
# Effect of genotypes on agronomic and antinutritional traits of *Lupinus albus* L. for livestock

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# INTRODUCTION



**This represents an essential protein source for animal feed**

**production of others plant protein**

**Italy is among the country that most of all import soybeans and soybean flour**

**The European Union (EU) is str dependent on soybeans imports**

**o become self-sufficient in its vegetable protein needs**

**ne war and al feeding) has affected milk and meat production price**

**SUSTAINABILITY OF AGRO-FOOD-ZOOTECHNICAL CHAIN**

**Promote and facilitate the transition to**

[1] Abraham E.M. *et al.*, 2019. *International Journal of Molecular Sciences* 20, 851. doi: 10.3390/ijms20040851.
[2] de Visser *et al.*, 2014. *Oilseed & fats Crops and Lipids* 21. doi: 10.1051/ocl/2014021.

***Glycine max* L.**

***Pisum sativum* L.**

***Vicia faba* L.**

***Lupinus* spp.**


[3] Sedláková K. *et al*., 2016. *Acta Veterinaria Brno* 85, 165-175. doi:10.2754/avb201685020165.
[4] Almeida M. *et al*., 2022. *Animals* 12, 1758. doi: 10.3390/ani12141758.
[5] Písaříková B. *et al*., 2009. *Acta Veterinaria Brno* 78, 399-409; doi:10.2754/avb200978030399.
[6] Rémond D. *et al*., 2003. *Animal Feed Science and Technology* 105, 55-70. doi:10.1016/S0377-8401(03)00040-3.
[7] Park J.H.. *et al*., 2016. *Veterinarni Medicina* 61, 701-709. doi: 10.17221/330/2014-VETMED.
[8] May, M. G. *et al*., 1993. *Journal of dairy science* 76, 2682-2691. doi: 10.3168/jds.S0022-0302(93)77604-3.
[9] May P.J. and Barker D.J., 1985. *Animal Feed Science and Technology* 12, 7-64.

# Lupin (*Lupinus* spp.) species

Lupinus is a genus of flowering plants (*Fabaceae*).

Its **development** has been **promoted by the selection of varieties with a very low alkaloid content** which has increased its use in animal feed[10,11].

The genus includes 182 species mainly native of North and South America, **cultivated in West Europe and in Australia**, and to a **lesser extent in** countries surrounding the **Mediterranean basin**.



[10] Gresta F. *et al*., 2010. *Italian Journal of Agronomy* 4, 333-340.
[11] Calabrò S. *et al*., 2014. *Journal of the Science of Food and Agriculture* 95, 3127-3136. doi: 10.1002/jsfa.7049.

# Nutritional value of Lupin seed

## SUSTAINABLE SOURCE OF NUTRIENT[12,13,14]

**PROTEINS**

High content

**LIPIDS**

UFAs of nutritional interest

**BIOACTIVE COMPOUNDS**

Antioxidants
- Polyphenols
- Apigenin derivates


[12] Gresta F., *et al*., 2023. *Agriculture* 13, 434. doi:10.3390/agriculture13020434.
[13] Musco N. *et al*., 2017. *Journal of Animal Physiology and Animal Nutrition* 101, 1227–1241. doi: 10.1111/jpn.12643.
[14] Chiofalo B. *et al*., 2012. *Animal Feed Science and Technology* 171, 230–239. doi:10.1016/j.anifeedsci.2011.11.005.

# Lupinus in animal nutrition

Among grain legumes, lupin species (*Lupinus spp*.) could **represent a suitable alternative protein source in both monogastric and ruminant feeds[3].**

Monogastrics

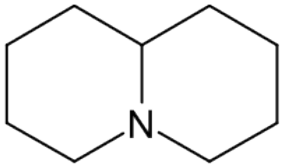
Ruminants

# Limit of Lupin seed

## ANTINUTRITIONAL FACTORS[11,12,13]

**ALKALOIDS**

Quinolizidine alkaloids

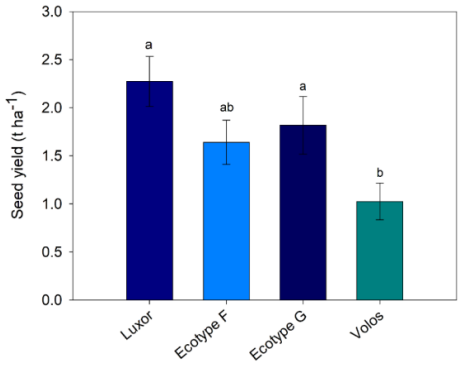


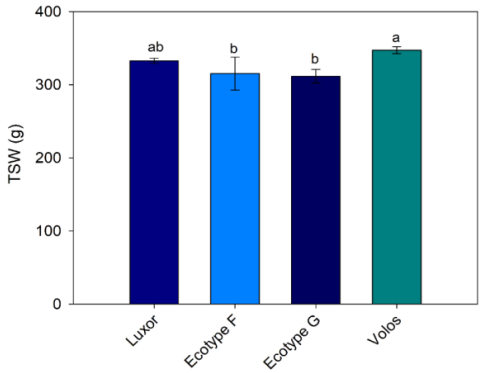
# AIM

## *Lupinus albus* L.

- ✓ Volos
- ✓ Luxor
- ✓ Ecotype F
- ✓ Ecotype G

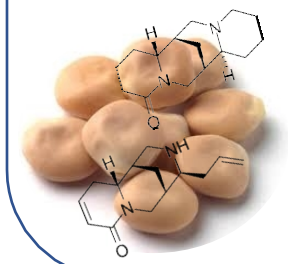

## Productive traits

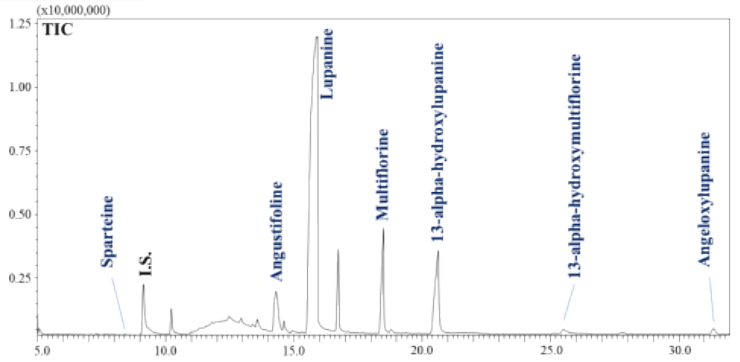



## Alkaloids

**Total Alkaloids Content**






**Characterization of Quinolizidine Alkaloids**

**Cultivated in the Mediterranean area**

# MATERIAL AND METHODS

## *Environmental conditions*

- ✓ **Field trial: Four genotypes of *Lupinus albus* L.** [two recently released varieties (Volos and Luxor) and two ecotypes from Southern Italy (Ecotype F and Ecotype G)] were sown in a medium-textured loamy soil in Southern Italy (**Calabria, Italy**);
- ✓ **Experimental design:** randomized block, 3-time replicated, with a single plot of 8 $m^2$;
- ✓ **Seeds were harvested** between May and June, **according to the physiological maturity of the different ecotypes**

## *Agronomic traits*

- ✓ Seed yield (SY) and the thousand seed weight (TSW) were determined by harvesting plants within the two central rows in each plot.

# MATERIAL AND METHODS

## *Extraction of Alkaloids*

Alkaloids extraction were carried out according literature[14,15]

## *Analysis of Alkaloids*[11,13,16]

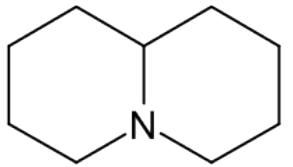
- ✓ Identification: HRGC/MS, EI mode (Shimadzu TQ8030 HRGC-MS/MS, Shimadzu, Milan, Italy)
- ✓ Column: SLB-5MS (30 m × 0.25 mm, 0.25 µm; L × I.D., *dp*)
- ✓ Quantification: I.S. method (Caffeine 0.5 mg/mL) (LOQ: 0.1 mg/Kg)
- ✓ Data acquisition: GC-MS Solution Software (Shimadzu, Italy)

**Sample**

- ✓ Volos
- ✓ Luxor
- ✓ Ecotype G
- ✓ Ecotype F

***Lupinus albus* L.**

**Sample preparation**




*Quinolizidine alkaloids*

Extraction

Centrifugation

Purification

HRGC-EI-MS

**Analysis**


[14] Muzquiz, M. *et al.*, 1994. *Journal of Agricultural and Food Chemistry* 42, 1447–1450.
[15] Oboh, H.A. *et al.*, 1998. *Journal of Chromatography A* 823, 307–312.
[16] Nossack, A.C. *et al.*, 2000. *Journal of the Brazilian Chemical Society* 11, 495–501.

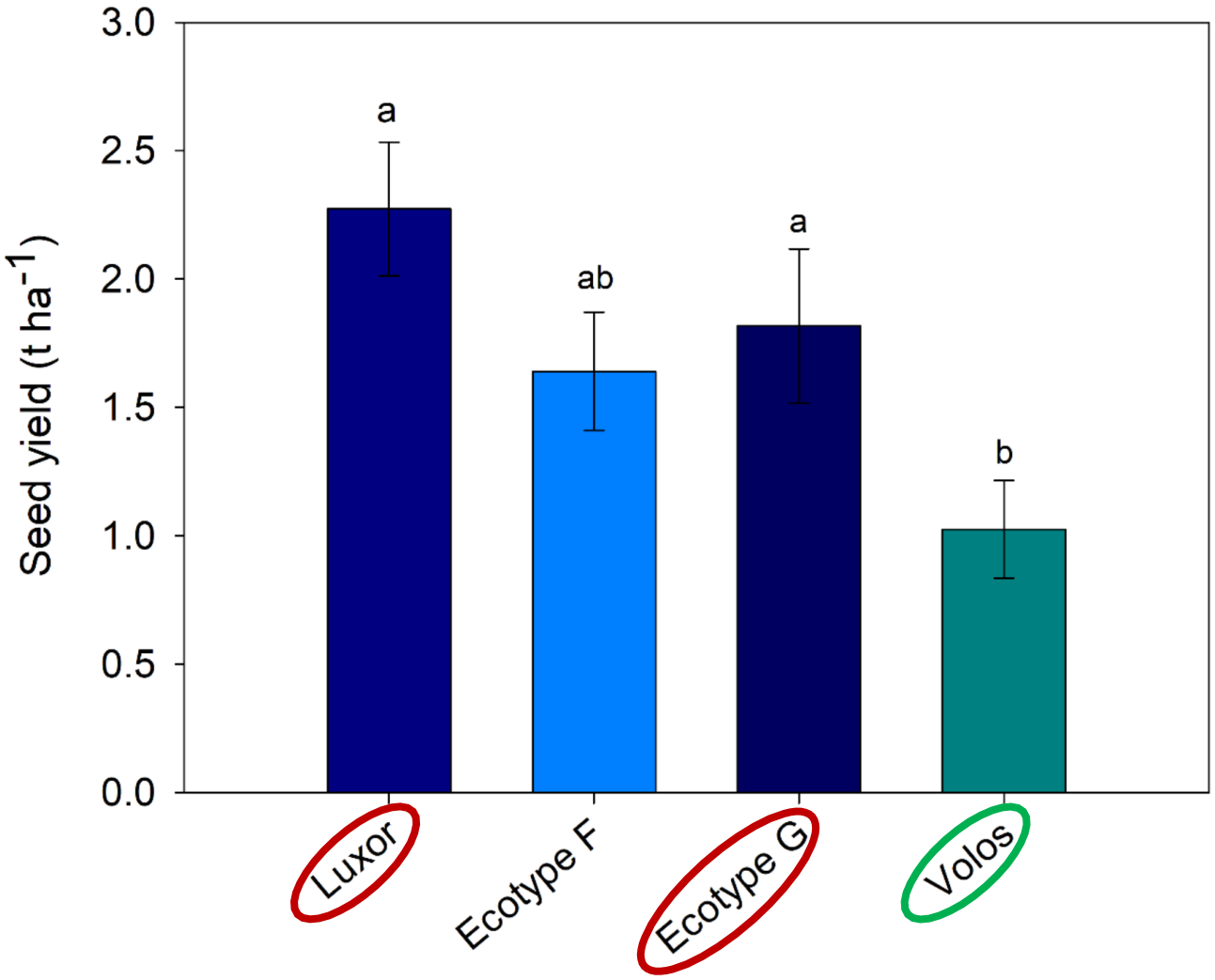
# MATERIAL AND METHODS

## *Statistical analysis*

- ✓ All **data were statistically analysed by one-way ANOVA** to assess the genotype effect according to the experimental layout.
- ✓ **Means were separated by the Tukey HSD test ($p \leq 0.05$)**

# RESULTS and DISCUSSION

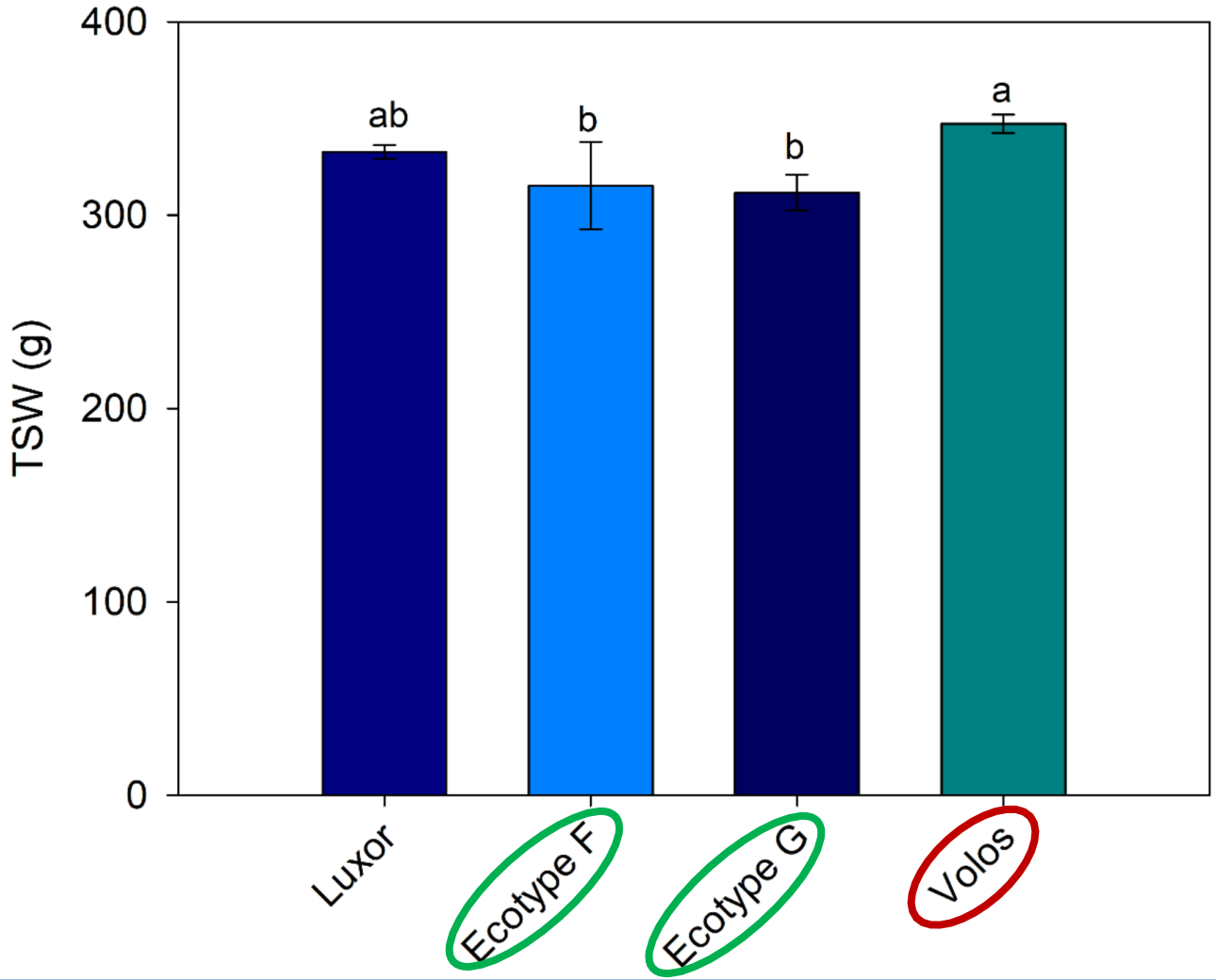
Figure 1: Seed yield of four genotypes of *Lupinus albus* L.




a,b: $p \leq 0.05$.

# RESULTS and DISCUSSION

Figure 2: Thousand seed weight of four genotypes of *Lupinus albus* L.




a,b: $p \leq 0.05$.

# RESULTS and DISCUSSION

## Chemical composition of four genotypes of *Lupinus albus* L. (g/kg, as fed)

*Article*

**White Lupin (*Lupinus albus* L.), an Alternative Legume for**

Table 2. Chemical composition (g $kg^{-1}$, as fed) of the six genotypes of *Lupinus albus* L. (n = 18).

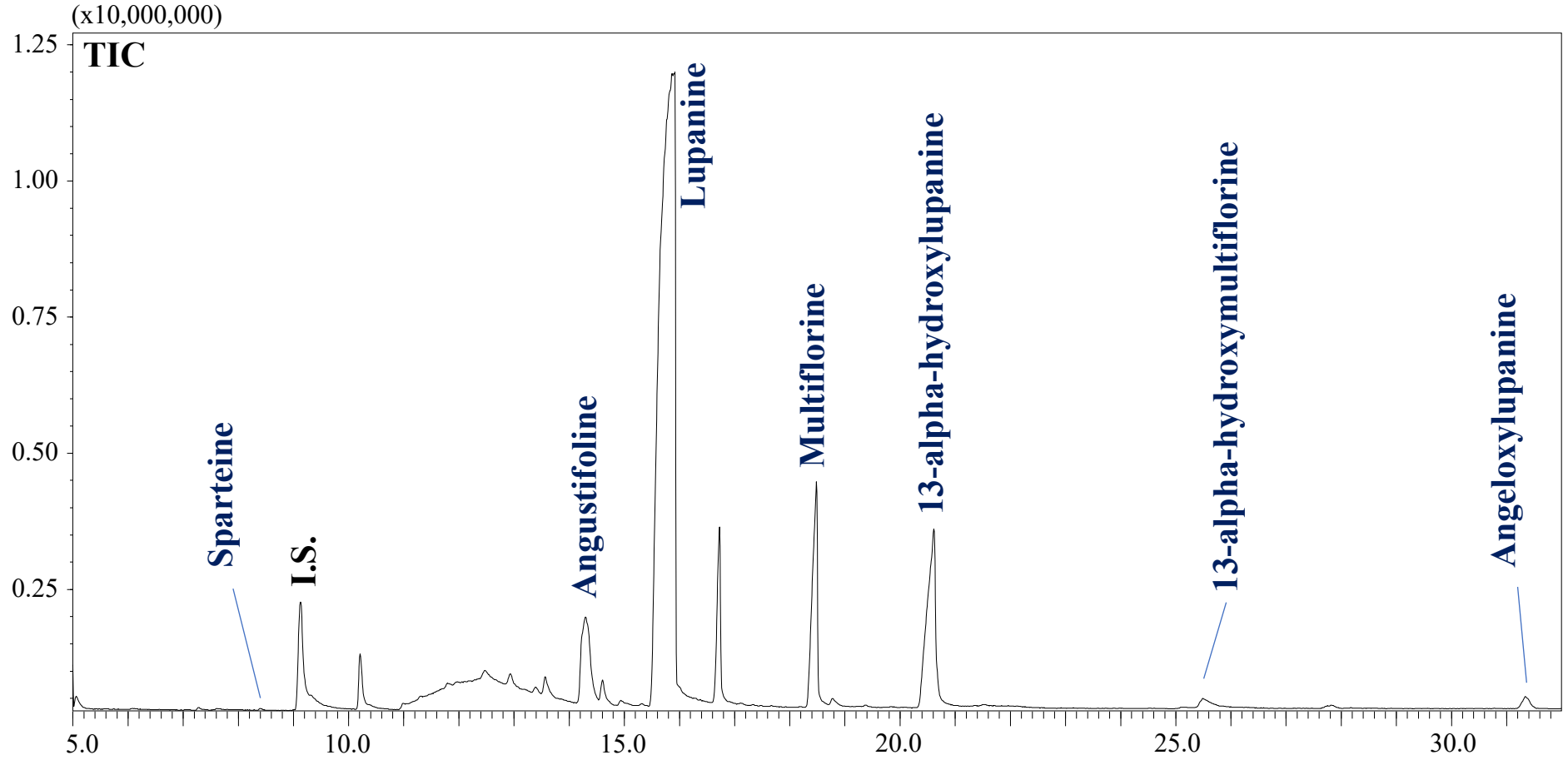
| | Genotype | | | | | | *RMSE* |
|---|---|---|---|---|---|---|---|
| | Volos | Luxor | Lublanc | Multitalia | Ecotype F | Ecotype G | |
| CP | 356 $^{a}$ | 331 $^{b}$ | 331 $^{b}$ | 342 $^{ab}$ | 327 $^{b}$ | 340 $^{ab}$ | *0.087* |
| EE | 86 $^{d}$ | 93 $^{c}$ | 112 $^{a}$ | 107 $^{a}$ | 96 $^{bc}$ | 99 $^{b}$ | *0.025* |
| CF | 120 $^{a}$ | 120 $^{a}$ | 111 $^{ab}$ | 101 $^{b}$ | 116 $^{a}$ | 113 $^{a}$ | *0.052* |
| Ash | 31 $^{a}$ | 30 $^{a}$ | 27 $^{b}$ | 27 $^{b}$ | 28 $^{b}$ | 28 $^{b}$ | *0.005* |
| AK | 0.05 $^{b}$ | 0.06 $^{b}$ | 0.19 $^{b}$ | 2.3 $^{a}$ | 2.5 $^{a}$ | 2.0 $^{a}$ | *0.497* |

CP: crude protein; EE: ether extract; CF: crude fiber; Ash: total mineral content; AK: total alkaloids. RMSE: root-mean-square error. Mean values followed by different letters within the same row differ significantly ($p \leq 0.05$).

- All genotypes showed chemical composition in agreement with data reported in literature[3,5,10,13]

# RESULTS and DISCUSSION

Figure 3: GC-EI-MS chromatogram of quinolizidine alkaloids in *Lupinus albus* L.



# RESULTS and DISCUSSION

Table 1: Alkaloids Content of four *Lupinus albus* L. genotypes (mg/Kg)

| Genotypes | SP | AG | LP | MT | 13-α-HL | 13-α-HM | AL | TOT |
|---|---|---|---|---|---|---|---|---|
| **Luxor** | 0.01$^{b}$ | 3.35$^{b}$ | 48.63$^{b}$ | 1.25$^{b}$ | 6.68$^{b}$ | 0.96$^{b}$ | 0.01$^{b}$ | 60.88$^{b}$ |
| **Ecotype F** | 2.45$^{a}$ | 391$^{a}$ | 1833$^{a}$ | 162 $^{a}$ | 46.63$^{a}$ | 22.98$^{a}$ | 42.28$^{a}$ | 2500$^{a}$ |
| **Ecotype G** | 1.33$^{ab}$ | 289$^{a}$ | 1461$^{a}$ | 161$^{a}$ | 61.60$^{a}$ | 28.80$^{a}$ | 16.68$^{ab}$ | 2020$^{a}$ |
| **Volos** | 0.01$^{b}$ | 1.98$^{b}$ | 38.47$^{b}$ | 1.13$^{b}$ | 7.58$^{b}$ | 0.01$^{b}$ | 0.60$^{b}$ | 49.77$^{b}$ |

SP: Sparteine; AG: Angustifoline; LP: Lupanine; MT: Multiflorine; 13-a-HL: 13-α-Hydroxylupanine; 13-a-HM: 13-α-Hydroxymultiflorine ;AL: Angeloxylupanine; TOT: Total Alkaloids.

Below the limit of toxicity (0.02%) for animal consumption

# CONCLUSIONS

***Agronomic***

- The improved Luxor variety resulted in the highest productive traits;
- The improved Volos variety was characterized by a low productivity.

***Antinutritional***

- Luxor and Volos resulted the best genotypes in terms of antinutritional factors (61 and 50 mg/Kg, respectively)
- ANFs < max toxicity limit for animal, 200 mg/Kg.

The two ecotypes F and G were the second highest yielding but with too high ANFs content.

This study underline the importance of genetic improvement for the production of lupine varieties with low content of alkaloids and genotype selection for specific growing conditions towards a safe and sustainable animal and human nutrition.

…The present data suggest that Luxor genotype of *Lupinus albus* L. could be considered a valuable crop and feed resource for livestock in the Mediterranean area…


Further studies are needed to ascertain the best species for:

- Different Mediterranean environmental conditions;
- Sustainability of cultivation and introduction into Mediterranean farming systems;
- *ad hoc* formulations in relation to the different metabolic pathways of animals

...AND.....

Further effort is needed to breed new white lupin genotypes well adapted to a wide range of climatic conditions and resilient to abiotic adversities.


Thank you
for your attention!!