The characteristics of Lecithin in Bakery Products.

Lecithin for Bakery Products

This paper discusses the many quality and processing benefits bakers are realizing when using The Solae Company's value-added fluid and deoiled lecithins. These lecithins meet the demanding requirements of today's competitive marketplace: applications like improved machinability of low-fat products; extended shelf life in bakery products of all kinds; better extrudability of doughs-including low-fat snack foods; and enhanced tenderness, spread and crumb structure.

Lecithin

Lecithin is a naturally occurring group of phospholipids that is widely used in processed foods like baked goods because of its surface active properties. Phospholipids are one of nature's principal emulsifiers. Phospholipids are natural components of ingredients such as eggs and milk. They can also be added directly as commercial soybean lecithin to exert a significant, positive effect on product quality, shelf life and processability.

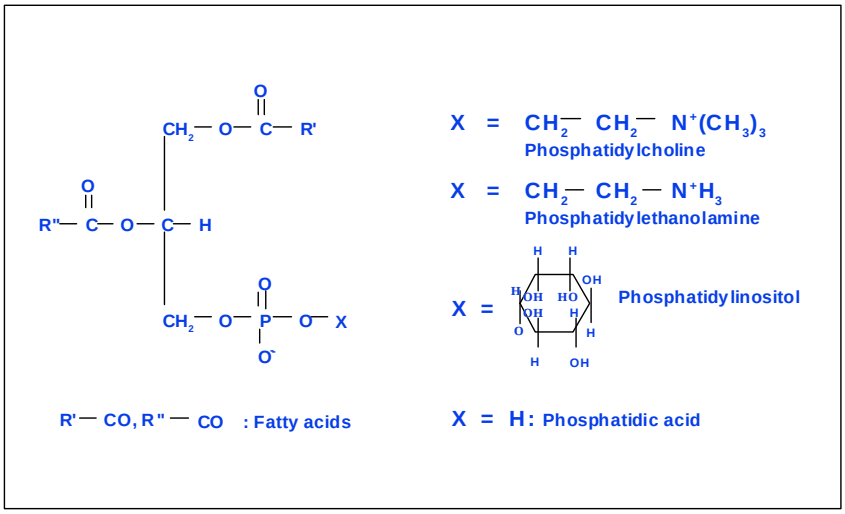

Figure 1: Molecular Structure of Phospholipids

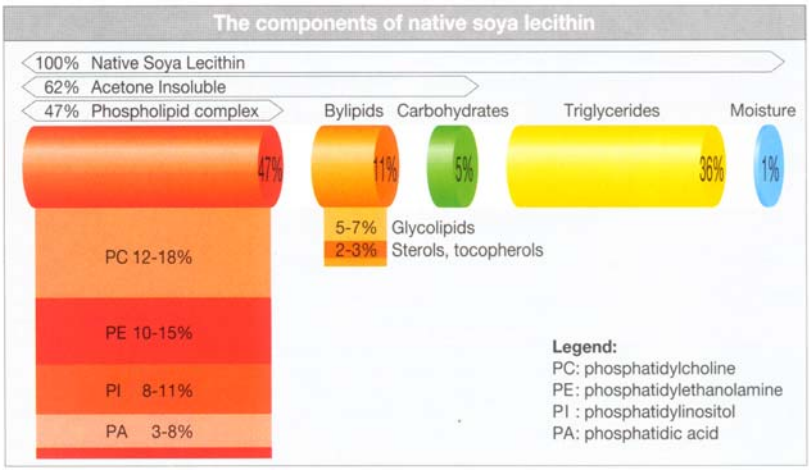

Figure 2: Composition of a native soya lecithin

Lecithin has been used for years in baked foods because of their unique functionalities compared to other Man-made emulsifiers. Other emulsifiers usually only have 1-2 functionalities at a time. In the following we will travel through the landscape of the lecithin applications in bakery products.

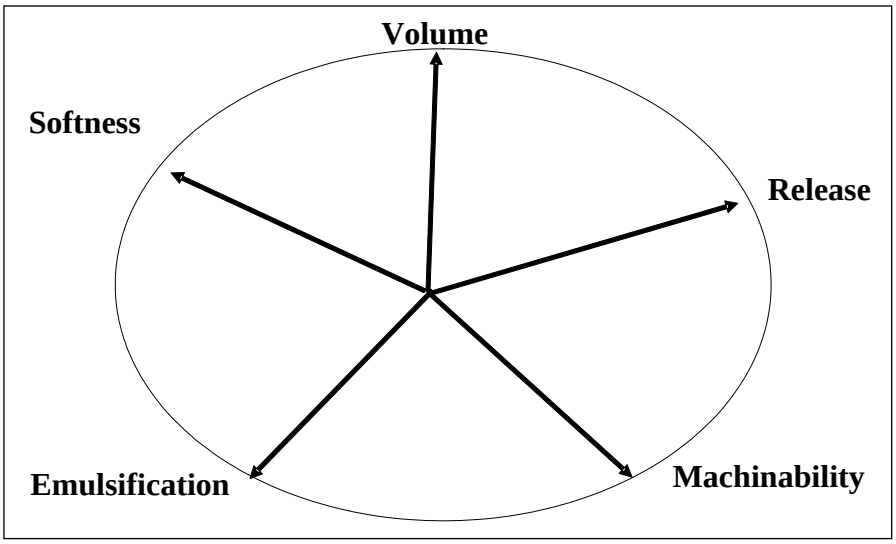

Figure 3: Desirable Functionalities from Lecithin's in Baked Goods.

Shelf Life – Lipid-Starch interaction

Value-added lecithin products extend the shelf life of baked goods. Staling occurs in yeast-raised baked products (breads, doughnuts, buns and rolls) primarily because of starch retrogradation. Traditionally, monoglycerides have been used to prevent starch retrogradation. Our hydrolysed lecithins (CENTROSOFT RW 50, STERNPHIL E 60 and PRECEPT 8160) have a structure similar to a monoglyceride, but with a polar head group; they also complex with amylose. This complex reduces the tendency of the starch component to crystallise and become hard. Unlike monoglycerides which are lipophilic, enzyme modified lecithin disperses easily in water and water based systems like dough. They are an obvious choice to extend shelf life in yeast-raised bakery products. Standard grade lecithin, however, contributes little to the shelf life of most yeast-raised baked goods. It has two fatty acids per molecule and cannot form a complex with amylose.

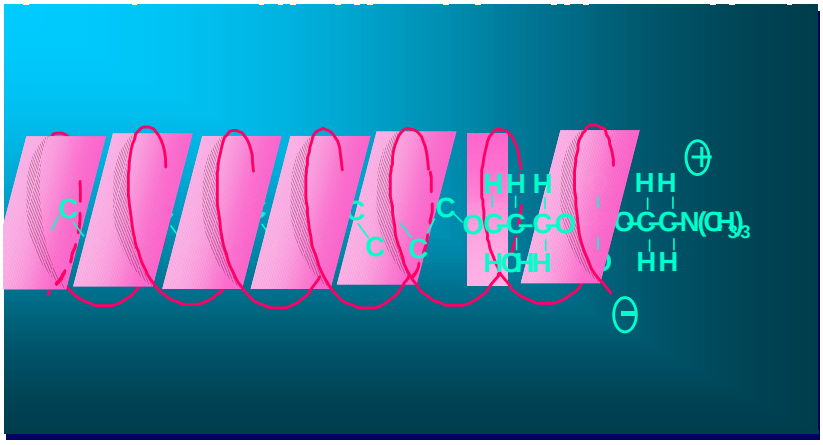

Figure 4 Starch-Lipid Complexes

The chemical structures shown indicate the similarity between monoglycerides and enzyme modified lecithin, and the difference between enzyme modified lecithin and standard grade lecithin.

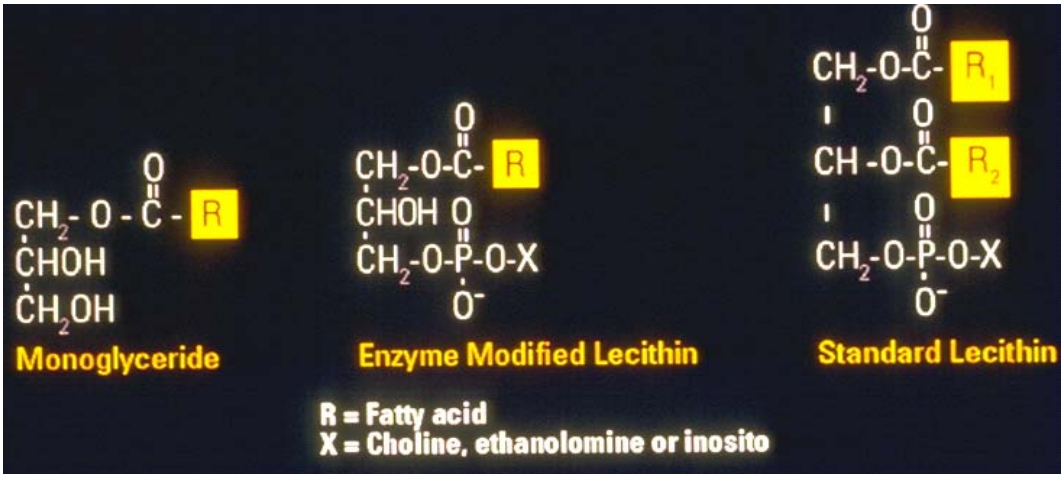

Figure 5: Chemical structure of a monoglyceride and different lecithins

Bakers have three choices of lecithin products for extending shelf life in yeast-raised baked goods:

STERNPHIL E 60, a fluid enzyme modified lecithin

PRECEPT 8160, the deoiled version of enzyme modified lecithin in powder form

CENTROSOFT RW 50, a hydrolysed rapeseed lecithin sprayed on wheat flower

Dough Conditioning – Lipid-Protein interaction
The Solae Company's lecithins also have dough strengthening properties which benefit yeast-raised baked products. The hydrophilic nature of CENTROLEX F, PRECEPT 8160, and STERNPHIL E 60 makes them available during flour hydration, so they strengthen gluten as dough is formed. This results in improved symmetry, volume, grain and texture. Typical applications include pan bread, frozen dough, pizza dough, buns and rolls.

Figure 6 schematically illustrate how different types of lecithins can give surprisingly different bread volumes and overall bread score results. In reality lipid-protein interactions also affect Dough Rheology/Machineability and of cause the changed Volume also affects perceived Softness.

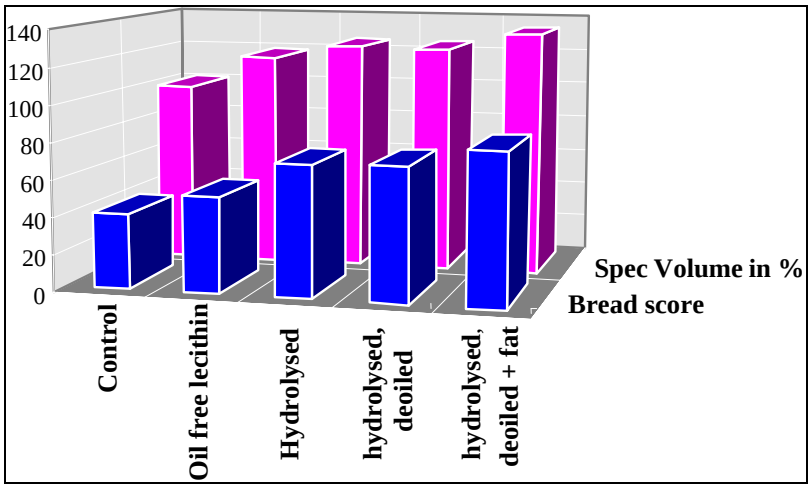

Figure 6 Lipid-Protein Interactions Determined by Different Types of Lecithins

Case Example: European White Pan Bread

In the above described effects of lecithins on the Softness and Specific Volume (figure 6) the control recipe is without lecithin.

However, in practice lecithins and / or emulsifier blends are used. In another series of trials selected lecithins were compared with a commercial DATEM ester.

The used white pan recipe with a rather high protein flour contains also alpha-amylase in addition to ascorbic acid (table 1)

Ingredients	% on flour basis
Bread flour Ceres –Belgium, 13.8% protein	100
Water	60
Yeast, fresh	2.5
Dextrose	2
Shortening	0 or 2
Salt	1.7
Ascorbic acid	20 ppm
Alpha Amylase	100 ppm
Lecithin basis A.I.	0.3 or 0.5
Control Datem	0.3 or 0.5

Table 1: White pan bread recipe for comparing lecithin with DATEM.

The Specific Volumes of all the 4 different conditions (shortening, lecithin dosage) show that lecithins match DATEM ester (Figure 5).

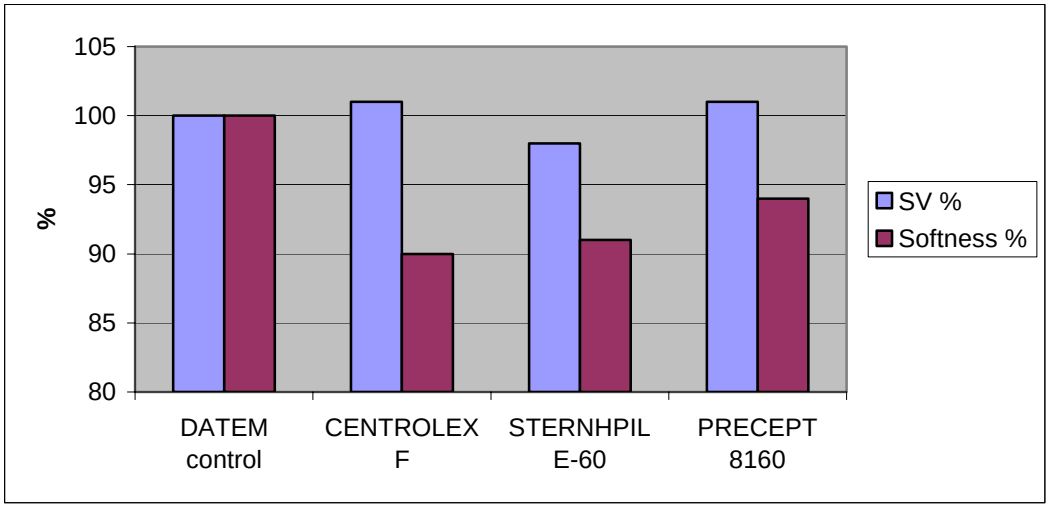

Figure7: Specific Volume and Softness of Lecithins in comparison to DATEM

The Softness was measured with the SMS – TA.XT2 Texture Analyzer program. The lower Softness Values are positive and show that lecithins significantly soften the bread more than the control recipe.

In another white pan bread recipe with a softer Danish flour (table 2) hydrolyzed lecithin was compared with a common European or American emulsifier combination as listed in table 3.

Ingredients	**% on flour basis**
Bread flour “Fortuna” Valsemøllen	100
Protein content > 11.4 %	
Ascorbic acid optimized	
Water	65
Sugar	5
Yeast, fresh	4
Soy oil	2
Skimmed milk powder	2
Salt	2
Dry Improver	See Table 2

Table 2: Formulation for Pan Bread.

In this formulation we compare CENTROSOFT RW-50, a hydrolyzed rape seed lecithin sprayed on wheat flour for convenient use.

Test No.	**Tested Improver**	**Actual Dosage**	**Level of Acetone Insolubles tested %**	**Emulsifier Sources**
1	PANODAN ™ A 2020 DIMODAN® B 727	0.5 % 0.5 %	N/A	E 472e E 471
2	CENTROSOFT RW 50	1.75 %	0.49	Rape Seed Lecithin

Table 3: Improver Ingredients Tested

Table 4 shows the baking results. The investigated parameters are Specific Volume and Softness. All tests are duplicated and show no statistical differences versus the control with man-made emulsifiers. Softness, or as written hardness, is measured with a SMS-Texture Analyzer. The figures are in grams and they are an average of 5 slices of bread. You will notice that figures increase with shelf life as bread become harder or "stale".

Improver	S.V.	Softness day 1	Softness day 4	
GMS+DATEM Mix	5.1	207	376	
	4.8	192	382	duplicate
CENTROSOFT RW 50	4.8	243	438	
	4.9	214	421	duplicate

Table 4 Results of CENTROSOFT RW50 Baking experiment

The overall results of the various white pan baking trials show the following benefits of Hydrolyzed Lecithins:

- **Match DATEM/GMS for Volume and Softness-Shelf life in wheat flour**
- **Offer a more pleasant bread-like smell and taste**
- **Give cost effective dough machineability**
- **Offer convenient handling**
- **Use natural renewable resources enjoying consumer acceptance; clean label.**

Emulsification – Lipid-Hydro interaction

Emulsification is an important role for lecithin in bakery products. Lecithins are natural surfactants and therefore they will influence the ease of mixing oil into water/batter and the stability of the batters during processing. This is a significant functionality in cakes, cookies and wafers.

Lecithins have the property to concentrate in the interface between oil and water and subsequently reduce the interfacial tension.

The Solae Company's value-added lecithins are highly functional emulsifiers that can improve the creaming stage of cookie production, the foam formation in cake batter, and air entrapment for icings.

STERNPHIL E 60 added during the creaming stage of cookie production will result in a smooth, consistent and stable cream phase, making it easy to blend in flour with minimal energy input. The lecithin will enable the sugar granules to be thoroughly coated with the shortening. The result is a more tender cookie with ideal spread and surface characteristics. CENTROLEX F and PRECEPT 81 60 powdered lecithins can also be used to improve tenderness and surface characteristics of cookies.

In cakes CENTROLEX F will increase air entrapment. This result in excellent volumes and more consistent grain.

Case example: Benefits of using Lecithins in Cake

The objective of the specific "model system" in table 1 is to illustrate the relative performance of different types of lecithins for replacement of several Man-made emulsifiers.

INGREDIENTS	DOSAGE
Whole eggs	24.0 %
Sugar	23.8 %
Duo Flour Ceres	19.8 %
Cake margarine	19.8 %
Wheat starch	7.9 %
Emulsifier Veromix [1)], 10 % is mixture of Mono-diglyceride of fatty acids, E 471 Polyglycerolesters of fatty acids E 475, and lecithin E 322	1.4 %
Water	1.4 %
CERESTAR Dry GL 01934 – Spray dried glucose syrup	1.2 %
Baking powder	0.3 %
Salt	0.3 %
Potassium sorbate	0.1 %
Vanilla cake flavor IFF	q.s.
Total	100.0%

1) Manufactured by Zeelandia. Composition of Veromix (1998): 39 % carbohydrates, 38 % water, 23 % fat of which 10 % is emulsifier mixture as mentioned above.

Table 5: Reference Formulation for Pound Cake

Test No.	Emulsifier	Dosage	Level of Acetone Insoluble tested %	Emulsifier Sources
1	*VEROMIX*	1.4 %	N/A	Zeelandia
2	CENTROLEX F	0.5 %	0.5 %	Deoiled standard lecithin
3	Pure PC Lecithin	1.0 %	0.2 %	Very high PC fractionated lecithin
4	STERNCITHIN F-10	0.5 %	0.3 %	Standard lecithin
5	STERNPHIL E 60	0.5 %	0.3 %	Hydrolyzed lecithin hydrolysis degree 60 %
6	STERNLIPID PC 30	0.5 %	0.3 %	Fractionated PC lecithin

Table 6: Emulsifiers Tested and Content of Phospholipids

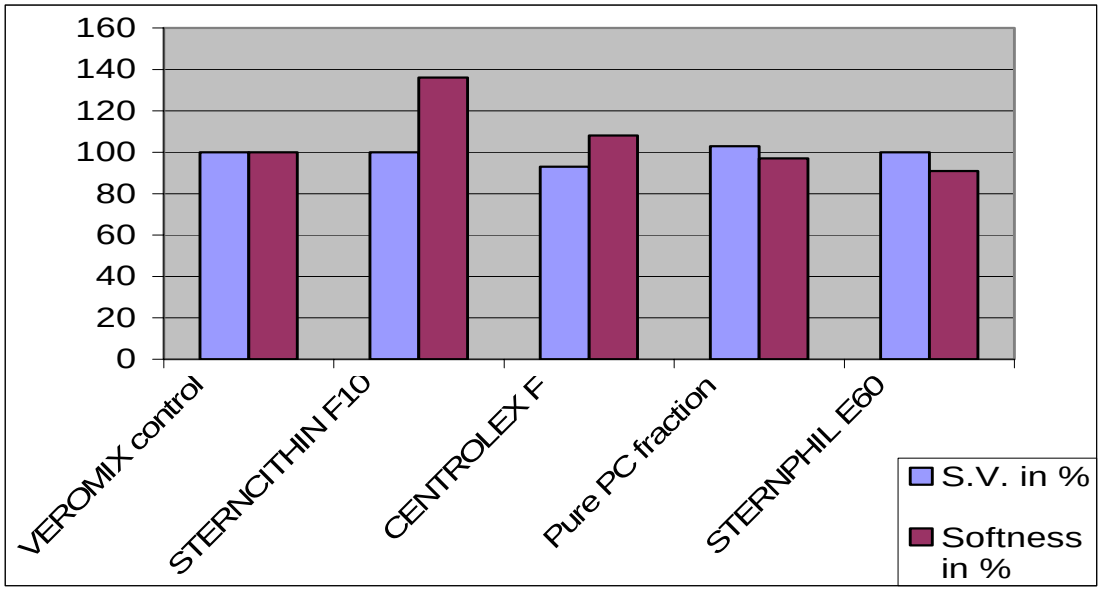

Figure 8: Lecithin effect on shelf life of pound cake during 6 weeks storage

In this case fractionated lecithin STERNLIPID PC 30 and hydrolyzed lecithin STERNPHIL E 60 showed the following benefits in the test case:

- **Similar cake score & specific volume as 2 other Man-made emulsifiers**
- **Good softness and shelf life**

Later after this test the combination of deoiled and hydrolyzed lecithin PRECEPT 8160 has become available which is likely to offer similar even better benefits than STERNPHIL E 60.

Crumb Structure

Lecithin is well known for its ability to improve the crumb structure of chemically leavened baked goods. In cakes it results in a finer, consistent grain with fewer open cells. Applications include layer and sheet cakes, snack cakes and cake mixes. In low-fat or fat-free muffins, deoiled lecithin prevents tunneling and toughness often present when fat is reduced. Typical usage level is 1-2% (flour basis) CENTROLEX F has been shown to improve crumb structure of pound cake.

Machinability

A common challenge in making fat reduced products is the dramatic change in textural characteristics both in respect of consumer appeal as well as in respect of processability. One such example is fat reduced cookies as outlined in table 7. Reducing the fat increases the dough stickiness and the dough sticks to the rollers and cutter, giving massive production problems.

	ORIGINAL	LOW FAT
-Flour	100	100
-Margarine	27	20
-Sugar	59	59
-Dextrose	7	8
-Salt	1	1
-Sodiumbicarbonat	1	1
-Water	30	30

Table 7 Cookie Formulations

The solution to the problem is to add 1% of deoiled lecithin CENTROLEX F based on the flour. The use of deoiled lecithin offers an unexpected reduction in the stickiness of the dough and makes the dough as smooth and well running on the line as the original full fat formulation.
The values in figure 9 are measured in a laboratory Instron-SM-TPA Texture-Analyzer and SMS Chen-Hoseney Cell: The smaller “power area” under the curves, the smaller is the stickiness. The control recipe is the one with reduced fat without any lecithin.

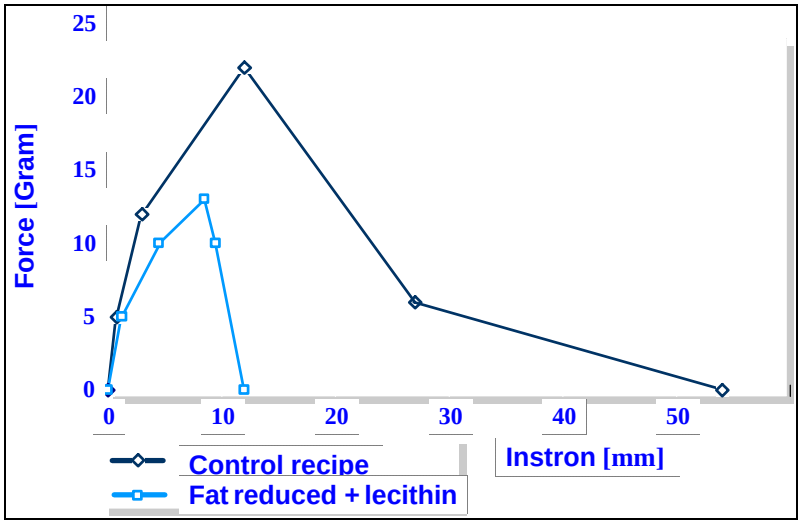

Figure 9: Stickiness of Fat Reduced Cookie Dough

Release
This is the last typical functionality of lecithins in the bakery area. Also release is difficult to demonstrate on lab scale. It is a phenomenon that happens on large scale continuous process equipment. The function of release can best be illustrated in the use of wafer cone production. It is assumed that the oil in the batter try to escape from the hydrophilic hot surfaces of the baking irons. Subsequently this might lead to - poor release, - colour variation of the surface of the cones, - possible burning on the plates and - more cleaning. When lecithin is added, the more hydrophilic lecithin aligns on the surface of the baking irons and the oil aligns to this lecithin layer. The end effect is an undisputable and pronounced improved “release effect”.

Lecithin also helps to control batter viscosity for wafer, pancakes and other batter products to yield consistent, controlled flow. Batter viscosity is important in the production of pancakes and waffles to ensure

that the finished pancakes have a consistent shape and there are no rounded corners on waffles that should be square.
Furthermore the use of spray dried lecithins on milk carriers offer a better distribution of the lecithin in the dough and again a better release. Central Soya offers several different spray-dried lecithins for wafer production. Two based on Soya; LECIFLOW 60 and STERNMULS 545, one based on Sunflower called CENTROSOFT SM 545 and one based on Rapeseed called CENTROSOFT RM 545.

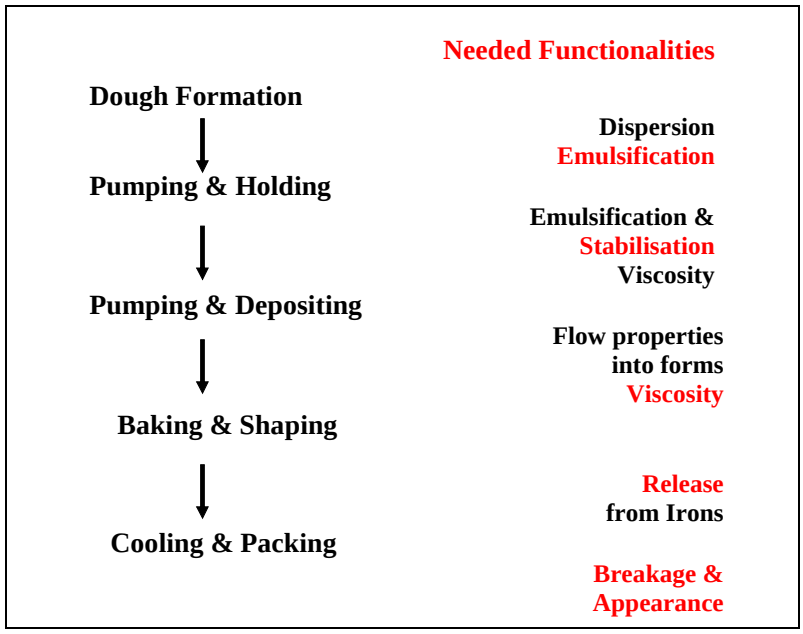

Figure 10: Flow Diagram of Wafer Production.

In the test case listed in table 8, standard lecithin is replaced with LECIFLOW 60 and a reduction in the amount of coconut oil is attempted. The plant scale line used for production is HAAS TRO-1220, approx.10.000 cones/h.

Ingredients	Quantity Kg			
	Control	Test 1	Test 2	Test 3
Wheat flour	36	36	36	36
Coconut oil	2	1.6	1.6	2
Sugar	17	17	17	17
Salt	0.24	0.24	0.24	0.24
Water	42	42	42	42
STERNCITHIN F-10	1.1			
LECIFLOW 60		1.5	2	2
Appearance	--	**0**	+	++
Structure	--	-	**0**	+

Table 8: Formulations for Ice-Cone production

The evaluation of this test case shows that LECIFLOW 60 (powder lecithin) gives a better result than STERNCITHIN F-10 (standard lecithin). This is even the case if the oil is reduced, but the overall best result is the recipe with 2% LECIFLOW and 2% coconut oil.

The benefits of using powder lecithin in the wafer production are:

- **Simple to dose and easy to handle**
- **Ensures a fast and thorough emulsification of the fat**
- **Provides an even distribution of all the ingredients in the batter**
- **Improves the flow properties of the batter**
- **Provides an easy release from the baking surfaces, especially needed on modern, high-speed automatic equipment**
- **Reduces soiling giving less burnt residue, less cleaning, longer running machine times, less wear and tear.**

Furthermore they give the following advantages on the baked products:

- **Even, golden browning without the typical spots due to poor dispersion of the fat and the protein in the batter**
- **Smooth surfaces with uniform grain**
- **Greater resistance to breakage because of the more homogeneous inner structure**
- **Easy packaging and fewer returns**
- **Longer shelf life due to slower moisture absorption**

Release - Spray
Lecithin is the active ingredient widely used in release systems. In the bakery industry lecithin is the functional component in most pan/trough greases and aerosol spray release products. Very low levels of lecithin are needed. This reduces the high calorie level when oil is used because so little lecithin is needed. It also results in less overspray than oil alone, improving the safety of the plant work environment. Typical formulas for release products used in the bakery industry are shown in table 9.

Pan Bread	Aerosol Spray
Oil 98%	Oil 70%
Lecithin 2%	Lecithin 8%
----	Propellant 22%

Table 9: Formulation of release products

Extrusion
Lecithin also has a positive effect on lubricity in extruded products. It contributes to increased throughput and decreased clean-out time. Lecithin improves product flow, and it does not have a negative effect on density. In the production of extruded fat-free pretzels, down time for cleaning the cutting knives can be significantly reduced with the use of 0.5-0.75% (flour basis) CENTROLEX® F deoiled lecithin. Deoiled lecithin can also be used to replace monoglycerides in some extruded breakfast cereals and special pastas.

Using CENTROLEX F in extruded products can also improve texture of the finished extruded products. CENTROLEX F has been shown to counteract the brittle bite of fat-free pretzels, resulting in a more delicate, tender structure

Dust Control

Lecithin is widely used for dust control. Manufacturers of bakery mixes or dusty ingredients can spray a small amount of lecithin (less than 1 %) on to the surface of a dusty powder to greatly decrease the dustiness of that powder without harming its functionality. In many cases the flow characteristics and dispersibility of the powders are actually improved. Low viscosity, low flavour lecithins, like STERNPHIL MB 45, can be sprayed to control dusting.

Concluding from the above case examples, lecithin E 322 has multiple functionalities and it is an art to formulate these functionalities based on the selection of the optimal type of lecithin. When one tests only standard lecithin, by no means one has exhausted all the formulation possibilities with value-added lecithins!