NEW FEED PROTEIN SOURCES
Products from fermentation
-yeast-

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For Cofalec

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History shows search for food self-sufficiency

- Max Delbrück, **1910**, work on surplus brewer's yeast as a feeding supplement for animals.
- **WW1**: Germany can replace 50% of its imported protein sources by Yeast (aerobic fermentation)
- **1919**: Progress in fermentation by Sak and Hayduck
- **WW2**: plans in Germany to produce 100 000 T/y to incorporate in army and civilian diets (only 15 000 produced) – In UK distinction between food yeast (bakers' yeast)/fodder yeast (Brewer's yeast).
- During **Cold war**, the need to be self sufficient in proteins incited both the US and Soviet Union to develop yeast production as both food and fodder, around 250 000T produced in the mid 60's. Plans to produce 900 000T/y in the Soviet Union.
- **In the 80's**, improvements in plant and crop production, lowered the interest for yeast.
- **In the 90's** , the end of cold war and the GATT agreement, did not push the price of agricultural crops, so costs of yeast as food source was less interesting.

Source: Ugalde and Castrillo 2002

Now: Production of single cell proteins has a renewed interest

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What are Single Cell Proteins (SCP)?

- Edible unicellular microorganisms.
- **Algae, yeasts, fungi or bacteria**
- Can be used for human consumption, animal feeds.
- Can be grown on agricultural, human, animal waste products waste.
- Could be produced independently through autotrophic growth

"*Microbial products like yeast represent potential **sustainable ingredients** in aquafeeds due to their ability to convert low-value biomass from forestry and agricultural industry into **high-value feed ingredients** and with limited dependence on agricultural land, water, and changing climatic conditions*". (Overland *et al* 2013)

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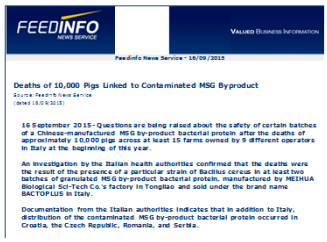
Single Cell Protein, the ideal and cost-effective protein…

… But accident can happen with low quality grade products…



FEEDINFO NEWS SERVICE — VALUED BUSINESS INFORMATION

Feedinfo News Service - 16/09/2015

Deaths of 10,000 Pigs Linked to Contaminated MSG By-product

Source: Feedinfo News Service (dated 16/09/2015)

16 September 2015 - Questions are being raised about the safety of certain batches of a Chinese-manufactured MSG by-product bacterial protein after the deaths of approximately 10,000 pigs across at least 15 farms owned by 9 different operators in Italy at the beginning of this year.

An investigation by the Italian health authorities confirmed that the deaths were the result of the presence of a particular strain of Bacillus cereus in at least two batches of granulated MSG by-product bacterial protein, manufactured by MEIHUA Biological Sci-Tech Co.'s factory in Tongliao and sold under the brand name BACTOPLUS in Italy.

Documentation from the Italian authorities indicates that in addition to Italy, distribution of the contaminated MSG by-product bacterial protein occurred in Croatia, the Czech Republic, Romania, and Serbia.

SCP like bacteria can produce also toxins.

Example: B. cereus, toyoi Toyocerin.

What about regulation?

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Use of SPC already enclosed in feed regulation

COMMISSION REGULATION (EU) No 68/2013 of 16 January 2013
on the Catalogue of feed materials

(1) The use of this Catalogue by the feed business operators **shall be voluntary**. However, the name of a feed material listed in Part C may be used only for a feed material complying with the requirements of the entry concerned.

(4) In accordance with good practice as referred to in Article 4 of Regulation (EC) No 183/2005 of the European Parliament and of the Council (1), **feed materials shall be free** from chemical impurities resulting from their manufacturing process and from processing aids

12. Fermentation (by-)products from micro-organisms

- Bacteria, yeasts, fungi, by-products from fermentation.
- A large number of yeast species listed

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The QPS status helps evaluating the risk

The Qualified Presumption of Safety (QPS)
is a **common risk assessment approach** for use **within EFSA**.

QPS is NOT an EFSA approval of safety
QPS is NOT a regulatory status

Currently, the QPS approach is used for **microorganisms** of the broad categories listed below:

- Gram-Positive Non-Sporulating Bacteria
- Bacillus
- Gram-Negative Bacteria
- Yeasts
- Virus (plant viruses and insect viruses)

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Here also a large number of yeasts are QPS

Species			Qualifications
Candida cylindracea†††			QPS only applies when the species is used for enzyme production
Debaryomyces hansenii			
Hanseniaspora uvarum			
Kluyveromyces lactis	*Kluyveromyces marxianus*		
Komagataella pastoris *Lindnera jadinii* *Ogataea angusta*			QPS only applies when the species is used for enzyme production
*Saccharomyces bayanus***** *Schizosaccharomyces pombe*	*Saccharomyces cerevisiae*†****	*Saccharomyces pastorianus*****	
*Wickerhamomyces anomalus*****			QPS only apply when the species is used for enzyme production
Xanthophyllomyces dendrorhous (imperfect form *Phaffia rhodozyma*)			

HOWEVER, by-products from fermentation may be subject to restrictions
in accordance with the GM feed and food legislation (R1929/2003)
if the fermentation process involves GMMOs.

What does it mean for producers?

The operator is responsible for the safety of its products
and should put in place a **risk analysis and controls**. (R 186/2005)

Yeast (*Saccharomyces cerevisiae*), as primary production,

belongs to the **feed/food industry**,

and yeast producers are well aware of the risks.

They then have put in place **appropriate controls** to evaluate the risks

Controlled bacterial protein production

Spirulina (cyanobacterium).
The aim is to produce bacterial as a protein source using waste .

Some projects in development

Nutrisync: aerobic wastewater treatment process to augment protein production by the heterotrophic bacteria responsible for wastewater treatment.

Unibio: using U-Loop fermentation technology to convert *Methylococcus Capsulatus* a naturally occurring methane eating bacterium into UniProtein®, a highly concentrated protein.

FeedKind™: is a premium fish feed ingredient produced from naturally occurring microbes found in soil. Using a natural fermentation process similar to making yeast.

- 2 last ones aim at the fish meal market.
- Projects are at small scale development.
- Commercialization not scheduled before 2018.
- Needs to be GRAS/QPS

Use of yeast in animal feed


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Yeast: a living Treasure

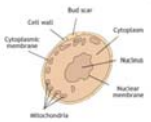

Diagram of a yeast cell

A dividing yeast cell, as seen under a microscope

Yeast is a **fragile, delicate organism**: We do not manufacture yeast. **We grow it.**

- Yeast is a **living microorganism.** This microscopic fungus is no larger than 6 to 8 thousandths of a millimeter in size, yet has **exceptional fermentation characteristics**
- The most well-known yeast is ***Saccharomyces cerevisiae***.
- **In the presence of air** and nutrients introduced into the fermenter, yeast multiplies (yeast propagation).
- In the bread-making process, **in the absence of air**, it produces gas and aromas.
- Yeast can be used for a **variety of purposes**. These include:
  - *Making bread dough rise*
  - *Contributing to the flavor, sensory and nutritional qualities of bakery products*
  - *Producing fermented drinks*
  - *Improving the well-being of people, animals and plants*
  - *Producing bioethanol and new green chemistry products*

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Not only one yeast but yeasts

A **large variety** of species
Some particular species in food/feed industries

Saccharomyces cerevisiae
- Baker's, brewer's yeast
- Can be grown on molasses (corn, beetroot, sugar cane)

Candida utilis
- Torula yeast
- Can be grown on wood liquor, paper industry by-products

Kluyveromyces marxianus/lactis
- Dairy yeast
- Can be grown on whey by-products

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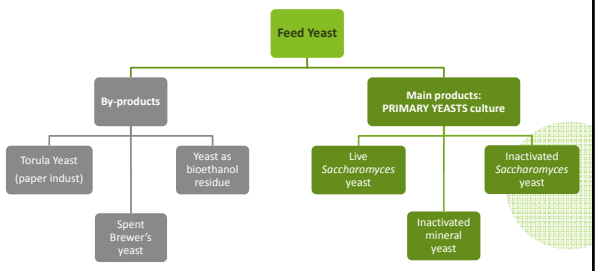
Huge diversity of marketed yeast derived products



Source BCC yeast

Health through nutrition with live yeast and fractions

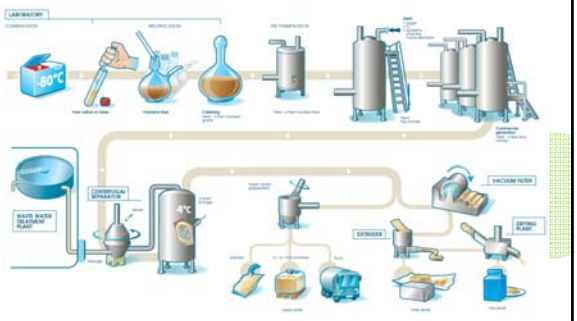
Probiotic yeast

- Microflora modification
- Rumen stabilization
- Pathogen exclusion

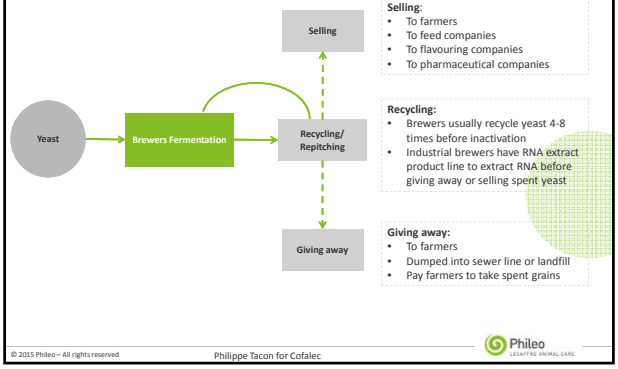
Feed additives

- Immune stimulant (Beta glucans –mannans)
- Palatability enhancer (AA- nucleotides)
- Improvement of gut health (Nucleotides)
- Mineral yeast

Primary dried yeast: a very controlled process



Spent Yeast –Brewery Origin

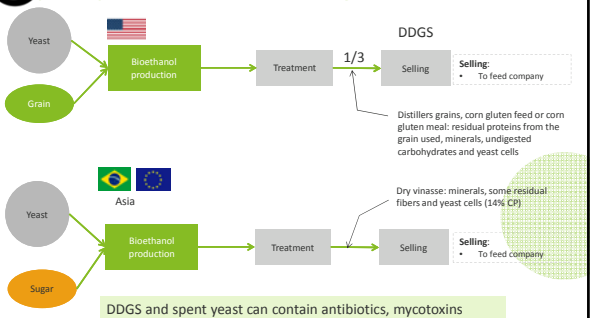


Selling:
- To farmers
- To feed companies
- To flavouring companies
- To pharmaceutical companies

Recycling:
- Brewers usually recycle yeast 4-8 times before inactivation
- Industrial brewers have RNA extract product line to extract RNA before giving away or selling spent yeast

Giving away:
- To farmers
- Dumped into sewer line or landfill
- Pay farmers to take spent grains

Spent yeast – Bioethanol origin

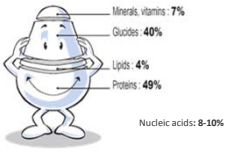


DDGS and spent yeast can contain antibiotics, mycotoxins

Food/feed safety issue: The Food Modernization Act?

Yeast a good protein source

- Nutritional composition of yeast



Nucleic acids: **8-10%**

Vitamin	Typical content Units
B1 Thiamin	2 - 15 mg/100 g
B2 Riboflavin	2 - 8 mg/100 g
B6 Pyridoxin	0.5 - 6 mg/100 g
B8 Biotin	0.05 - 0.25 mg/100 g
B9 Folic acid	1 - 4 mg/100 g
PP Nicotinic acid	10 - 60 mg/100 g

Composition varies according to:
- **Strain/substrate**
- **Process, autolysis, separation**

Process must be optimized

Very close in AA composition to fish & soy bean meals

Amino acids %	Yeast	Fish meal LT70	Soybean meal 48
Essential AA			
Arg	3.4	3.7	3.0
His	1.1	1.4	1.0
Ile	2.1	2.5	1.8
Leu	3.45	4.5	3.0
Lys	3.6	4.7	2.4
Thr	2.1	2.5	1.6
Trp	0.57	0.7	0.5
Val	2.5	2.7	1.9
Met	**0.2**	**1.8**	**0.6**
Cys	**0.05**	**0.4**	**0.6**
Phe	2.2	2.4	2.0
Tyr	1.8	1.9	1.4

Amino acids %	Yeast	Fish meal LT70	Soybean meal 48
Non essential AA			
Ala	3.2	3.9	1.8
Asp	5.25	5.6	4.5
Glu	8.75	8.1	7.1
Gly	2.35	3.8	1.7
Pro	2.25	2.4	2.0
Ser	2.65	2.6	2.0

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High digestibility of yeast in animals

Nutritional parameters in rats, from Rivière 1977

Organism	Digestibility%	Biological value%	Protein efficiency
S. cerevisiae	81	59	--
C. utilis	85-88	32-48	0.9
C. Utilis + 0,5% DL met	90	90	2.3

Ileal digestibility in pigs (Data from Phileo) – Instant dry

Amino Acid	Digestibility%
Lysine (lys)	84%
Methionine (met)	91%
Threonine (thr)	77%
Tryptophane (trp)	89%

Apparent digestibility in salmon Overland et al 2013

Amino Acid	Fish meal	Candida	Kluyveromyces	Saccharomyces
Lysine (lys)	87%	87%	84%	68%
Methionine (met)	86%	83%	79.5%	74%
Arginine (arg)	89%	89%	87%	75%
Leucine (leu)	88%	89%	81%	67%

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Given facts

- High nucleic acid content limits the dose incorporated because of Uric acid deposition
- Risk of acidosis
- Supplementation with sulfur AA

Incorporation rates must be optimized through nutrition studies according to species needs.

Need to work with standardized products

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What is yeast future as an alternative protein source?

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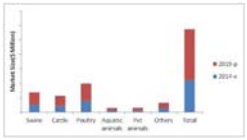
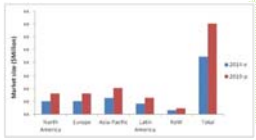
Spent yeast, a dynamic and promising market…

	Volume ,000 metric tons	CAGR 2014-2019
Spent yeast	151 or 700*	9.5%

Animals species: Poultry, Swine, Cattle



Largest market: Asia and North America



*depending on market studies

(Market and Markets 2014)

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But a standard and safe product has a price.

Market will require guaranteed safe products

Controlled production

Optimize production costs

Primary yeast culture (fermentation)

Develop high value products

High costs/protein source on the market

Cost of production highly dependent of cost of substrate (molasses)

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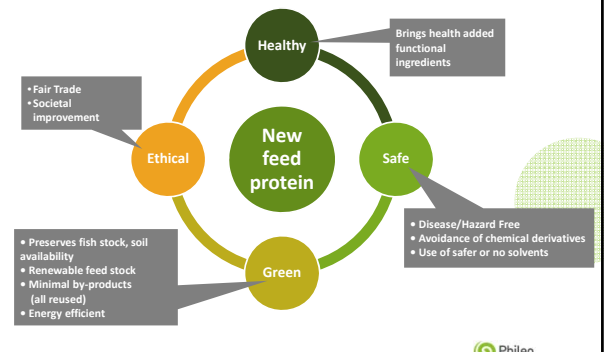
Yeast can help build better food



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Yeast a promising protein source

A Sustainable High Quality Protein

- Good protein content; AA balance, digestibility
- Possible use as a supplement in SDPP, fish meal, replacement strategies
- Ethical production

Yeast is not yeast

- Safety guaranteed with Primary yeast culture

High capacity production

- An experienced industry
- Improvement of cost effectiveness.

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Thank you for your attention

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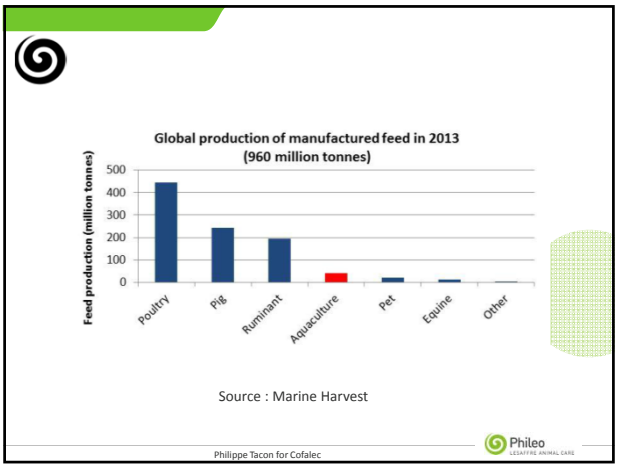

Source : Marine Harvest

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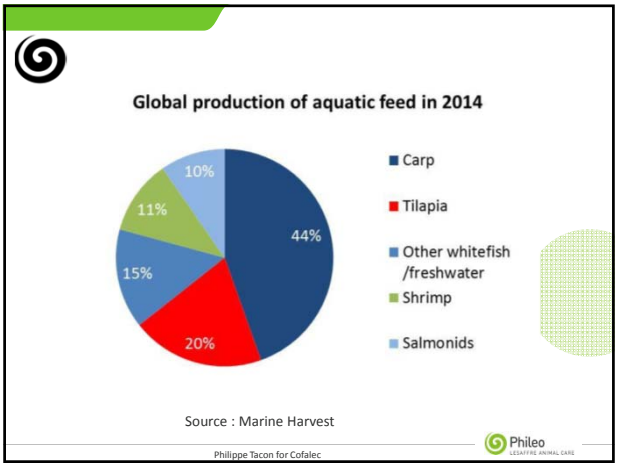

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