Linsmaier and Skoog (LS) Medium

Linsmaier and Skoog (LS) Medium in Plant Tissue Culture: Origins, Uses, and Formulation

Linsmaier and Skoog (LS) medium is a widely used plant tissue culture medium, particularly valuable for its effectiveness with certain plant species where other media struggle. Understanding its origins, applications, and formulation is crucial for researchers working in plant biotechnology.

Origin:

Developed in 1965 by Erich M. Linsmaier and Folke K. Skoog, renowned plant physiologists, the LS medium was initially designed to improve the in vitro propagation of woody plants, a group notoriously challenging to culture. Previous media, like the widely used Murashige and Skoog (MS) medium, while successful with many herbaceous plants, often proved less effective for woody species. Linsmaier and Skoog aimed to create a formulation that would enhance growth and regeneration in these recalcitrant plant types, focusing on nutrients and growth regulators known to promote development in woody plants.

Applications:

LS medium has demonstrated considerable success in various plant tissue culture applications, although its primary niche

remains in the propagation of woody plants. It is particularly effective for:

- **Callus induction:** The formation of undifferentiated cell masses from explants (plant tissue samples). The balanced nutrient supply and hormone flexibility of LS make it suitable for stimulating callus formation in a range of species.
- **Organogenesis:** The development of organs (shoots and roots) from callus or other explants. Careful manipulation of growth regulators in the LS medium is key to achieving this.
- **Rooting:** While used less exclusively for rooting compared to other media optimized for this purpose, LS is still viable, particularly when combined with appropriate auxins to induce root formation.
- **Micropropagation:** The process of rapidly multiplying plants through in vitro techniques. LS contributes to efficient clonal propagation by supporting robust shoot proliferation in many woody species.

Its efficacy is particularly notable in species like fruit trees (e.g., apple, pear), conifers, and some orchids. While not a universal panacea, numerous studies have showcased LS’s advantages over other media in generating healthy and robust plantlets from these otherwise difficult-to-culture species.

Formulation:

The precise composition of LS medium can vary slightly depending on the specific application and plant species. However, a typical formulation includes the following

components:

Component	Concentration (mg/L)	Role
NH_4NO_3	1650	Nitrogen source
KNO_3	1900	Nitrogen and potassium source
$CaCl_2 \cdot 2H_2O$	440	Calcium source
$MgSO_4 \cdot 7H_2O$	370	Magnesium and sulfur source
KH_2PO_4	170	Phosphorus and potassium source
$FeSO_4 \cdot 7H_2O$	27.8	Iron source
Na_2EDTA	37.3	Chelator for iron
$MnSO_4 \cdot H_2O$	2.2	Manganese source
$ZnSO_4 \cdot 7H_2O$	0.86	Zinc source
KI	0.83	Iodine source
$CuSO_4 \cdot 5H_2O$	0.025	Copper source
$Na_2MoO_4 \cdot 2H_2O$	0.25	Molybdenum source
H_3BO_3	6.2	Boron source
$CoCl_2 \cdot 6H_2O$	0.025	Cobalt source
Thiamine HCl	1.0	Vitamin B1
Nicotinic acid	0.5	Vitamin B3
Pyridoxine HCl	0.5	Vitamin B6
Glycine	2.0	Amino acid
Myo-inositol	100	Inositol
Sucrose	30000	Carbon source
Agar	8000-10000	Solidifying agent

Growth regulators (auxins and cytokinins): These are added separately based on the specific experimental needs, varying

concentrations are used to promote callus induction, shoot proliferation, or root formation. Commonly used auxins include NAA (1-naphthaleneacetic acid) and IBA (indole-3-butyric acid), while cytokinins like BA (benzyladenine) and kinetin are frequently employed.

Conclusion:

LS medium remains a valuable tool in plant tissue culture despite its age. Its strengths lie in its effectiveness with many woody species, often outperforming other media in promoting their growth and regeneration. However, like all media, it has limitations. The stability of some hormones in the medium might be a concern, and the optimal formulation may need adjustments depending on the target plant species. Compared to MS medium, which is more broadly applicable to a wider range of plant species, LS tends to be more specialized. Similarly, B5 medium has its own strengths and is favoured for specific purposes. The choice of medium depends ultimately on the specific requirements of the research project. While overshadowed in some applications by more recently developed media, LS continues to hold its place as a valuable asset in plant biotechnology, especially in studies involving woody and recalcitrant species.