**Lemna (duckweed), a new system for the production of vaccines and monoclonal antibodies**

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**Summary:**

Due to the deficit in capacity production and to the development in the area of oral vaccines, there is a need for new production systems to complement the ones already used, micro-organisms and mammalian cells. Transgenic animals or plants can offer such alternative.

LemnaGene, a French-based company created in October 2003, is developing Lemnaceae as a system for production of recombinant proteins. *Lemna* and *Spirodela*, commonly named duckweed, are free floating plants which develop on water. They present several advantages compared to other systems: safety, no risk for viral contamination or release in the environment, rapidity and flexibility, only a few months are needed to have a production system operational, high productivity, two days doubling time and high protein content, low costs.

This plant is currently used for human and animal nutrition, the recombinant proteins produced in such plants can thus be either extracted and purified or the plant containing the protein can be used directly, dry or fresh, without the extraction/purification of the active ingredient.

A technology for transformation of Lemnaceae and expression of foreign proteins has been designed by the Weizmann Institute (Israel). LemnaGene has an exclusive license on the technology and Collaboration between LemnaGene and the Institute is in place to develop the technology.

We are currently using this plant species for the production of active ingredient for vaccines and various proteins for the pharmaceutical market. *This is done under fully contained conditions.*

The monocot family, Lemnaceae (duckweed), is composed of small, aquatic, floating plants. Two of the genera, *Lemna* and *Spirodela*, are distributed worldwide. The biomass doubles in 48 hours under controlled and axenic conditions. Reproduction is typically vegetative. It has high protein content (35 to 50% of the dry weight).

*Lemna* is transformed with *Agrobacterium*, the transformants are selected in the presence of kanamycine. Shoots appear 2 to 3 months after transformation. Transgenic lines are stable for the gene insertion and its expression. Proteins produced are active and conform to the original protein.

**The Products can be:**

- Recombinant proteins for pharmaceutical and veterinary industry;
- Recombinant vaccines for human and animals;
- Feed additives such as enzymes;
- Enzymes and monoclonal antibodies for diagnostic and laboratory reagents.

**Advantages of Lemna over other systems:**

- **Safety**
  - No release in the environment, including at the production step
  - No risk of viral contamination from animal origin
- **Fast and Flexible**
  - A few months for setting up the mother line
  - Fast adaptation of the production system and level
- **High productivity**
  - Biomass doubling every two days
  - High protein content
- **Low in investment and running costs**

**Delivery of the Products can be:**

- A *Lemna* containing the active ingredient. This will be the case for application in the human or animal nutrition domain and for oral vaccines
- A crude extract, for certain applications in the industrial domain (enzymes)
- A purified protein, for all the applications in the pharmaceutical area.

**Conclusions:**

- *Lemna*, an aquatic plant, offers an attractive system for the production of recombinant proteins and other molecules;
- It is safe, all steps are done in a confined environment. It is flexible and quick to put in place and has a high productivity. Investment and running costs are reduced compared to mammalian cells;
- It can be used to produce pharmaceuticals, including vaccines, laboratory and diagnostic reagents
- Moreover, *Lemna* can be dried and used as a powder containing the active ingredient and thus offers an attractive system for oral vaccines.

**LemnaGene, your Partner to develop your recombinant protein**

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