



History of Making Omega-3 Lipids with Torula Yeast

- Waldhof is near Mannheim, which was in the American sector after the war, and American engineers interviewed Waldhof engineers and made copies of all the drawings for this fermenter.
- Waldhof fermenters were built at sulfite mills in Great Lakes area (Rhinelander, Wisconsin), most wood was hardwood
- Wasn't very profitable, but cleaned up water from sulfite mills
- Eventually most sulfite mills closed, Kraft pulp mills became dominant, only one Waldhof fermenter remained (Rhinelander).

- In 1947, the long-time director of Waldhof,
 E. Schmidt, published a complete technical description of the experiences at Waldhof, doubtful that anyone in USA ever read it.
- Schmidt, E. "Eiweiß-und Fettgewinnung über Hefe aus Sulfitablauge." Angewandte Chemie 59.1 (1947): 16-20.
- "the sum of fat and protein in Torula, around 50%, i.e. if you have 10% fat, there are also 40% protein, but you have 25% fat, so only 25% protein, etc."



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Making Torula Yeast with Omega-3 Lipids

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YEAST

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- About 5% glucose accumulates about 7% fatty acids
- Waldhof fermenter can produce 150 g/L yeast dry mass
- This is probably how Schmidt produced 25% lipids in Candida utilis
- Babij, T., F. J. Moss, and B. J. Ralph. "Effects of oxygen and glucose levels on lipid composition of yeast Candida utilis grown in continuous culture." Biotechnology and bioengineering 11.4 (1969): 593-603.





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- Higher oxygen concentration leads to higher linonenic acid (C18:3, Omega-3) concentration
- Can produce up to 240 uM oxygen concentration in foam fermenter
- This shows that a foam fermenter with Candida utilis can produce lipids with 35% Omega-6 and 30% Omega-3
- Babij results confirmed in Johnson, B.,
 Sheila J. Nelson, and C. M. Brown. "Influence of glucose concentration on the physiology and lipid composition of some yeasts."
 Antonie van Leeuwenhoek 38 (1972): 129-136.





Key: C_{16:0} Palmitic; C_{16:1} Palmitoleic; C_{18:0} Stearic; C_{18:1} Oleic; C_{18:2} Linoleic; C_{18:3} Linolenic.

🥑 НаноТаига Current market for Torula yeast (Lallemand)



- Lallemand is now the world leader in producing Candida utilis (Torula) for the food industry, in Rhinelander, Wisconsin
- Purchased Waldhof fermenter and assets of Provesta (Phillips Petroleum fermenter)
- Sulfite pulp mill is closed, Lallemand uses glucose and molasses, standard batch aseptic aerobic fermenter, doesn't use Waldhof fermenter any more.
- There's something magic about a Waldhof fermenter that produces Torula yeast with Omega-3 lipids





Primary grown, dried whole cell torula inactive yeast. It is a specialty product range with the unique ability of delivering superb flavor carrier properties in different food applications, with distinctive savory notes and superior texture enhancement.



DESCRIPTION

Lake States® production begun in 1948 in Rhinelander, Wisconsin. For over 50 years the site has been a leader in the development and commercialization of inactive dried torula yeast for the food industry, pharmaceuticals, industrial fermentations, animal feed, and pet food markets. Thanks to Lallemand investments, it is today the largest torula inactive yeast production site in the world.

The Lake States[®] products can be used to help to reduce the use of additives such as MSG and HVP. They are designed to impart savory notes, enhance texture and nutritional characteristics in foods. They are ideal for a broad range of processing temperatures and preparation techniques, including microwave.

If you are interested in receiving "Lake-States®" leaflet, or to learn more about our inactive yeast range, please contact us or send an e-mail to info@bio-lallemand.com.

We will be happy to support you in the choice of the most suitable product!

PRODUCT HIGHLIGHTS	>
RECIPES	>





Importance of Omega-3 Lipids

- Omega-3 and Omega-6 fatty acids are essential to human life
- The human body does not have FAD2 and FAD3 enzymes so we need linoleic acid (Omega-6) and linolenic acid (Omega-3) in our diet
- Ratio of Omega-6 to Omega-3 must be between
 2:1 and 1:2 for optimal health
- More oxygen = more Omega-3
- The Waldhof fermenter has higher dissolved oxygen at high cell concentrations than any other type of fermenter





Importance of Omega-3 Lipids



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- Omega-3 is precursor to EPA and DHA, the major fatty acid in the brain is DHA
- The human body can produce EPA and DHA, but the more Omega-6, the less EPA and DHA (competition for the same enzymes)
- Chickens and salmon (and most animals) can produce EPA and DHA from Omega-3
- Epidemiological studies suggest that consumption of DHA is associated with a reduced incidence of Alzheimer disease. Animal studies demonstrate that oral intake of DHA reduces Alzheimer-like brain pathology.





Why are Americans Fat?

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America's most widely consumed oil causes genetic changes in the brain. New UC Riverside research shows soybean oil not only leads to obesity and diabetes, but could also affect neurological conditions like autism, Alzheimer's disease, anxiety, and depression.

University of California, Riverside, Jan 17, 2020

- Soybean oil has a 7:1 ratio of Omega-6 linoleic acid to Omega-3 linolenic acid.
- A ratio of more than 2:1 Omega-6 to Omega-3 leads to reduced levels of DHA in the body. DHA is the main fatty acid in the brain.
 - Animals are usually fed grain-based feeds containing soy and corn. Fats in the meat are mostly Omega-6 while grass fed animals are 1:1.



1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010



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Healthy and Unhealthy Fats

- Unhealthy fats have a ratio of linoleic acid to linolenic acid greater than 2:1. This leads to low production of DHA, which is needed for the brain.
- Soybean (7:1), corn (57:1), sunflower (71:1) and cottonseed oil (54:1) are very unhealthy
- Canola (rapeseed) oil (2:1) is reasonably healthy, most margerine in the world today uses this
- Flaxseed (linseed) oil (1:3) is the healthiest, but oxidizes easily so not useful for cooking oil and margarine
- Can feed flaxseed to chickens without grinding, commonly used to make Omega-3 eggs

Dietary Fat			Fa	atty ad	cid content normalize	ed to 100 perce	nt
Canola oil	7	61			11	21	
Safflower oil	8	77				1 14	
Flaxseed oil	9	16	57			18	
Sunflower oil	12	16	1 71				
Corn oil	13	29			57		
Olive oil	15	75				19	
Soybean oil	15	23		8	54		
Peanut oil	19	48			- 33		
Cottonseed oil	27		19		• 54		
Lard	43				47	19	
Palm oil	51				39	+ 10	
Butterfat	68				28	1	3
Coconut oil	91					7	2
						* Tra	ce
Saturated Fat	M	onounsaturate	ed Fat	Pol	yunsaturated Fat		
•	•	Oleic acid (an Omega- fatty acid)	9	-	Alpha-linolenic acid (an Omega-3 fatty acid)	Linoleic acie (an Omega- fatty acid)	6





What's New in CelloFuel Fermenters?

- Waldhof fermenter has a 1.5 m diameter spinning disc to make a 10% emulsion, Cellofuel fermenter uses 75mm bubbler tubes to make foam with 10% liquid, using much less energy with no moving parts.
- Waldhof fermenter removes heat by cooling emulsion with heat exchanger, but emulsion is an insulator and can't easily be cooled. Cellofuel fermenter cools fermentation liquid after breaking foam with cyclone.
 - Waldhof fermenter uses spinning disk to break foam and reinject air. CelloFuel fermenter uses cyclone to break foam and reinject air, which uses much less energy with no moving parts.

- Waldhof fermenter uses a stainless steel fermenter, Cellofuel fermenter uses a UPVC fermenter in a shipping container, reducing cost.
- Waldhof fermenter uses stainless steel heat exchanger, Cellofuel fermenter uses either titanium or 316L heat exchanger to reduce nickel leaching, which works with contamination control (discussed later).





20 ft. CelloFuel Container







40 ft. CelloFuel Container

