ultrafiltered milk manufacturing. Milk permeate has a similar composition to whey permeate, but because it is derived directly from milk, its organoleptic profile will be different. Milk permeate is known for its clean, consistent flavor.



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- The United States is the world's largest producer and exporter of permeate. In 2024, U.S. production of whey permeate exceeded 563,000 metric tons (Source: U.S. Dairy Export Council estimate).
- The number of tracked new products launched with permeate globally grew at a compound annual growth rate of 19% between 2019-2024 (Source: Innova Market Insights).
- In 2024, confectionery, bakery, hot drinks, snacks and dairy ranked as the top five food and beverage categories respectively for permeate new product launches (Source: Innova Market Insights).



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Advantages and Opportunities



FIG. 1: COMPOSITION OF WHEY PERMEATE AND MILK PERMEATE

COMPONENT	WHEY PERMEATE	MILK PERMEATE
Protein ^{*a}	Typical 2-7% (Max. 7%)	Typical 3-5% (Min. 2%)
Fat ^a	Typical 0-1.0% (Max. 1.5%)	Typical 0-1.0% (Max. 1.5%)
Lactose ^a	Typical 76-85% (Min. 76%)	Typical 78-88% (Min. 76%)
Ash ^{#a}	Typical 8-11% (Max 14%)	Typical 8-11% (Max 14%)
Moisture ^a	Typical 3-4.5% (Max. 5.0%)	Typical 3-4.5% (Max. 5.0%)
Sodium ^b	0.70-0.89%	0.38-0.66%
Calcium ^b	0.36-0.62%	0.36-0.46%
Magnesium ^b	0.10-0.13%	0.10-0.12%
Potassium ^b	2.18-5.36%	1.91-2.58%

^a American Dairy Products Institute. Dairy Permeate Standard | ^b Commercial specification | ^{*} Nonprotein nitrogen |

[#] Codex Alimentarius standard is max 14% ash for dairy permeate, max 12% ash for whey permeate, max 12% ash for milk permeate.

Benefits of Permeate

Permeate provides cost-effective functional and flavor benefits to foods. Because 76-85% of permeate is lactose, the functionality of permeate is really dictated by the lactose content. The ash contains calcium, phosphorus and other valuable minerals, which will contribute to the overall mineral profile of a food product. Fat content in permeate is very low, so there is no added functionality from the fat.

Technically speaking, permeate may be used in several applications where lactose or whey are used. Permeate could be used to replace a portion of ingredients such as skim milk or whole milk powder as well, but it is cautioned that permeate will not be able to replace the functionality of the protein or fat in these ingredients. Permeate has also been used to replace other carbohydrates, to remove maltodextrin, to reduce sodium and sugar in foods and for added nutrition in food products, as an important source of dairy minerals. A reality of the food industry is that cost is an important factor when determining ingredient usage. The more functionality a food processor can get for the same cost, the better.

The lactose in permeate contributes to browning, is a crystallizable sugar, is less sweet than sucrose, absorbs volatile flavor compounds and attracts and absorbs synthetic and natural pigments.

BAKED GOODS

Permeate contributes to browning of baked goods by the Maillard reaction of lactose and other reducing sugars present (combined with available protein) in a formulation, which provides color when heated. Browning not only enhances appearance but also imparts a pleasant caramelized flavor. Retaining moisture is an added benefit in baked goods. Lactose content in dough can also produce breads, muffins, cakes and cookies that retain their softness for a longer period of time and extend shelf life. In cakes, permeate contributes to a smoother and more flowable batter, which makes commercial processing easier and more efficient.

SOUPS AND SAUCES

In addition to reducing sodium, permeate can enhance flavor and contribute to the body/texture of a product for soup and sauce makers. Use in dairy-based soups or sauces is a natural fit for permeate.

It will help contribute to the dairy-based flavors, texture and creamy appearance already present in these applications. Permeate can also be used in tomato-based soups and sauces to enhance flavor and balance the acidity present in these products.

CONFECTIONERY

Icings, coatings and non-chocolate candies can use permeate to reduce sweetness, while providing important crystallization characteristics. In caramel type products, permeate can help develop sweet, browned flavors and color. It is recommended to watch the amount of permeate added to a caramel due to the high lactose content. Lactose has a limited solubility and at higher than optimum levels, will crystallize in a product like caramel, once it is cooled, creating a gritty texture. It is recommended to have a maximum of 14% lactose in the water phase of the caramel (post processing). It is also important to remember that other dairy ingredients such as condensed skim milk or sweetened condensed milk used in caramel manufacture also contain high levels of lactose and the total lactose content should be determined to calculate the addition of permeate.

DRY MIXES

Seasoning mixes, macaroni and cheese mixes, instant noodle mixes, and seasoning blends for salty snacks can use permeate to help deliver a clean dairy flavor and reduction of sodium for these savory applications. Permeate is a good carrier for seasonings and dry flavors and helps to disperse them uniformly throughout a snack or prepared dish.

MEATS

In addition to reducing the sodium in meats, permeate can enhance browning and protect color, mask bitter flavors and improve structure formation. The lactose in permeate provides an effective starter culture carbohydrate for the preparation of fermented sausages and cooked hams.

DAIRY FOODS

Applications such as dips, cheese sauces, process cheese food and ice cream could also include permeate, as long as usage falls within the standards of identity. Permeate can be a good source of dairy solids and can provide a clean flavor. Cheese sauce and ice cream are additional applications that are impacted by the solubility of lactose. It will be important to consider all the ingredients in the application that contribute lactose in order to determine that amount of permeate that can be added. If the 14% lactose in water is exceeded post-processing, a gritty cheese sauce or ice cream will be the result.

BEVERAGES

Milk permeate has been used as an ingredient in beverage applications. Research conducted at Jiangnan University in China demonstrated that adding dairy (milk or whey) permeate to milk tea dry mix was able to decrease costs and fat content, while improving the stability of the reconstituted beverage. Sensory evaluation determined that using up to 20% whey permeate or 38% milk permeate may be acceptable for consumers. Either milk or whey permeate can be used in a dry mix or ready to drink beverage. Both ingredients will contribute to the nutrient content of the beverage because they contain lactose and naturally occurring minerals like sodium, potassium, calcium, and magnesium. Many beverages are fortified with vitamins and minerals and using permeate allows a developer to add these minerals from a dairy source and not rely on chemical sources, which helps keep a cleaner label. It is possible to make a dairy-based isotonic drink using permeate which provides the important electrolytes (sodium and potassium) to help re-hydrate the body and lactose to provide a carbohydrate source for energy.





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Health and Wellness



FIG. 2: DIFFERENCE IN SODIUM CONTENT: SALT VS. PERMEATE

PRODUCT PROTOTYPES (SERVING SIZE)	CONTROL - WITH SALT SODIUM CONTENT (MG)	PERMEATE - WITHOUT SALT* SODIUM CONTENT (MG)	SODIUM REDUCTION (%)
Scones (55g)	230	110	52
Chocolate Chip Cookie (30g)	100	40	60
Snack Cake (55g)	45	40	11
Pound Cake (88g)	150	80	47
Muffins (55g)	230	70	70
Broccoli Cream Soup (1 cup)	550	135	75

Source: Center for Dairy Research, Madison, Wisconsin

*In some bakery formulations, sodium-based leavening agents are responsible for the remaining system.

Permeate for Sodium Reduction

The Wisconsin Center for Dairy Research at the University of Wisconsin-Madison began conducting projects using permeate in the 1990s. The initial focus was on browning, flavor enhancement and cost reduction, but researchers learned that permeate also had salt-enhancement characteristics. It is not clear which components of permeate are responsible for the salty properties. While the mechanisms are uncertain, it is possible that the non-protein nitrogen compounds — urea, creatine, creatinine, uric acid, orotic acid and ammonia — may serve as flavor potentiators. The mineral salts — calcium phosphate, magnesium, sodium and potassium — may function as salt and flavor enhancers. Permeate also has an umami effect that potentiates flavors and allows reduced usage of other flavor-characterizing ingredients (e.g. cocoa, flavorings).

Subsequent USDEC research conducted with innovation collaborators in China, Singapore and Vietnam since 2018 have also successfully demonstrated permeate's ability to reduce sodium use in local-friendly applications while maintaining consumer acceptable flavors.

In general, 10g to 11g of permeate will replace 1g of salt. It is recommended to balance the addition of permeate by reducing other macro-ingredients such as flour, fat, eggs, granulated sugar and other carbohydrates. In many instances, a total cost-reduced formula can also be achieved as permeate replaces other more costly ingredients.

USDEC wishes to acknowledge Kimberlee (K.J.) Burrington for contributing her expertise.



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Looking to buy milk and whey permeate?

While USDEC does not manufacture or sell dairy products, we proudly support the people who do. Search the U.S. Dairy Supplier Directory at ThinkUSADairy.org.

To learn more and find a USDEC representative near you, go to ThinkUSADairy.org/global-presence.

