Technical Memorandum

TM 1535-2e

LysoMax® Oil – new enzyme for improved oil yield in water degumming of vegetable oils

DANISCO

INTRODUCTION

Danisco has developed a new approach towards enzymatic water degumming of vegetable oils – an innovative acyl transferase for increased oil yield. The yield-enhancing ability is the result of two interrelated features: the transferase reaction of the enzyme and the simultaneous formation of lyso-phospholipids, which improve the separation of the oil and gum phase. High quality degummed oils with phosphorus levels below market specifications are guaranteed.

The enzymatic water degumming process is easily implemented. All that is required is an enzyme dosing system for induction into the water stream with subsequent mixing into the oil. In addition the reaction temperature must be adjusted to 55°C, as this produces the highest enzyme activity (figure 1).

BENEFITS OF LysoMax® Oil

The benefits of Danisco's enzyme for water degumming are summarised below.

- Increased oil yield – higher profit – minimum capital investment
- Increased formation of phytosterol esters in degummed oil
- Controlled formation of free fatty acids in degummed oil due to transferase reaction
- No hydrolysis of triglycerides and, thus, no extra formation of free fatty acids
- Significant reduction in gum phase viscosity – improved separation of oil and gum phase

ENZYME CHARACTERISTICS

pH profile

The stability of LysoMax® Oil is highest at a pH of 5 to 10 (figure 2).

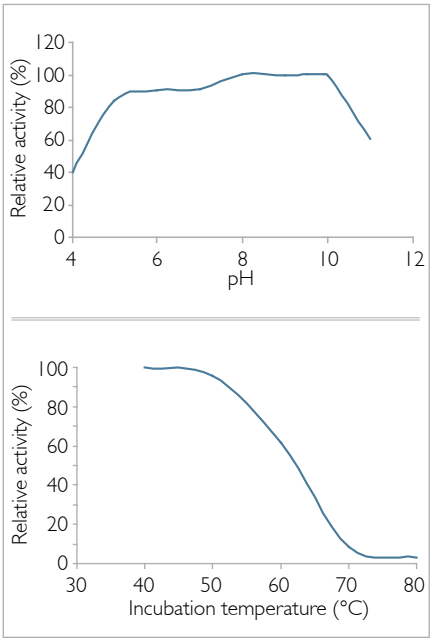

Figure 2. Relative stability measured as a function of various pH levels and temperatures (determined after 30 minutes' incubation).

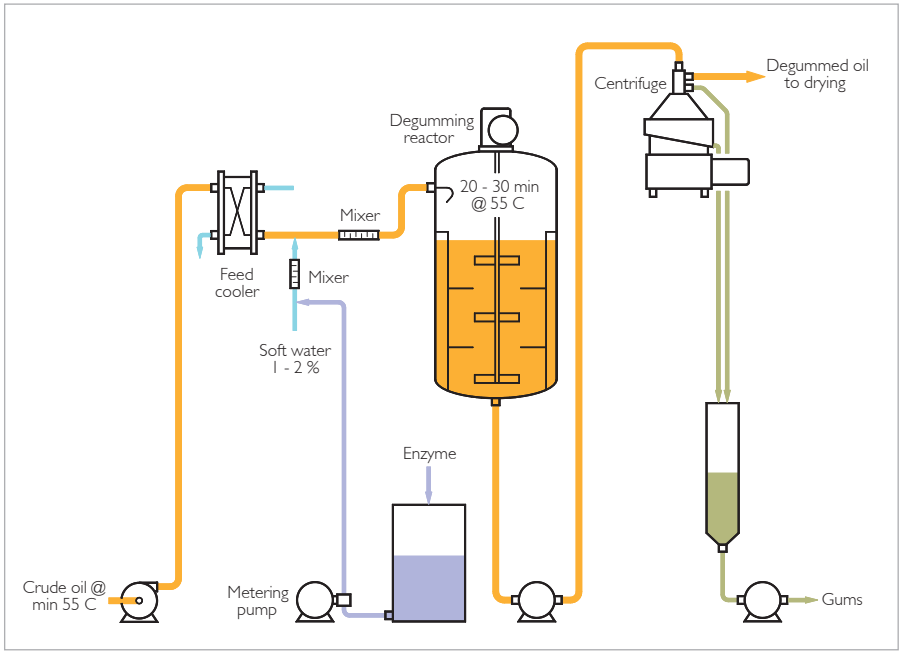

Figure 1. Enzymatic water degumming process. The amount of gum is reduced compared to non-enzymatic degumming.

Temperature profile

Optimum enzyme activity is achieved at 65°C, although the enzyme readily denaturises at higher temperatures. Tests show the enzyme is stable (relative activity more than 80%) for 30 minutes up to 55°C (figure 2). Hence, the water degumming temperature should be kept at 55°C.

ENZYME REACTION MECHANISMS

LysoMax® Oil primarily catalyses the transfer of acyl groups from the sn-2 position of phospholipids to phytosterols in the oil. The transferase reaction contributes to the formation of lyso-phospholipids and phytosterol esters, as illustrated in figure 3 for phosphatidyl-choline.

Essentially, the transferase reaction controls the formation of free fatty acids, maintaining the high quality of the degummed oil. The binding of free fatty acids to phytosterols contributes further to increased oil yield, as the phytosterol ester remains in the oil.

A secondary effect is that the enzyme hydrolyses phospholipids into lyso-phospholipids and free fatty acids, when the level of phytosterols in the oil is depleted. Figure 4 shows the reaction for phosphatidylcholine.

The conversion of phospholipids into hydratable lyso-phospholipids reduces the content of phosphorus in the oil, as the hydratable phospholipids are removed in the centrifugation step. Moreover, the formation of lyso-phospholipids has a favourable effect on the consistency of the gum phase, making the separation of the oil and gum phase more efficient. A further advantage of LysoMax® Oil in oil processing is that it is not active on triglycerides.

APPLICATION

LysoMax® Oil is highly suitable for water degumming of crude vegetable oils such as soya bean oil, canola oil, corn oil and sunflower oil with a high phosphorus content. The enzyme is active on all major phospholipids, such as phosphatidylcholine (PC), phosphatidic acid (PA), phosphatidylethanolamine (PE), and phosphatidylinositol (PI).

To ensure optimal enzyme performance, the following process parameters are recommended.

Water

- ✓ Demineralised water should be used to prevent contamination with calcium and magnesium ions.
- ✓ Amount: 1-2% depending on the level of phosphorus in the oil. Reduced water consumption during enzymatic degumming could represent an advantage over conventional water degumming.

Mixing

- ✓ Proper mixing of water, oil and enzyme is necessary for optimal enzyme performance. A dynamic mixer is preferred.

Temperature

- ✓ Reaction temperature must be kept at 55°C. A higher reaction temperature

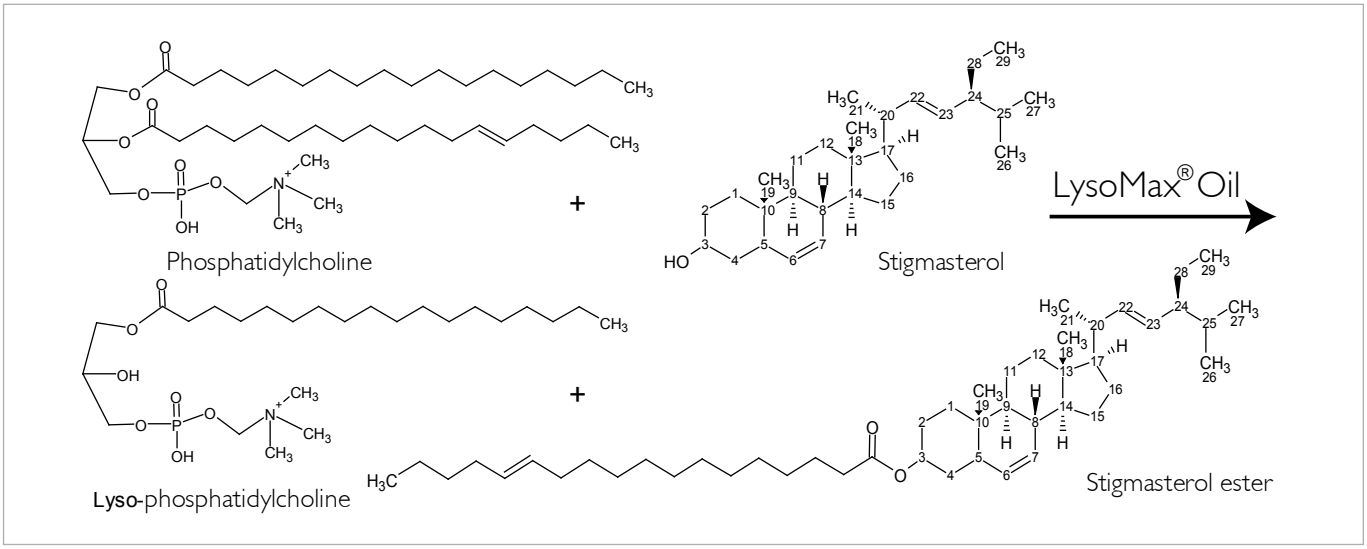

Figure 3. Schematic illustration of transferase reaction by LysoMax® Oil. An acyl group in the sn-2 position of phosphatidylcholine is transferred to stigmasterol and lyso-phosphatidylcholine and stigmasterol ester are formed.

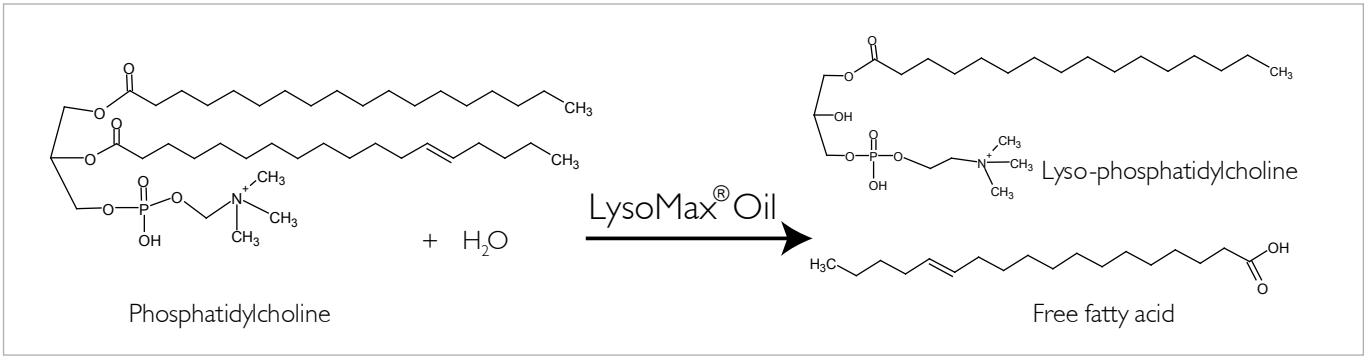

Figure 4. Hydrolysis of phosphatidylcholine into lyso-phosphatidylcholine and free fatty acid by LysoMax® Oil.

will also give a yield benefit if the enzyme dosage is increased accordingly.

Time

✓ Recommended reaction time is 30 minutes. No change in reaction time compared to conventional water degumming.

OIL YIELD

Enzymatic water degumming changes the mass balance, giving increased oil yield compared to a non-enzymatic process. This is due to the transferase reaction of the enzyme. The transfer of fatty acids from phospholipids to phytosterols (figure 5) reduces the amount of gum phase and increases the degummed oil phase.

Another factor contributing to increased oil yield is the transformation of phospholipids into lyso-phospholipids, which improves the separation of the oil and gum phase. Lyso-phospholipids are more water soluble than phospholipids and are, thus, more easily separated from the oil during centrifugation.

The easiest way to measure the increase in oil yield is to make a mass balance of oil and gum resulting from the enzyme process and compare this with the conventional water degumming process.

In practice, it is not always possible to measure the oil and gum flow from the water degumming process. It is, however, possible to determine the increase in oil yield by calculating the mass balance based on analysis of:

- crude oil
  % FFA, % sterol, % sterol ester, %-water, ppm phosphorus
- dried degummed oil
  % FFA, % sterol, % sterol ester, ppm phosphorus
- the gum phase
  acetone insoluble (AI), % FFA dry basis

From these analytical results, it is possible to calculate the mass balance for the phospholipids, based on the assumptions:

- acetone-insoluble material (AI) is a measure of the relative amount of phospholipid in the gum phase
- the increase in free fatty acids by the enzyme reaction with LysoMax® Oil is caused by hydrolysis of the phospholipids
- the formation of sterol ester is caused by an acyl-transfer reaction from phospholipid to sterol

The amount of solids in the oil is not included in the equation because it is not expected to change in the control process and the enzyme process.

The analysis of sterol and sterol ester is required to obtain the mass balance. But, when repeated analysis during processing has confirmed that the conversion of sterol to sterol ester is constant, this conversion rate can be used in the calculation instead of doing sterol analysis on a routine basis.

A spreadsheet for the calculation of oil yield is available on request.

ENZYME INACTIVATION

During enzymatic water degumming, the enzyme will follow the gum phase, which is normally added back to the meal. Addition of the gum to the meal before the drying process will secure total enzyme inactivation.

STORAGE AND HANDLING

LysoMax® Oil should be stored dry and cool (below 10°C/50°F). Under these conditions, the enzyme will remain stable for at least 6 months.

In processing plants, the enzyme should not be kept at 30°C for more than two weeks.

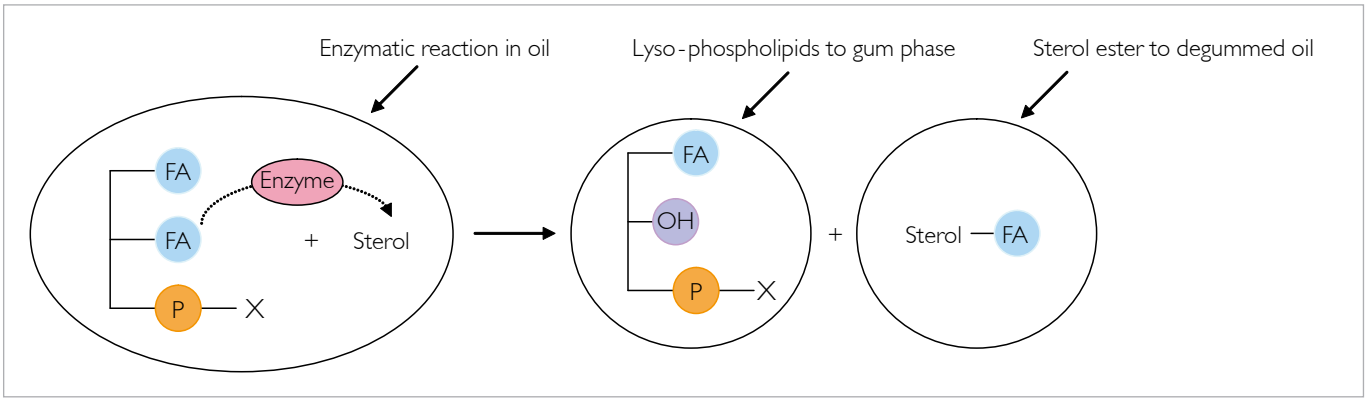

Figure 5. Transferase reaction, where a sn-2 fatty acid is transferred from a phospholipid to a sterol in the oil. Reaction products are lyso-phospholipid and sterol ester.

Danisco A/S
Edwin Rahrs Vej 38
DK-8220 Brabrand, Denmark
Telephone: +45 89 43 50 00
Telefax: +45 86 25 10 77
info@danisco.com
www.danisco.com

Danisco USA Inc.
Four New Century Parkway
66031 New Century, Kansas, USA
Telephone: +1 (800) 255 6837
Telefax: +1 (913) 764 5407

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