Polyglycerols

Polyglycerols in Food Applications

Application Data Sheet

Polyglycerol esters are non-ionic surfactants that are allowed for food use in many countries.

In addition to the stabilization of emulsions, foams, and dispersions, polyglycerol esters can act as aerating agents, dough strengtheners, rheology modifiers, crystal modifiers, anti-spattering agents, beverage clouding agents, humectants, solubilizers, or fat substitutes.[1]

Furthermore, they are biodegradable, biocompatible, and free from ethylene oxide and nitrosamines.

Note that Solvay produces Diglycerol and Polyglycerol-3 but not their ester derivatives. For additional information about the composition and unique properties of Solvay Polyglycerols, please refer to our other Data Sheets on the web site posted at the bottom of the page.

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Polyglycerols in Food Applications

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General properties

Polyglycerol esters have been used as food additives for many years.[2] From the legal point of view, food grade polyglycerol esters are divided in 2 classes: polyglycerol esters of edible fatty acids (E-number: E475, also known as “PGFA”) and polyglycerol polyricinoleate (E-number: E476, also known as “PGPR”).

Depending upon their HLB, polyglycerol esters can act as water-in-oil (W/O) or oil-in-water (O/W) emulsifiers. As mentioned in the “Polyglycerols for ester production” Application Data Sheet, Diglycerol and Polyglycerol-3 esters allow a strong interfacial tension reduction between water and a wide variety of oils. In many systems, they have an even better surface activity than glycerol or homologous polyol esters.[3,4]

Diglycerol and Polyglycerol-3 esters also form highly stable α-gels in water, while gels produced from glycerol monostearate transform with time into a β-crystal structure called coagel.[5,6] The high stability of α-gels is a key advantage of polyglycerol esters in food applications. Indeed, it leads to better emulsification properties and a higher viscosity of the external water phase, resulting in enhanced stabilization of O/W emulsions and foams.

Bakery products

Cake emulsifiers are extensively used to produce low-fat cakes with improved texture, flavor and shelf-life. They also reduce production costs by allowing an “all-in-one” ingredients mixing process, leading to reduced labor and mixing time.[7]

Polyglycerol esters are preferred emulsifiers in baked products due to a variety of properties including enhanced volume and shelf-life of yeast dough. They can also act as whipping emulsifiers with improved texture, water binding and taste in fine baked goods.

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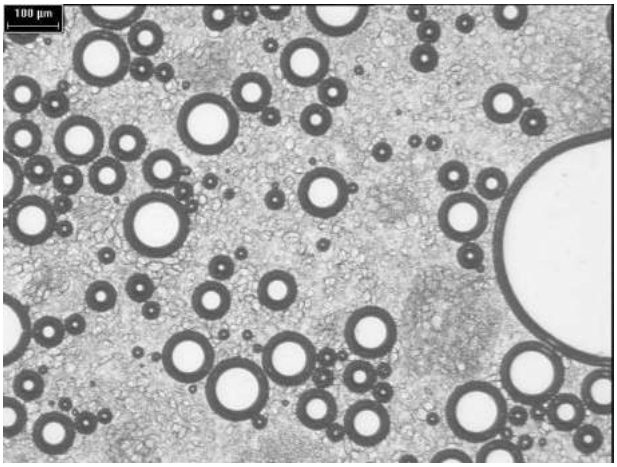
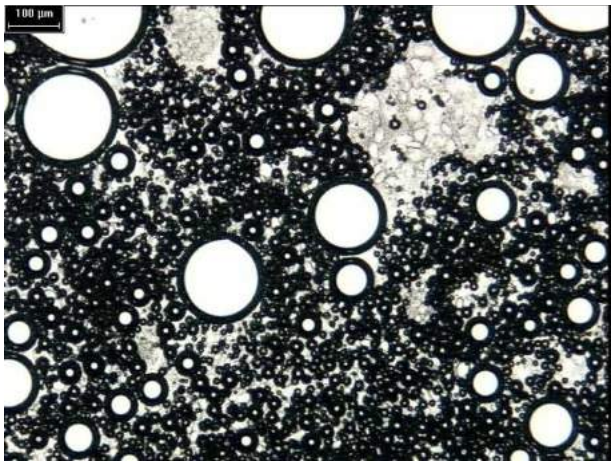
The most popular food grade PGFAs are Diglycerol and Polyglycerol-3 monostearates. When mixed with water, these emulsifiers form highly stable α-gels and exhibit α-tending properties. These esters are of special interest, for example in sponge cake technology, where they lead to an optimal stabilization of the batter and a more uniform foam structure.



Cake batter with no emulsifier



Cake batter with 3g/kg Diglycerol Monostearate

α-Gels also improve batter rheology and crumb structure (more regular and softer), and enhance starch complexation leading to increased cake shelf-life.

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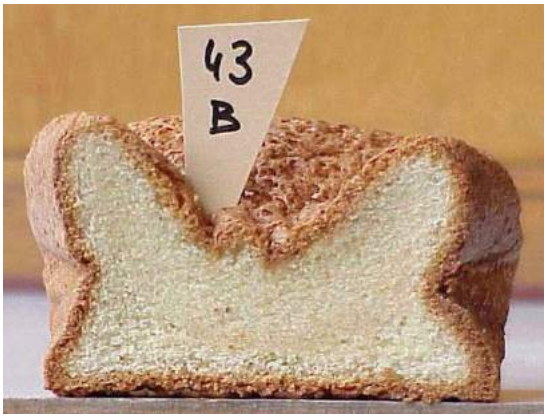
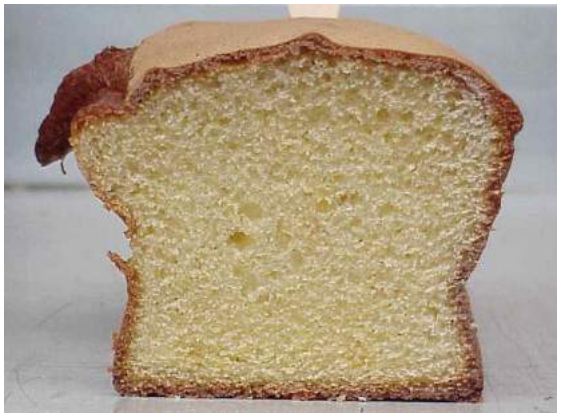
Comparison to glycerol esters

The efficiency of various polyglycerol monostearates vs. the corresponding monoglyceride was studied in sponge cakes by comparing their appearance, and dough and crumb densities.

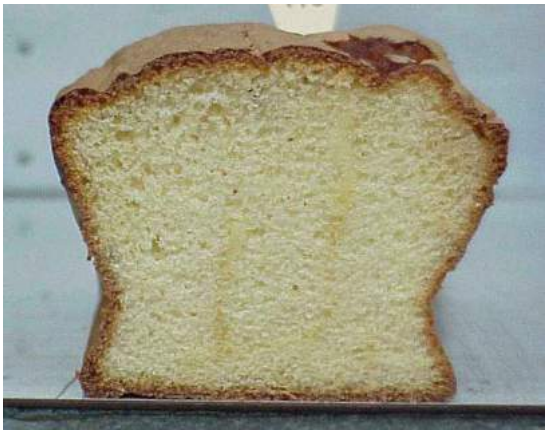
- Fresh gels made from esters based on Solvay polyglycerols were found to have equivalent performance to those made from the corresponding monoglyceride.



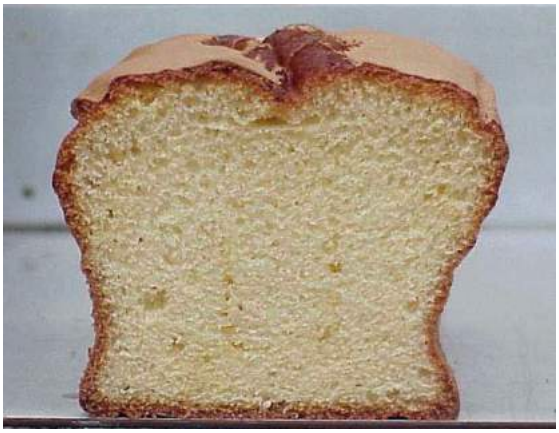
No emulsifier
Dough density: 0.76 g/cm³ Crumb density: 0.93 g/cm³



Glycerol Monostearate
Dough density: 0.40 g/cm³ Crumb density: 0.23 g/cm³



Diglycerol Monostearate
Dough density: 0.41 g/cm³ Crumb density: 0.22 g/cm³



Polyglycerol-3 Monostearate
Dough density: 0.44 g/cm³ Crumb density: 0.22 g/cm³

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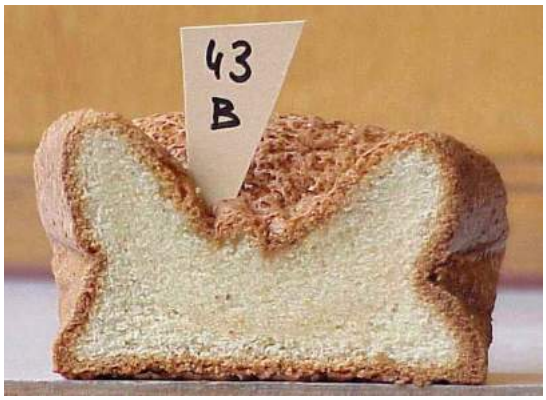
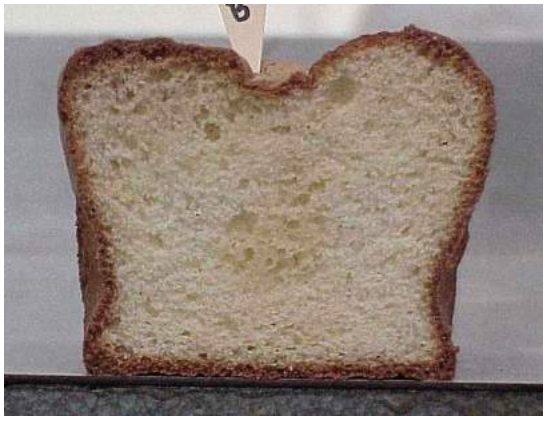
- Two months old gels made from esters based on Solvay polyglycerols have superior performance compared to the corresponding monoglyceride.

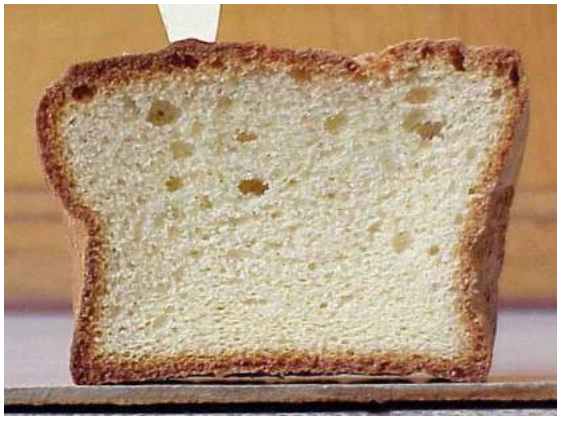


No emulsifier
Dough density: 0.76 g/cm³ Crumb density: 0.93 g/cm³

Glycerol Monostearate
Dough density: 0.86 g/cm³ Crumb density: 0.56 g/cm³



Diglycerol Monostearate
Dough density: 0.43 g/cm³ Crumb density: 0.23 g/cm³



Polyglycerol-3 Monostearate
Dough density: 0.45 g/cm³ Crumb density: 0.23 g/cm³

In addition, polyglycerol esters exhibit higher heat stability than the equivalent glycerides.[8]

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Polyglycerols in Food Applications
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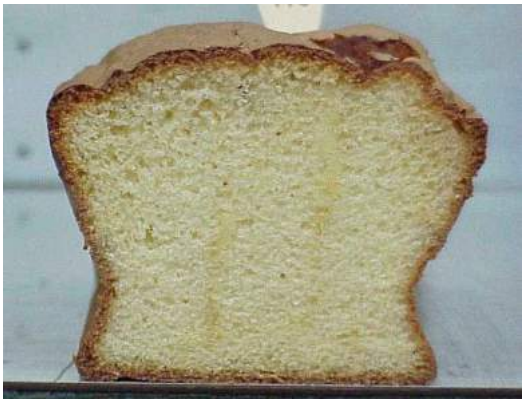
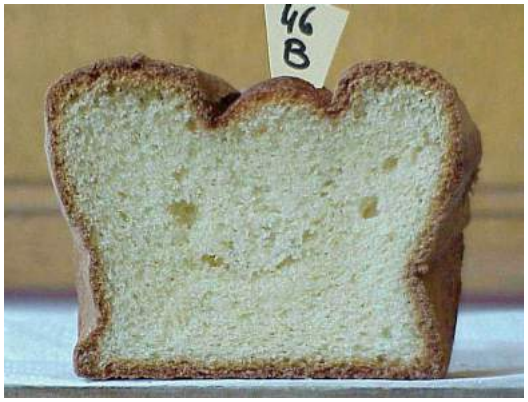
Comparison to condensation polyglycerol esters

As explained in the Data Sheet “Polyglycerols - General Overview”, Solvay manufactures its Diglycerol and Polyglycerol-3 by a special process which generates a narrow oligomer distribution with very low content of residual glycerol and cyclic by-products. The higher purity of Solvay polyglycerols vs “condensation polyglycerols” (obtained by glycerol condensation processes, under alkaline catalysis)[9] has an added value in the final applications of their esters.

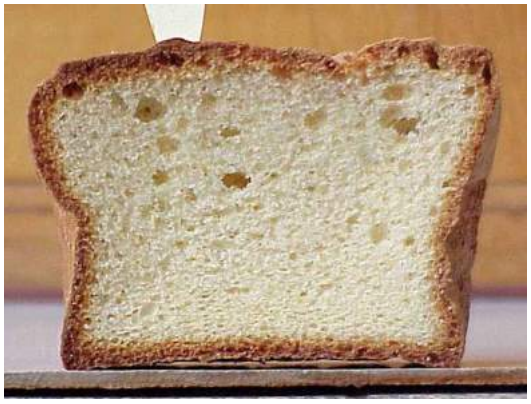
For example, esters made from Solvay polyglycerols have a better performance than condensation polyglycerol esters in baking. The following results were obtained using fresh gels.



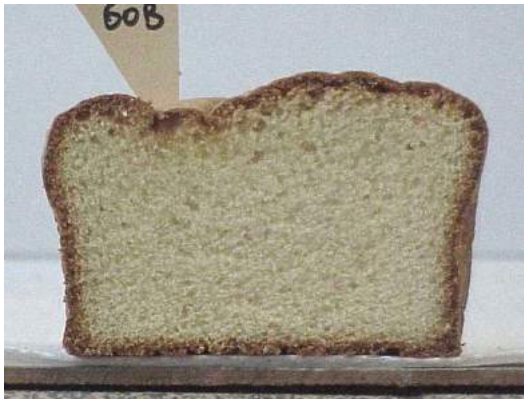
Diglycerol (Solvay) Monostearate
Dough density: 0.41 g/cm³ Crumb density: 0.22 g/cm³



Polyglycerol-2 (condensation) Monostearate
Dough density: 0.48 g/cm³ Crumb density: 0.27 g/cm³



Polyglycerol-3 (Solvay) Monostearate
Dough density: 0.44 g/cm³ Crumb density: 0.22 g/cm³



Polyglycerol-3 (condensation) Monostearate
Dough density: 0.57 g/cm³ Crumb density: 0.34 g/cm³

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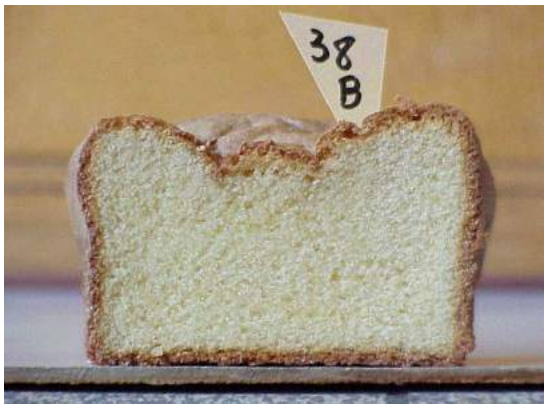
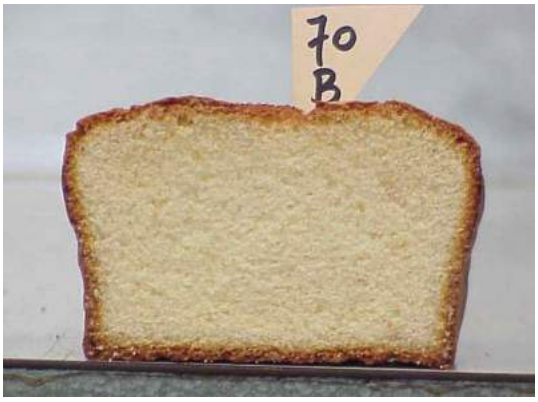
The superior performance of esters based on Solvay polyglycerols is likely due to several reasons:

- Lower content in glycerol.
- Lower content in high molecular weight oligomers.
- Lower content in cyclic byproducts.

Indeed, the following results, using fresh gels, show the detrimental effect of cyclic and long chain polyglycerols on cake quality.



Cyclic Diglycerol Monostearate
Dough density: 0.69 g/cm³ Crumb density: 0.29 g/cm³



Polyglycerol-6 Monostearate
Dough density: 0.71 g/cm³ Crumb density: 0.37 g/cm³

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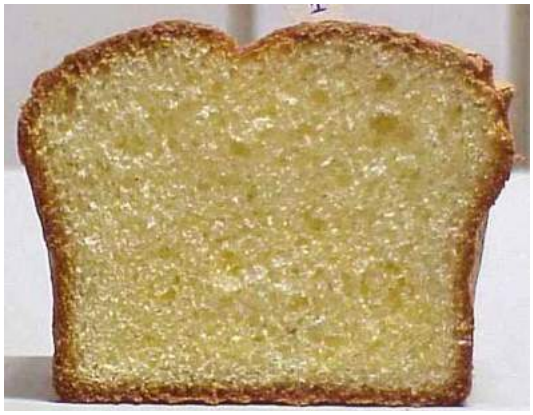
Combination of polyglycerol esters with glycerol esters

It has been shown that blending polyglycerol esters with glycerides can help stabilize the α-crystalline structure of the latter. The α-tending properties of polyglycerol esters were confirmed by comparing the effect of a 6 weeks old gel based on a blend of glycerol monostearate - polyglycerol-3 monostearate (95:5, w:w) to one made from pure glycerol monostearate.

Glycerol Monostearate
Dough density: 0.86 g/cm³ Crumb density: 0.56 g/cm³



Glycerol Monostearate - Polyglycerol-3 Monostearate 95:5 (w:w)
Dough density: 0.48 g/cm³ Crumb density: 0.22 g/cm³

Polyglycerol esters can thus be used alone or in combination with distilled monoglycerides, in order to obtain an optimal performance/cost ratio.

Polyglycerol esters also have advantages in the production of pulverized emulsifier compounds.

Polyglycerol esters can also be incorporated in margarines used for cakes.[7] This simplifies cake production, allowing an “all-in-one” process which leads to better aeration and stability of the batter. As described previously, this also leads to better volume, more uniform crumb structure, softer texture, and longer shelf-life.

Incorporating polyglycerol esters in margarine for puff pastry results in an excellent plasticity of the margarine.[7]

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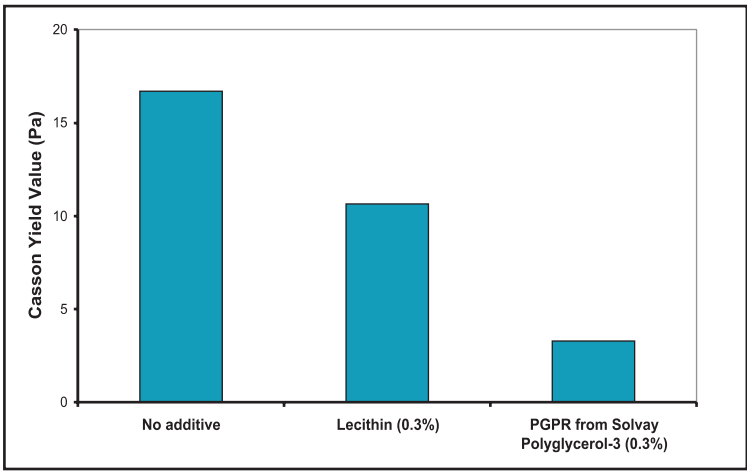
Chocolate

One of the main applications of polyglycerol polyricinoleate (PGPR) is the adjustment of the rheological properties of chocolate.

It is especially important for chocolate coatings to flow properly during the enrobing process. This can be achieved by the addition of PGPR, which improves the flow characteristics of molten chocolate by reducing the “Casson yield value” (which represents the viscosity of chocolate at low shear rate). By contrast, lecithin tends to be used to decrease the “plastic viscosity” (viscosity at high shear rate) of chocolate.

The following figure compares PGPR made from Solvay Polyglycerol-3 to lecithin in lowering the Casson yield value of molten dark chocolate.



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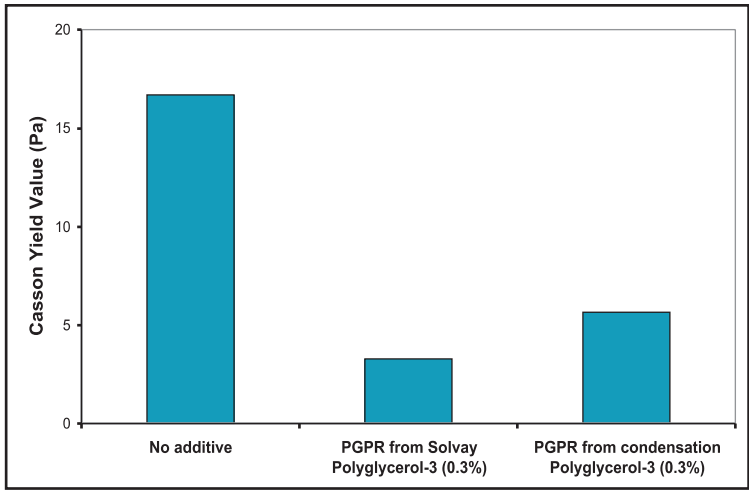
Since lecithin and PGPR have complementary rheological properties, they are often used in combination for an optimal control of chocolate rheology.[10,11] This allows a more even coating of confectionary pieces while reducing the consumption of expensive cocoa butter in the recipe.

Lowering yield value also improves the release of entrapped air in chocolate, leading to a smoother and more efficient molding and depositing. This is achieved without compromising quality and taste, and with cost savings.

An additional property of PGPR in chocolate is its ability to limit fat bloom. PGPR is also claimed to increase chocolate's tolerance to the thickening effect caused by small quantities of water sometimes introduced during enrobing operations.[12]

Due to its predominant linear composition and narrow oligomer distribution, Solvay Polyglycerol-3 produces PGPR of higher performance than the equivalent ester made by condensation polyglycerol as illustrated below.



Note that only PGPRs based on well-defined polyglycerols do comply with the severe requirements imposed by the European and US regulations.

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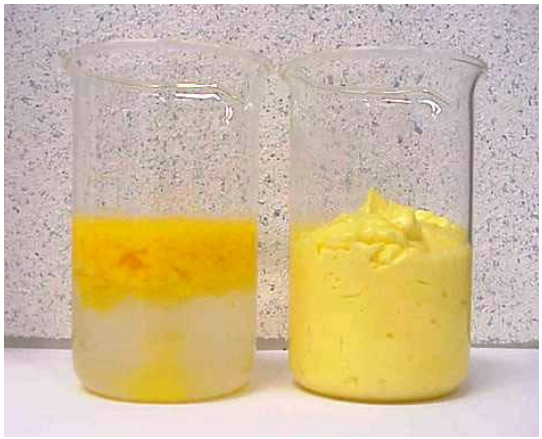
Low-fat spreads

Another important application of PGPR is its use as a water-in-oil emulsifier for the production of low-fat spreads.

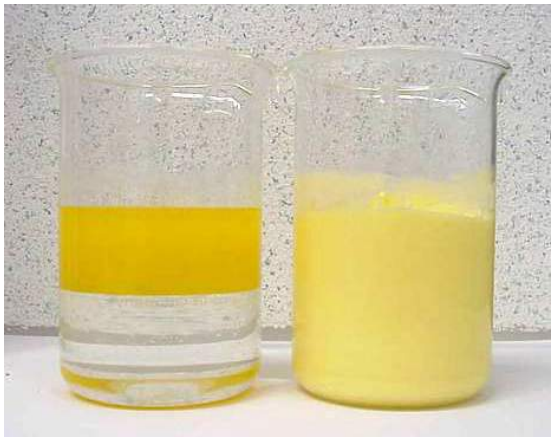
PGPR can be used alone or blended with monoglycerides to obtain an optimal quality/cost ratio.[13]



20% fat spreads

1% distilled monoglyceride

0.6% distilled monoglyceride + 0.4% PGPR



20% fat spreads

0.6% distilled monoglyceride

0.4% distilled monoglyceride + 0.2% PGPR

Example of a low-fat spread based on 20% fat and containing milk powder, gelatin and sodium alginate.

PGPR is compatible with milk products such as skimmed milk powder, usually incorporated to improve the mouth-feel and flavor of spreads. PGPR is also compatible with various additional stabilizers, such as gelatin, alginates, and caseinates.[14]

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Example of low-fat spread formulation with PGPR

Water phase	
Gelatin	2
Sodium alginate	2
Milk powder	1
Salt	1.5
Potassium sorbate	0.1
Lactic acid	to pH 5.5
Water	to 100
Oil phase	
Oil blend	19
Distilled monoglyceride	0.6
PGPR	0.4
β-carotene	q.s.

Production: *Heat water phase and oil phase to 55°C separately. Homogenize the water phase and correct its pH to 5.5 with lactic acid. Add the water phase to the oil phase while homogenizing. Homogenize for 3 minutes then cool to 15°C while stirring gently.*

As in previous application examples, the composition of the polyglycerol moiety influences the quality of the final low-fat spread. This is illustrated by the following results, showing that a PGPR based on Solvay Polyglycerol-3 leads to a stable and smooth spread, compared to a PGPR based on a traditional condensation polyglycerol-3.

0.4% monoglyceride + 0.2% PGPR based on condensation polyglycerol-3

0.4% monoglyceride + 0.2% PGPR based on Solvay Polyglycerol-3

PGPR also prevents or delays sandiness, and improves the spread's frying properties due to its anti-spattering properties.

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Other typical food applications

In addition to the previously described applications, polyglycerol esters can be used in:

- Whipped products, in which they act as emulsifiers and aerating agents for the manufacture of stable foams with softer textures,
- Ice creams, to improve foaming, stability and texture,
- Refined salad and cooking oils, as crystallization inhibitors,
- Dressings, to improve their freezing and thaw stability,
- Beverage whiteners, to improve their stability and their dispersibility in coffee,
- Coatings and glazes, to which they confer improved workability, gloss, gloss life, and stability,
- Reduced-fat foods, in which they contribute to their stability, texture and mouth-feel,
- Chewing gums, as softeners and to avoid sticking to teeth.

NB: All these applications are not allowed in all countries. Please check your local regulations.

Regulatory status

United States

Solvay Polyglycerol-3 and Diglycerol may be used in the production of polyglycerol polyricinoleates (PGPR) for use as emulsifiers in chocolate products at levels no greater than 0.3%. PGPR can also be used as an emulsifier in margarines, low-fat margarines, spreads, creamers, and dairy analogs at levels no greater than 1.0% by weight. Solvay Polyglycerol-3 and Diglycerol may also be used in the production of fatty acid ester emulsifiers (PGFA) when the fatty acids are from sources identified in 21 CFR § 172.854 and the Federal Food, Drug, and Cosmetic Act. With the use of appropriate esterification and production processes, the PGFA and PGPR should comply with the Food Chemicals Codex monograph for PGFA and the proposed monograph for PGPR.

PGFA registered under the Toxic Substances Control Act (TSCA) and made from Solvay Diglycerol may be incorporated as antifogging agents in polyfilms complying with FDA regulations set in 21 CFR § 177.1520 at a maximum use level of 0.152mg/in^2, or in other films at a maximum use level of 0.14mg/in^2, in accordance with applicable FDA Threshold of Regulation exemptions.

European Union

Solvay Polyglycerol-3 and Diglycerol comply with EU polyglycerol specifications for use of polyglycerol esters and polyglycerol polyricinoleate in food under EU Commission Directive number 98/86/EC (E 475 and E 476) of November 11, 1998 on food additives other than colors and sweeteners.

Esters made from Solvay Polyglycerol-3 and Diglycerol are approved for addition to food-contact materials under EU Directive number 95/3/EC of the European Parliament and Council of Europe of February 23, 1995 on plastic materials and articles intended to come into contact with foodstuffs.

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