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# Every Part of Yeast is the Best Part

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# Every Part of Yeast is the Best Part!

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## Introduction

As a world leader in yeast production, Lallemand is committed to highlight the animal nutrition market about the world of yeasts, what solutions exist, how they are made and what they can bring in terms of applications and benefits. This presentation is aimed at sharing the different end solutions originating from yeast productions.

Yeasts are single-cell, eukaryotic microorganisms classified in the fungi kingdom. They are generally around 10µm in size, have a nuclear membrane, a cell wall, and a cytoplasmic content. Yeasts are characterized as heterotrophs, which means they rely on organic material as sources of energy and nutrients.

Not all yeasts are equal. There are about 60 genera and about 1,500 species of yeasts. Only a few are used commercially. Thanks to its exceptional fermentative capacities and nutritional properties, *Saccharomyces cerevisiae* is the main yeast used in food, beverage and baking as well as in animal nutrition.

Within this species, there are thousands of different strains, each with a unique genetic makeup, leading to different outcomes in terms of metabolisms and activities. Each strain also possesses different properties and exerts various activities when fed to the animals. Hence, each product used for a specific application in animal nutrition must be carefully selected for its desired outcome. The main types of yeasts and yeast products used in animal nutrition are:

- Live Yeast Probiotics
- Whole-cell Inactivated Yeasts & Yeast Cultures

- Autolyzed Yeasts
- Hydrolyzed Yeasts
- Yeast Fractions such as Yeast Cell Walls & Yeast Extracts

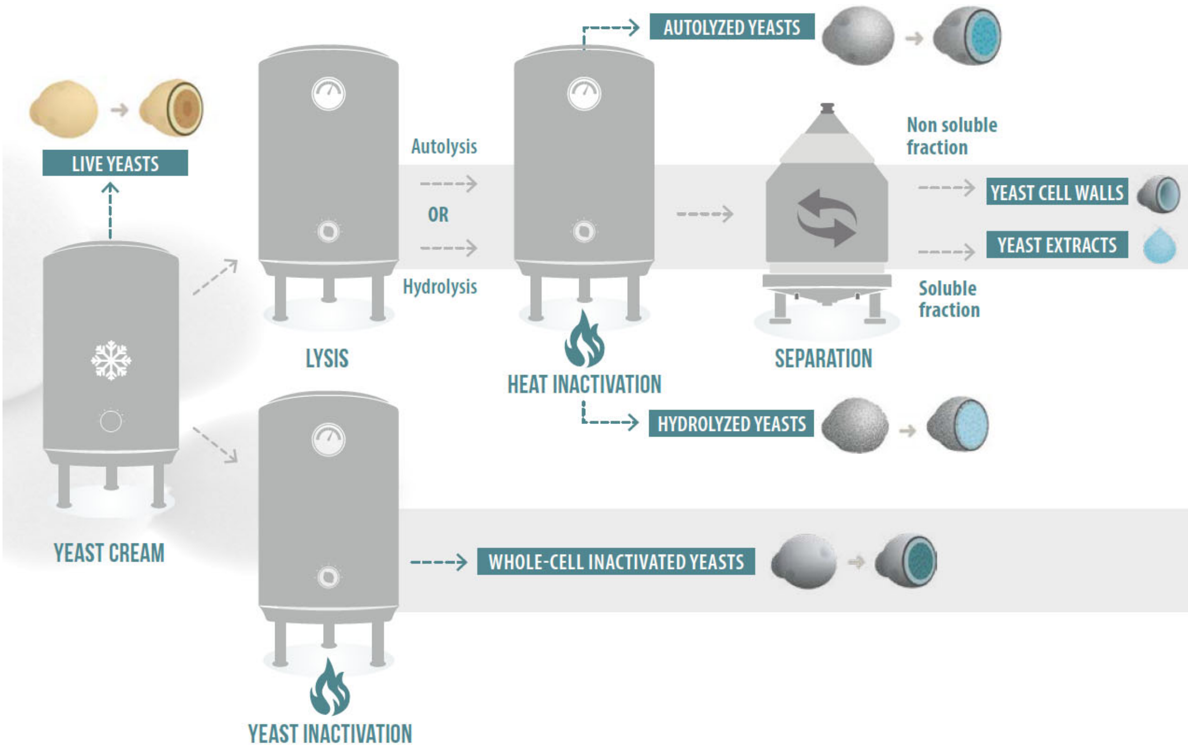
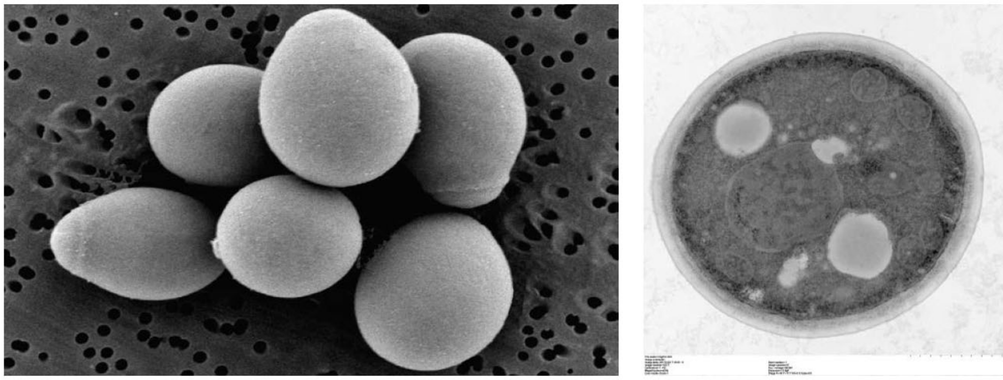



*Figure 1: The different types of yeast products*

## Live Yeast as Probiotics

Live yeasts (also known as active dry yeasts) are generally added to animal feeds for their probiotic effects. Probiotics are defined as "live microorganisms, which, when administered in adequate amounts, confer a health benefit to the host." (World Health Organization).

Not all live yeasts are equal: specific yeast strains will have unique effects on targeted species. One of the challenges of producing probiotic yeast is to ensure the yeast remains alive and active throughout the whole production process, and during further feed processing and storage, until it reaches the animal's digestive tract, where the products are active.



Live yeast cells *S. cerevisiae* (scanning electron microscopy)

Live yeast cells *S. cerevisiae* (transmission electron microscopy)

*Figure 2: Picture of live yeast Saccharomyces cerevisieae boulardii*

Specific live yeasts are known to induce positive effects both in ruminant (e.g., *Saccharomyces cerevisiae* CNCM I-1077) and monogastric species (e.g., *Saccharomyces cerevisiae boulardii* CNCM I-1079), depending on the yeast strain used. Some of the main benefits:

- In ruminants, where the main target is the rumen, there are proven benefits of certain live yeast strains in the control of the rumen pH (reduction of acidosis risks), through improved rumen fermentation conditions, improved fiber digestibility and enhanced ruminal microbiota establishment.
- In swine, live yeasts can help improve digestive comfort through beneficial action on the gut microbiota, resulting in improved feed efficiency and performance. It also helps maintain gut health, which can help reduce incidence of digestive disorders in piglets.
- In poultry, live yeasts help balance the digestive microbiota. As such, they favor the development of beneficial microorganisms. The presence of undesirable microorganisms (Salmonella, …), which can affect poultry and consumer health, is therefore reduced improving food safety. They also help improve performance. (Montzouris et al., 2015)

**Whole-cell Inactivated Yeasts**

After fermentation, the yeast biomass can be specifically treated so that it is no longer alive, thus avoiding further cell multiplication. In animal nutrition, typically, most of these yeast products are from secondary fermentation, often obtained from the brewing industry and ethanol production. In general, inactivated yeasts from primary grown fermentation are mainly applied for high value food or biotech applications.

Inactivated yeasts are typically used as flavor enhancers or for their nutritional benefits as a source of proteins and B vitamins. Most nutrients are located in the cytoplasm of the yeast cell. Yeast cells must be lysed to release these nutrients so that they can be absorbed by the animal. Therefore, the bioavailability of whole-cell inactivated yeasts is lower than more processed yeasts, such as hydrolyzed yeasts and yeast extracts.

**Yeast Cultures**

Yeast cultures contain a combination of yeast biomass, metabolites produced during specific fermentation processes, and the fermentation medium (grain). To produce yeast cultures, a specific culture media (e.g. grain containing starch) is inoculated with live yeast cells and allowed to ferment under specific conditions. At the end of the fermentation process, there is no separation between the washing step and the drying of the entire fermented media. The majority of the components of the yeast cultures are therefore the culture media and the untreated yeast cells. During fermentation, yeast cells produce certain metabolites such as peptides, alcohol, esters and organic acids. The composition of the metabolites can be related to the composition of the substrate used and the fermentation conditions; the types and quantity of metabolites are often not defined and are not guaranteed.

**Hydrolyzed Yeasts**

Hydrolyzed yeasts are obtained through yeast cell digestion by both endogenous and exogenous enzymes. Specifically, selected enzymes are added during the production process to obtain the desired level of hydrolysis. Proteins and nucleic acids are fragmented into small size peptides through an oriented and controlled process offering highly digestible nutrients. Hydrolyzed yeasts still contain the cell wall and the yeast extract as there is no separation step during the process. Hydrolyzed yeasts represent interesting alternative protein sources for animal feed (table 1). Such alternatives are increasingly sought on the market for different reasons:

- To support the reduction of the environmental footprint of animal production (Kim et al., 2019)
- To limit the usage of food-grade proteins
- To support the reduction of antibiotics use and improve animal welfare (Upadhaya et al., 2019) thanks to functional effects.

| | Yeat biomass | Blood plasma, fishmeal | Insect protein, algae | Bacterial biomass |
|---|---|---|---|---|
| Crude protein content | ++ | ++++ | +++ | +++ |
| Digestibility | ++++ | ++++ | ++ | +++ |
| Functionality | +++ | ++++ | ++ | ++ |
| Safety | ++ | -- | -/+ | - |
| Sustainability | + | -- | + | + |
| Availability | +++ | - | - | - |
| Affordability | + | -/+ | - | + |

*Table 1: Various alternative protein sources available on the feed market and their major characteristics and limits*

## Inactivated Enriched Yeasts

Mineral- or vitamin-enriched yeasts are a specific type of inactivated yeasts. Like humans, yeasts can naturally produce Vitamin D when exposed to B-ultra-violet light. In this process, natural sterols in yeast (ergosterol) are converted into vitamin D (ergocalciferol). Yeasts also have the ability to incorporate trace minerals (selenium, chromium, iodine, etc.) within its cells - making it ideal to produce mineral-enriched yeast biomass. Selenium-enriched yeasts, for instance, represent an important source of organic selenium used in animal nutrition. S. cerevisiae NCYC R397 can utilize inorganic selenium and incorporate it into the yeast proteins in the form of organic seleno-amino acids (such as selenomethionine and selenocysteine). Producing high-quality, concentrated, Se-enriched yeast is the fruit of proper yeast strain selection and specific process development.

## Yeast Cell Walls

Yeast cell walls (YCW) are the insoluble fraction of autolyzed or hydrolyzed yeasts, obtained after the separation from the cytoplasmic content (yeast extract). The YCW represents 30-40% of the dry weight of the yeast cell. It is formed of two layers (figure 3).
The external layer is rich in mannan oligo-saccharides (MOS) and represents 20-30% of the YCW depending on processing conditions. MOS are responsible for flagellated undesirable

bacteria binding, parietal exchanges, porosity/permeability and, more widely, the protection of the yeast from the environment. The internal layer, rich in β-1,3-glucans and β-1,6-glucans (representing 20-35% of the YCW), confers rigidity and flexibility to the cell wall. It also contains chitin (≈ 2% of the YCW), which has a major role in the integrity of the cell wall, affecting the "cohesion" of the wall. Each YCW product has its own specificities that influence the functionality and application in animal nutrition. YCW are either issued from primary orsecondary fermentation, which also influences their properties and mode of action.

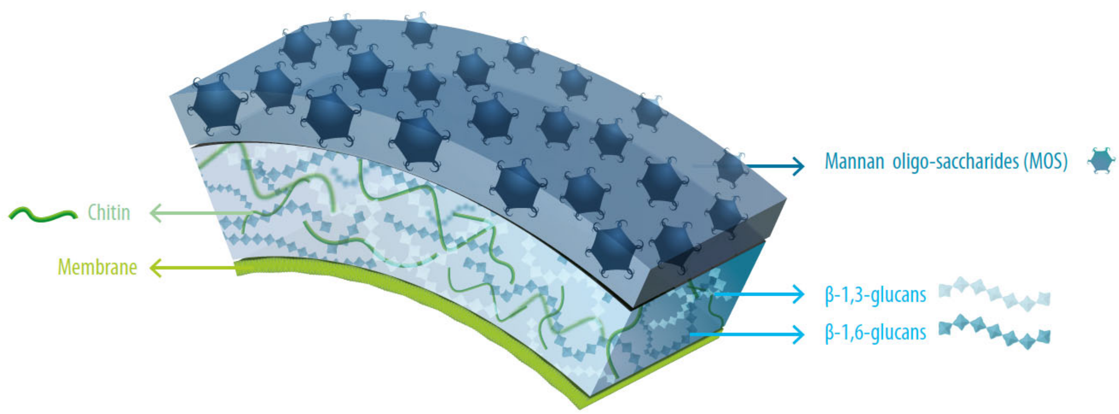



*Figure 3: Yeast cell wall composition and architecture*

**Summary**

Lallemand is a leader in the production of yeast. The educational purpose of this presentation is to bring to the animal nutrition market some highlights of the different yeast solutions that exist.

Live Yeasts are active micro-organisms used as probiotic to increase animal gut health and performances. Yeast strains will have unique effects on targeted species.

Whole-cell inactivated yeasts are inactivated yeast after fermentation (no longer alive) and mainly used as flavor enhancers or for their nutritional benefits as a source of proteins and B vitamins.

Yeast culture contain a combination of yeast biomass, metabolites produced during specific fermentation processes, and the fermentation medium (grain). The composition of the metabolites can be related to the composition of the substrate used and the fermentation conditions; the types and quantity of metabolites are often not defined and are not guaranteed.

Hydrolyzed yeasts are obtained through yeast cell digestion by enzymes. They still contain the cell wall and the yeast extract as there is no separation step during the process and are used as complementary protein source.

Inactivated enriched yeasts are specific type of inactivated yeast. These yeasts are highly efficient to incorporate trace minerals (selenium, chromium, iodine, …) and vitamins within their cells, making them ideal to produce mineral enriched yeast bimass.

Yeast cell walls are the insoluble fraction of autolyzed yeast containing, depending of the strain and process, a high percentage of MOS and β-1,3-glucans and β-1,6-glucans. Yeast cell walls are positive to support gut health and animal performances.

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