Jungbunzlauer

From nature to ingredients®

facts

ERYLITE® Erythritol in light protein ice cream

Introduction

A sorbet resembling ice cream was already known in European antiquity, more than 2000 years ago. A Greek poet describes it as being made from glacial snow with ingredients such as fruit, honey or rose water.

Ice cream itself is a sweetened frozen food typically eaten as a snack or dessert. The ingredients are mainly liquids such as dairy milk or cream. It is flavoured with a sweetener such as sugar in addition with spices, such as cocoa or vanilla and occasionally also butter and possibly egg yolk. In order to form a cream from this emulsion, nowadays natural thickening agents such as hydrocolloids are added. These also increase stability and shelf life. Simultaneously whipping or stirring while cooling the base mass and the food additives to below the freezing point, the ice mix incorporates air spaces and produces a cream without perceptible ice crystal formation. The result is a smooth, semi-solid and foamy suspension that solidifies on freezing to very low temperatures (below -10°C or 14°F). As its temperature increases it becomes more malleable.

More and more sugar-reduced or sugar-free ice cream varieties are appearing on the market, mainly in Europe and the American food trade, often in 400 ml portion sizes and labelled with calorie saving claims. The consumption of ice cream is much higher than that of other confectionery and analysts anticipate that it will evolve from an indulgence food to a staple in some regions. The prospect that consumption does not entail excessive calorie intake is very appealing to consumers. Appealing to the industry are the gains associated with higher pricing for this type of food speciality compared to standard products.

Healthier lifestyle through sugar reduction

Healthy food and especially a reduction in sugar, fat and salt is currently one of the most dominant topics in the public health debate. Consumers are also increasingly following new trends such as vegetarianism and veganism. This has resulted in the development of new products boasting all manner of “free from…” or “reduced…”, high protein, dairy free, and vegan claims, with associated impacts on taste and texture. However, the bottom line is that consumers rarely accept a compromise in taste and quality. Unfortunately, traditional ice cream has a high sugar and fat content (each up to 20%). Product developers are therefore in urgent need of innovations that result in equivalent products with the same pleasant taste and mouthfeel.

Sugar reduction can be achieved in different ways: total sugar exchange, partial sugar exchange or stepwise sugar exchange over a period of time. Ice cream with no added sugar is readily available on the market. However, it rarely compares favourably with sugar-containing ice cream in terms of taste and texture. The taste profile lacks the typical sugary sweetness and the texture is affected by the deviating freezing properties of the ingredients. High-quality sugar-free ice cream requires a sugar replacement that demonstrates both the sweetening quality and the texture-building functionality of sugar. ERYLITE® Erythritol largely meets these requirements.

ERYLITE® Erythritol – made naturally by bio fermentation

Unlike other sugar alcohols, erythritol is a naturally occurring sugar alcohol (polyol) that is present in many foods such as wine, soy sauce and a variety of fruits. It can be manufactured from glucose using a natural fermentation process. This makes it a great alternative to other polyols and bulk sweeteners: it is non-caloric, and it has a high digestive tolerance of around 0.8 g/kg bodyweight and low hygroscopicity. Systemic effect studies demonstrate that erythritol is readily absorbed, not metabolised, and excreted via the kidneys. Thanks to this metabolic profile, it is non-glycaemic, non-insulinaemic, and more easily tolerated without gastrointestinal side effects (den Hartog et al., 2010).

In traditional ice cream recipes, the calories contributed by sugar account for one-third of the overall caloric value. Since ERYLITE® has a calorie content of zero kcal/g it enables a 30% calorie reduction and the end product is suitable for low-sugar diets. This is a big advantage over other polyols, which deliver a calorie contribution of 2.4 kcal/g. Erythritol does not raise plasma glucose or insulin levels – a claim approved by the EFSA (European Food Safety Authority).

Erythritol is approximately 60% as sweet as sugar although this varies by application. It is possible to raise the level of sweetness by combining erythritol with fibres, although this alone would still fall significantly below sugar equivalence. However, erythritol can easily be blended with high intensity sweeteners (HIS) in order to overcome the missing sweetness and to mask off-tastes from other ingredients.

Erythritol and steviol glycosides

Steviol glycosides are the most commonly used natural high intensity sweeteners in frozen desserts and harmonise well with the overall flavour profile. In the following trials, therefore, it was decided to test erythritol in combination with steviol glycosides.

People have known about the sweet taste of the leaves of Stevia rebaudiana (Bertoni) for many years. The identification of the sweet components of stevia leaves showed that stevia leaf extracts contain several steviol glycosides, including rebaudiosides A, C, M and others. Rebaudioside A (RebA) is the most common steviol glycoside apart from RebM and is often used in a highly purified form (> 97%). The blend with erythritol usually yields a higher perceived sweetness than that which is calculated theoretically, and the synergy allows a reduction in high-intensity sweeteners and, consequently, in actual costs.

Stevia plant extracts always impart a characteristic taste profile even at highest purity levels. This taste profile is characterised by liquorice and a lingering effect that is hard to ignore. It is most likely that the liquorice and bitterness taste disadvantages are caused by the impurities still present even in the purified extract (Dubois G; 2019). Although steviol glycosides have improved in flavour over recent years, ERYLITE® significantly mitigates the remaining unpleasant notes and eliminates the lingering effect, as explained below.

Erythritol as a flavouring with modifying properties
The perception of a sweet taste on the tongue is triggered by several taste receptors. High intensity sweeteners like RebA bind to two different sweet taste receptors (T1R2 and T1R3) on the tongue in a similar way to sugar. Additionally, HIS may activate bitter oral receptors (T2Rs) (Turner A et al.; 2020).

The lingering taste mechanism of an HIS can be explained by extensive nonspecific binding of the sweetener to cell membranes throughout the oral cavity. When it dissociates from the sweet taste receptors T1R2 and T1R3 it may bind non-specifically to nearby receptor sites before becoming available for rebinding to sweet taste receptors, a process repeated over and over and resulting in the lingering sweetness. This rationale for the atypical temporal profiles of HIS is known as the nonspecific binding (NSB) hypothesis. The nonspecific protein bindings on the cell surfaces can be influenced by an osmolyte, which changes the osmotic pressure gradient (tonicity) and attenuates HIS non-specific binding, whereby the onset of sweetness is accelerated and the lingering sweetness phase shortened (DuBois GE et al; 2012).

Erythritol is a FEMA approved natural flavouring classified as a flavouring with modifying properties (FMP, FEMA 4819). Due to its high water solubility it can act as an osmolyte and shorten sweetness onset as well as increasing the sweetness peak (Woo A.; 2020). A mechanism describing how erythritol can influence bitter taste has not yet been described in the literature.

Nutrition Claims

A healthier lifestyle focusing on healthy foods requires the availability of food items that can claim nutritional advantages over comparable foods. The legal requirements for the nutrition claims for food items are regulated in Europe by EU Regulation 1924/2006 and in the United States by the FDA authority, with a few differences.

Protein: Claiming “high protein” content requires that 20% or more of the energy value of the food is provided by protein according to EU Regulation 1924/2006. In the United States, a claim “high”, “rich in” or “excellent source of” can be made when the food contains 20% or more of the Daily Value (DV) or Reference Amount Customarily Consumed (RACC). The DV for protein is 50 g. Therefore, a claim of high protein can be made in a food containing 10 g or more of protein per serving (FDA - 21 CFR).

No Added Sugar: In Europe, a “with no added sugar” claim can be made if the product does not contain any added mono- or disaccharides or any other sugar-containing food used for its sweetening properties. In United States, a claim of “no sugar added” is allowed if no sugar or ingredients containing sugar are added. Sugar alcohols are not considered sugar and may be present in a food with such a claim.

Natural: Erythritol and steviol glycosides are naturally derived sweeteners and are not considered artificial. The only global standard for “natural” is set by the International Standard Organisation (ISO). Based on the technical criteria for food ingredients of ISO 19657, ERYLITE® Erythritol can be considered “natural”.

Light food: In Europe a claim that a food is energy-reduced can be made where the energy value is reduced by at least 30%. In the US a food can be called “light” or “lite” if it contains 50% less fat or 33% fewer calories than the reference product. Ice cream that meets these criteria may be called light ice cream.

Fibre: A daily reference value (DRV) established by the FDA for fibre is 28 g. Therefore, a food containing 5.6 g or more of fibre per serving can make a claim of “high in fibre”. In Europe, a “high in fibre” claim can be made on a product containing at least 6 g of fibre per 100 g or at least 3 g of fibre per 100 kcal.

Figure 1 shows a typical ice cream composition. The cream and skimmed milk content as well as the sugar can vary widely. In general, a sucrose substitution in a formulation should be carried out very carefully as the influence on taste, texture and creaminess and freezing properties can lead to very unpleasant effects.

Figure 1: Reference formulation

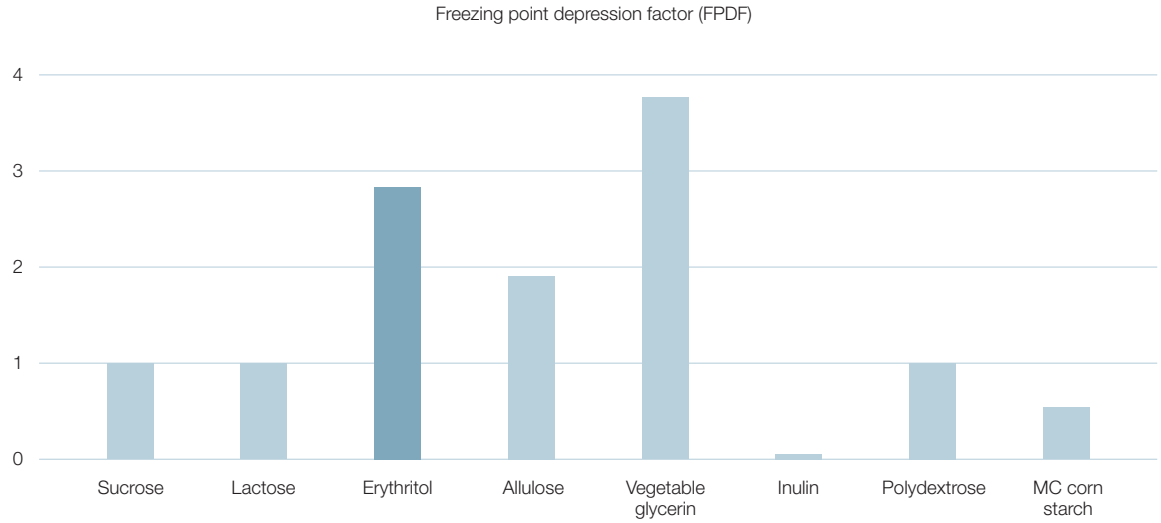
Ingredients	%
Cream	27.00
Skimmed milk	47.85
Skimmed milk powder	5.00
Sucrose	16.00
Egg yolk powder	1.00
Stabiliser compound	0.05
Milk protein isolate	3.00
Vanilla flavour	0.10
	100.00

Influence of ERYLITE® on texture and freezing point depression

The freezing properties of a formulation have an extremely important impact on the softness and taste impression of the ice cream. The carbohydrates present in the formulation strongly influence the freezing point through their inherent freezing point depression factor (FPDF). A change in the FPDF alters the temperature at which the liquid ice cream mix freezes over and becomes solid ice cream. It is imperative that the sugar replacement achieves a similar freezing point depression factor. Simply removing sugar from the ice cream base will result in a very hard and icy texture, as the freezing point is no longer depressed enough to keep a portion of the water unfrozen.

Water typically makes up to 60 to 70% of the ice cream mix. The addition of solutes into solvents, such as sucrose to water, increases the entropy of the solution, slowing the formation of the hydrogen bonds. More energy must be removed in order for hydrogen bonds to start forming. This results in a lowered freezing point, which is one of the key factors to a pleasant texture. Figure 2 illustrates the FPDF of various ingredients compared to sugar.

Figure 2: Freezing point depression factor



The greater the amount of solute added, the lower the freezing point. The smaller molecular size of erythritol (1/3 of sucrose) provides a much higher freezing point depression compared to sugar (2.8 fold). Adding too much, however, may depress the freezing point too far and result in an ice cream that is too watery. The ice cream consequently needs to be chilled to lower temperatures in order to achieve the desired texture. Crystallisation can also occur after freezing. Erythritol has a much stronger tendency to crystallise after freezing than sugar, leading to significant hardening of the texture during deep-freeze storage.

We developed several recipes with no added sugar and compared them to a full sugar reference. Erythritol, allulose and stevia in combination with inulin and other sweeteners were used to add bulk and sweetness and to control the freezing point depression. Recently allulose gained some interest as sweetener in ice cream applications. In our tests allulose as single sweetener resulted in a poor texture of the ice cream, only in combination with erythritol we observed an improved texture and scoopability.

The relative sweetness factor was closely matched in all samples. It was determined that the ideal usage level of erythritol would be in the range of 6.5-8.0% based on the total recipe. A minimum of 6.5% should be used to fully exploit erythritol's positive influence on taste performance.

Heat shock test and control of crystal growth

In order to understand how ice crystal formation is affected by temperature fluctuations, selected ice cream samples were scaled up in a continuous ice freezer before undergoing a heat shock test in which they were stored under cyclical temperature changes from -18°C (-0.4°F) to -10°C (+14°F) within 12 hours for 14 days. This test method is intended to simulate stability during transport to the point of storage in the freezer in the retail outlet. A full sugar ice cream without a stabiliser compound was tested as reference sample.

The microstructure of good quality ice cream reveals evenly distributed ice crystals and small evenly distributed air bubbles. Heat shock should not significantly affect these properties. The microstructure of the frozen ice cream samples was analysed using a scanning electron microscope (SEM) before and after the heat shock on day 0 and day 14: A 1.5mm cube was cryofixed with liquid nitrogen and then transferred and broken in a vacuum. The examination took place at -180°C.

Figure 3 shows the images of the full sugar reference without stabilisers taken with the SEM. The formation of much larger crystals and air cells can be observed in the sample post heat shock. Air phase instability leads to coalescence of the air cells and may lead to structural collapse.

Figure 3: Full sugar reference without stabiliser compound, day 0 and day 14

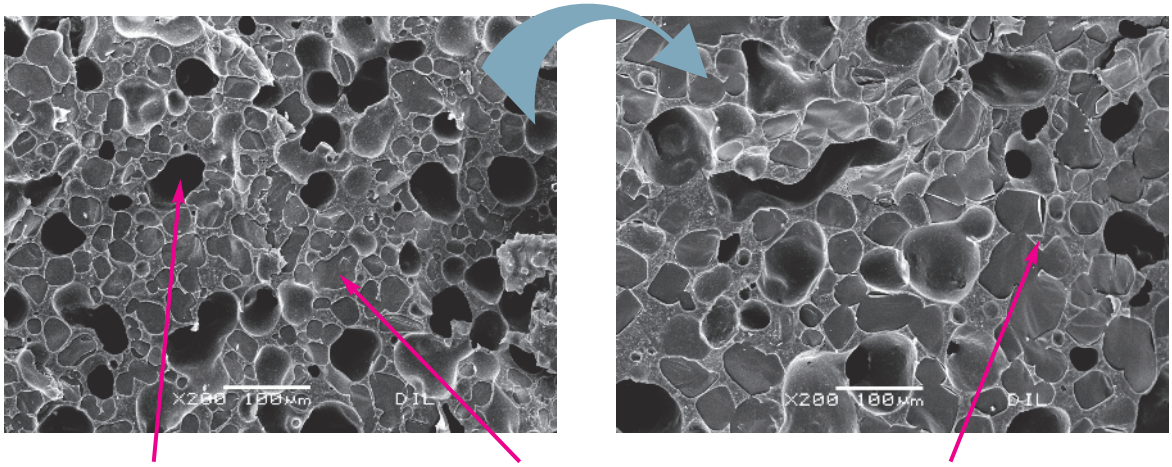


Figure 4 shows the SEM images of the no sugar added ice cream that uses a combination of erythritol, stevia and inulin. This sample was stabilised with 0.05% of a stabiliser compound comprised of xanthan and locust bean gum. After heat shock, there is only a small increase in ice crystal and air cell size.

Figure 4: ERYLITE® formulation with stabiliser compound (0.05%) day 0 and day 14

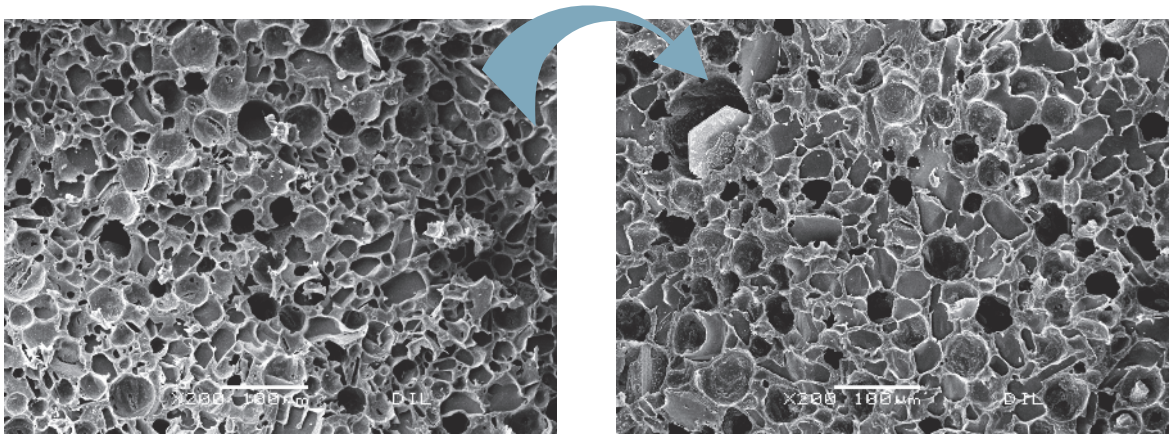
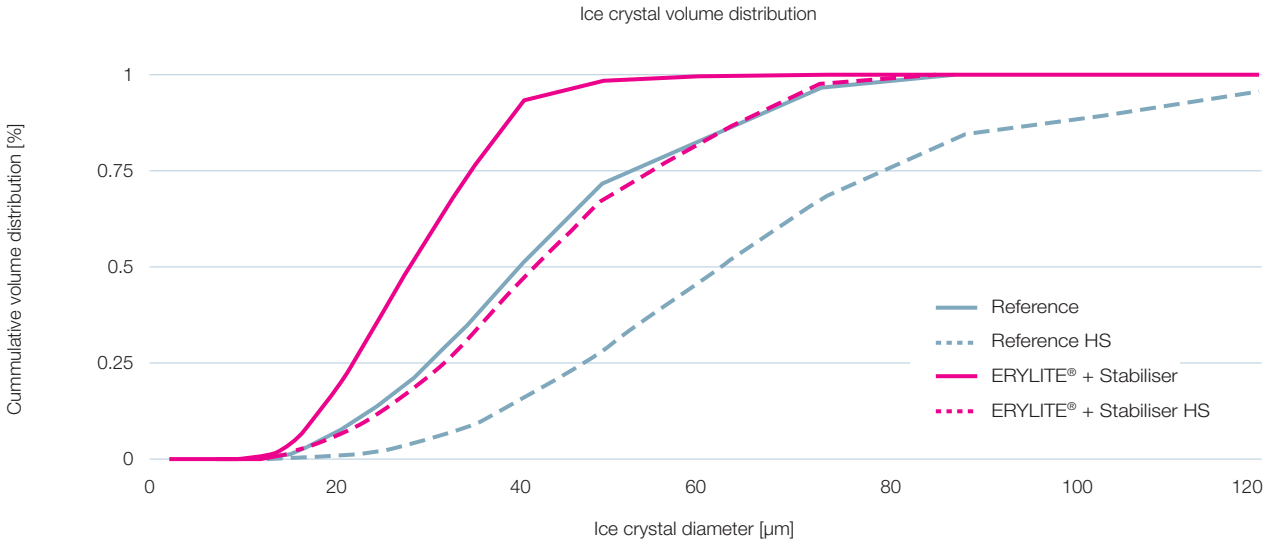


Figure 5 shows a comparison of the results from the heat shock test. The use of erythritol does not have a negative impact on heat shock stability. With the addition of just a small amount of stabiliser, the no sugar added sample with erythritol shows a good ice crystal volume distribution range. Even after heat shock, approximately 83% of the ice crystals are still below 60 µm in size.

Figure 5: Comparison of results of the heat shock test (HS) samples with full sugar reference and "no added sugar" with ERYLITE®



Summary

The variety of products with better-for-you type claims continues to grow on the market. ERYLITE® Erythritol is naturally occurring, as well as being the best tolerated and the only “zero” calorie sugar alcohol used in ice cream. As even health conscious consumers still refuse to compromise on taste, ERYLITE® and stevia represent powerful tools in formulations with no added sugar.
The combination overcomes missing sweetness and masks the lingering off notes inherently associated with high intensity sweeteners.

The freezing point depression of the ice cream mix is controlled by adjusting the levels of ERYLITE® and fibre, which keeps a portion of water unfrozen for optimal texture. Although we know erythritol alone does not stabilise the formulation, scanning electron microscope images show that with just a small amount of stabiliser added these formulations demonstrate good heat shock stability as well as good ice crystal and air cell distribution. A stable air phase indicates the ability to resist shrinkage.

These factors allow for the development of recipes with nutritional advantages such as protein and fibre fortification, and calorie reduction. “No added sugar” and “light” claims are also achieved by replacing all of the added sugar with a combination of erythritol, allulose, stevia and fibre.

Achieved Nutrition Claims (EU)
- With no Added Sugar
- Energy-Reduced
- High Protein
- High Fibre

Achieved Nutrition Claims (US)
- No Sugar Added
- Light Ice Cream
- Good Source of Protein
- Good Source of Fibre

Figure 6: : Recipes for US and EU and nutritional values

Ingredients	European Recipe %	American Recipe %
Cream (40% fat)	20.000	20.000
Skim milk	54.776	55.828
Skim milk powder	5.000	5.000
ERYLITE®	8.000	7.000
Reb A	0.024	0.022
Allulose	-	5.000
Inulin	8.000	3.000
Egg yolk powder	1.000	1.000
Stabilizer compound Ticaloid® 620	0.050	0.050
Milk protein isolate	3.000	3.000
Nat. Vanilla 412214	0.150	0.100
	Per 100 g	**Per serving (109 g)**
Calories	**595 kJ / 140 kcal**	**140 kcal**
Added sugar	**0 g**	**0 g**
Protein	**7.000 g**	**7.700 g**
Fibre	**7.800 g**	**3.200 g**

Directions

1 Weigh dry ingredients together (mix well)
2 Add dry mix to milk and cream and mix thoroughly until smooth
3 Heat mix to 55°C (131ºF), hold for 20 minutes while stirring
4 Pasteurise at 65°C (159ºF) for 30 seconds
5 Homogenise (150/30 bar) or (IKA T-25 speed 12) for 2 minutes
6 Age mix at 4-5°C (39.2-41ºF) for 12 hours
7 Add vanilla flavour if desired
8 Freeze in the ice cream machine
9 Store at -20°C (-4ºF)

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About Jungbunzlauer

Jungbunzlauer is one of the world's leading producers of biodegradable ingredients of natural origin. We enable our customers to manufacture healthier, safer, tastier and more sustainable products. Thanks to continuous investment, state-of-the-art manufacturing processes and comprehensive quality management, we are able to provide outstanding product quality.

Our mission "From nature to ingredients®" commits us to protecting people and their environment.

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