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SEMI-ACTIVE SOLAR DRYING AS A VALUE-ADDED POST-HARVEST TREATMENT FOR PLANT TISSUES

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FRAMEWORK – STEVIA PLANT - KA'A HE'Ê ("SWEET HERB")

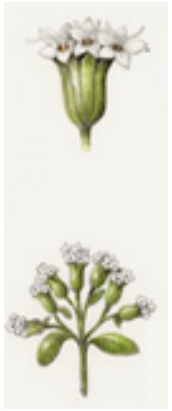
Stevia rebaudiana (Bertoni)

Asteraceae family

Genus **Stevia**: 230 species

species ***S. rebaudiana*** and ***S. phlebophylla*** with glycosides

- branched bushy shrub
- perennial herb
- sessile leaves, 3–4 cm long, elongate
- grows up to 1 m



Sweet molecule milestone:

- **1909** first isolated
- **1931** the **extract was purified** to produce Stevioside
- **1952** Chem. Struct. ⇒ **diterpene glycoside**
- **1971** as sweetener 1st commercially in **Japan**
- **1984 cultivation** in China
- **pure stevia extract:**
  - **2008** "**safe substance**" for **FDA**
  - **2011** approved in EU

E 960
Steviol Glycosides

Permited dosage
200 mg/kg

FRAMEWORK – SWEET COMPOUNDS: GLYCOSIDES

The yield of sweetening compounds in leaf tissue can vary according to:

- **method of propagation**
- **daylength**
- **agronomic practices**
- **variety**

1 ha = 1000/1200 kg of dried leaves

⇓

60–70 kg **Stevioside** (300x than sugar)

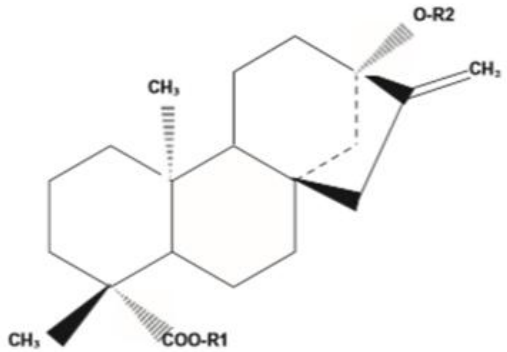
⇓

18-21 tons of sugar

Cases with 15 % of conc.

vs

sugar beet : **16%** | sugar cane: **12 - 13%**



Steviol - the "backbone" of the sweet glycosides

Steviol Glycosides are **DITERPENES -** Stevioside: $C_{38}H_{60}O_{18}$

Steviol Glycosides: (high-purity)

- **Rebaudioside A** with an extra glucose unit = 400 x Sucrose
- Total glycosides = **Stev.** 60–70% and **Reb. A** 30-40%
- thermostable 100°C/1h
- Non fermentative
- No caramelization effect
- Water soluble
- thought to posses:
  - **Antimicrobial**
  - **Antioxidant**
  - **Antifungal activity**
- low caloric
- natural origin

FOOD DEHYDRATION

MAJOR CONCERNS

1. **Speed of operation** - since high moisture foods are perishable, it is essential to lower the moisture content quickly before any significant spoilage can occur. Standard methods are not providing enough rapid dehydration.
2. **Energy efficiency** - drying of foods is a highly energy intensive operation. (Gunasekaran, 1986). Most foods are with high moisture and large latent heat of vaporization of water.
3. **Cost of operation** - due to low profit margins experienced by most food industries, the total cost of drying per unit mass of dried material (capital plus operating costs) becomes a major consideration. (Gempesaw and Gunasekaran, 1988)
4. **Quality of dried foods** - The quality of dried foods should go beyond they being microbially safe. Standard methods are with high level of heat damage and nutrient loss. (Gunasekaran, 1999)

AIMS

EVALUATE the impact of different cultivation **and post-harvest treatment** on the productivity of sweet composition

Specific questions

Pruning and fertilization affect **biomass** and **sweet compounds yield**?

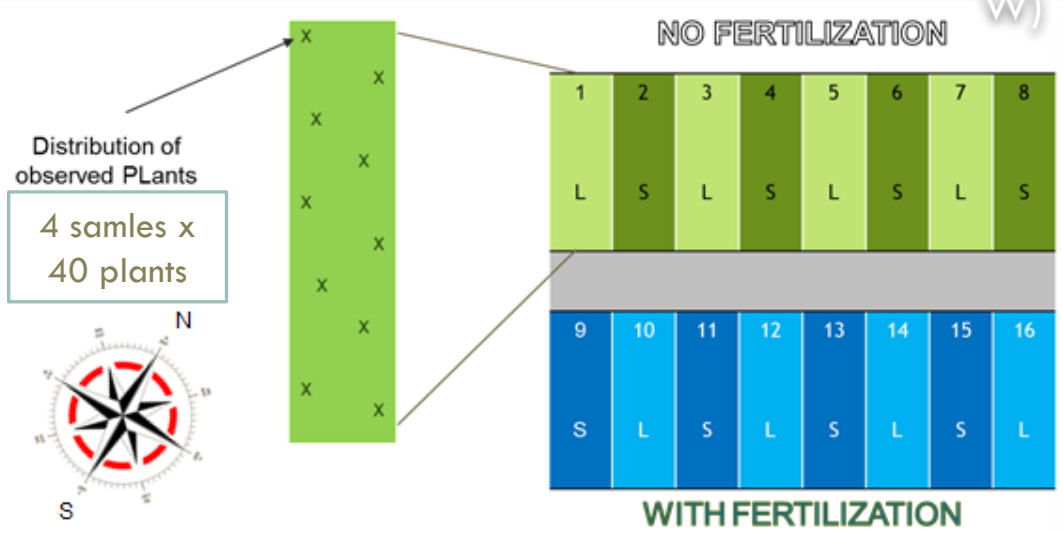
How drying affects quality of Stevia leaves?

Is there accumulation of Secondary metabolites during drying?

CERCICA can gain **low input production** with **value added** and **differentiation** end **products**?

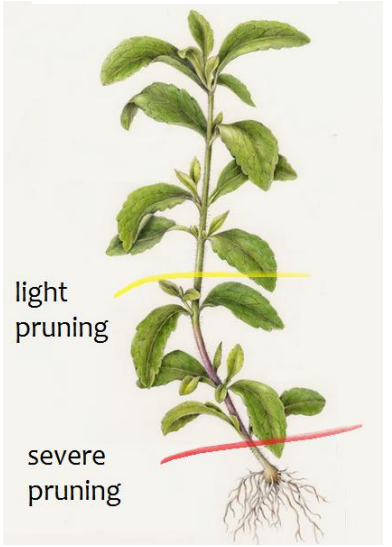
MATERIALS

2100 Stevia plants placed on CERCICA aromatic plant field plots (+38° 42' 44.28" N, -9° 22' 19.92" W)



variety:
'STEVIA/ 2149E15'

Pruning

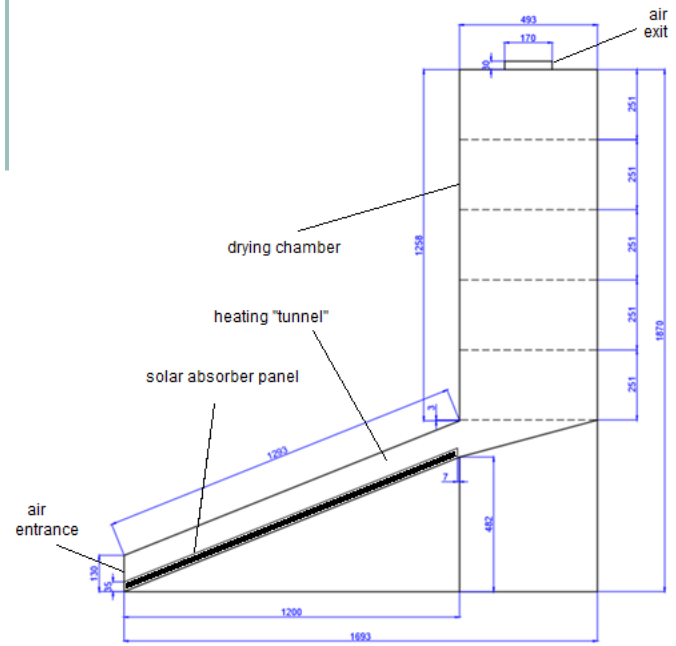


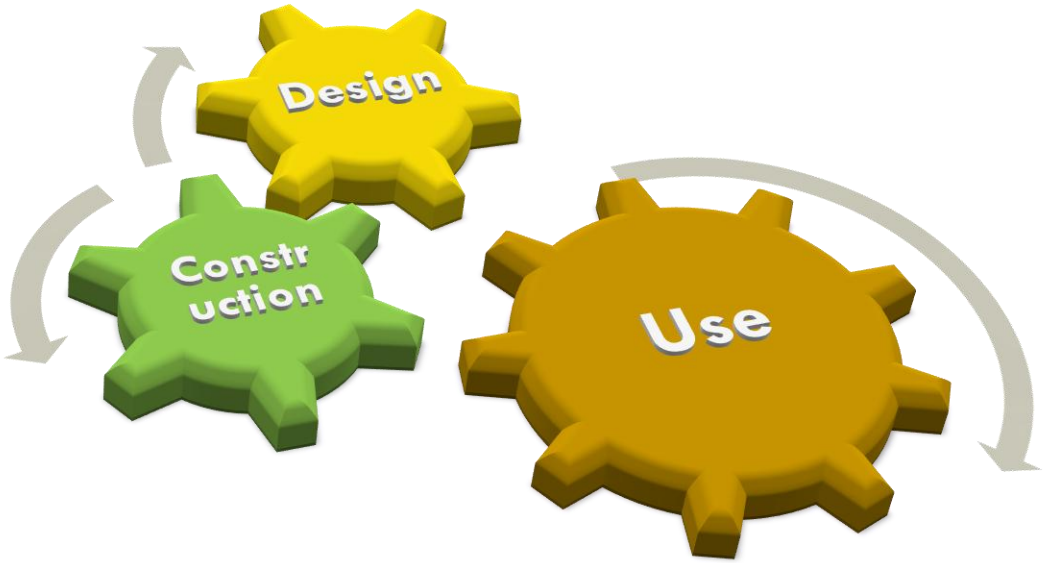
dSP - "d" – dried sample

Selected sample

fSP - "f" – fresh sample
Severe pruned, unfertilized

MATERIALS – SOLAR DRYER





Indirect, semi-active, cabinet Solar dryer

METHODS

Plant height

Plant yield

Leaf Area

Antioxidant capacity (ABTS, DPPH, Phenolic content)

Steviol Glycosides (HPLC)

Humidity

pH

°Brix

Color (CIE Lab)

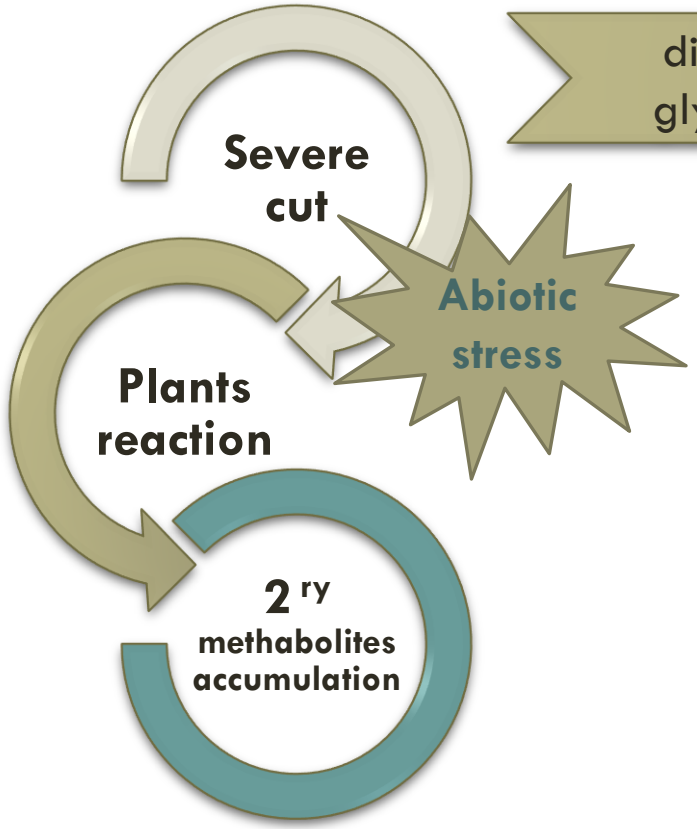
Results

FRESH LEAVES

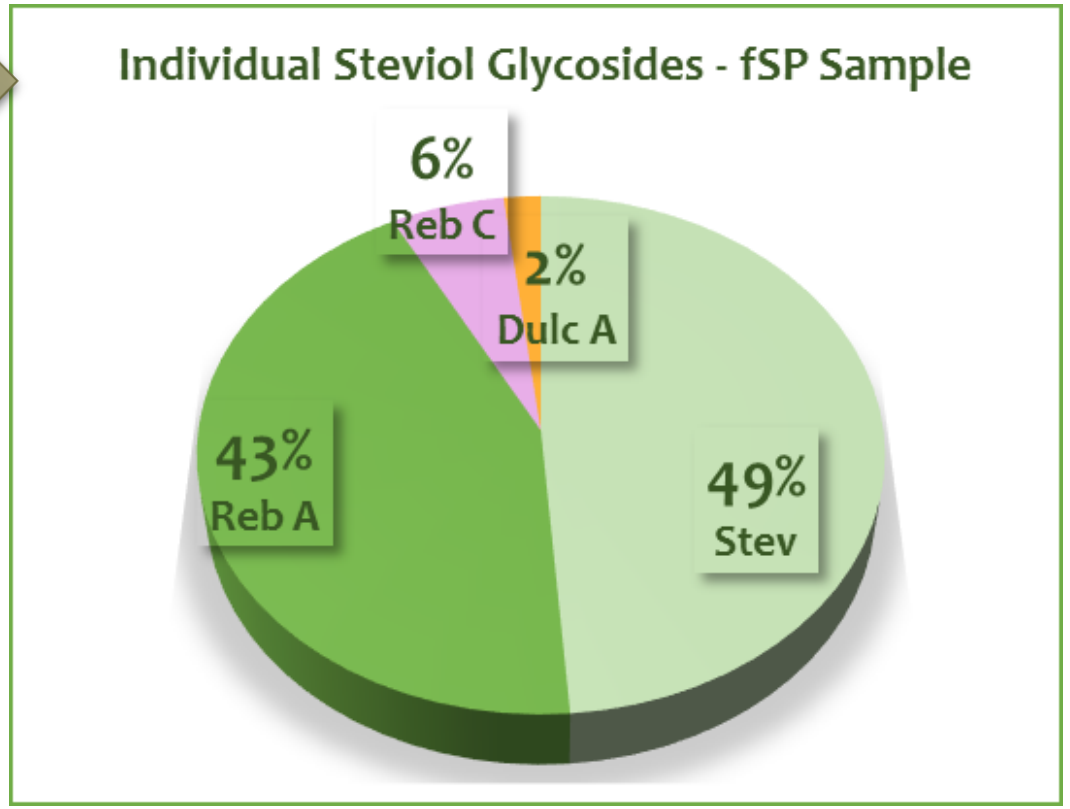
STEVIOL GLYC. COMPOSITION

Severe pruning ⇒ **higher accumulation** of secondary metabolites **Stev, Reb A, Reb C, Dulc A,** regardless of the regime of fertilization.

- **"fSP" sample** Global GLYC: 36.81 mg/g dry leaf



distribution of individual glycosides in fresh leaves



TOTAL STEVIOL GLYC AND REB. A : STEV RATIO

Fertilization ⇏ Sum of Glycosides
Severe pruning ⇒ increased sum of Glycosides in ca. **29.38%** (unfertilized)

Rebaudioside A: Stevioside ratio in best sample (fSP):
Severe pruning ⇒ increased more Stevioside, when compared to Rebaudioside A (= 0.89)

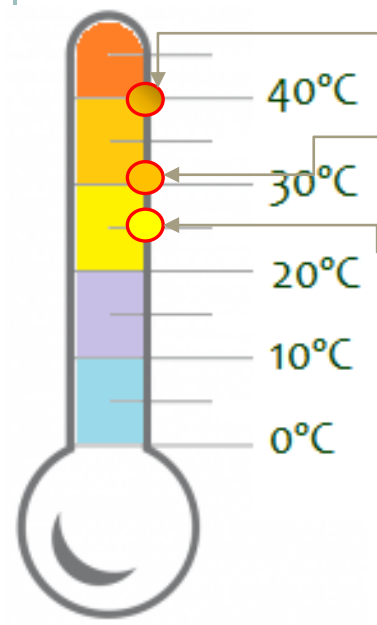
Stevioside increased as defense compound !

Treatment		Reb A : Stev RATIO	SUM GLYC mg/g dry leaf
Unfertilized	Light P.	1.02 ±0.16 [a]	28.45 ±3.59 [b]
	Severe P.	**0.89 ±0.08 [b]**	**36.81 ±2.63 [a]**
Fertilized	Light P.	0.92 ±0.07 [a,b]	25.31 ±3.41 [b]
	Severe P.	0.96 ±0.08 [a,b]	36.05 ±4.93 [a]

Results

DRIED LEAVES

DRYING REGIME AND PRE-HEAT TREATMENT



39.19°C - entrence air T

30.45°C – T in the leaves surface

25.33°C – ambiente T

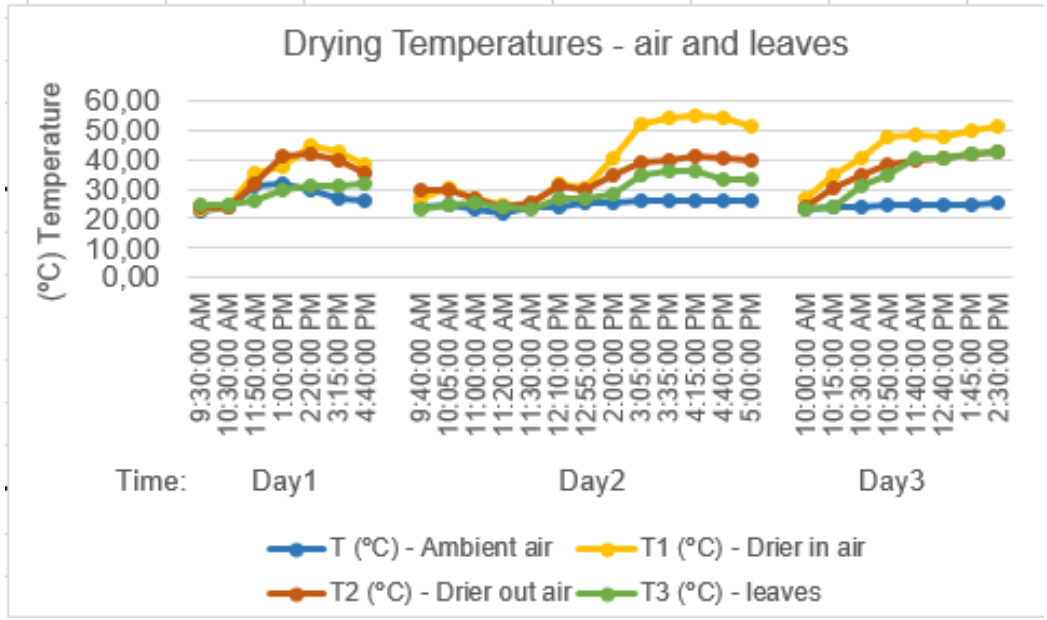
Still:

exiting air conditions:

Air flow vel.: 0.69 m/s.

RH: 40.52 %

Ambient air RH: 41.74%



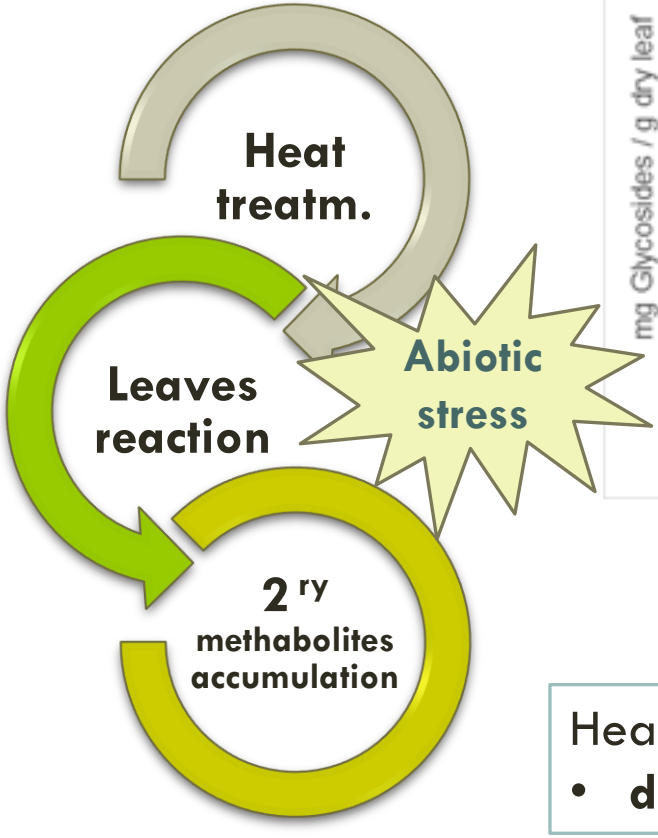
Active drying duration + 2h of pre-heating

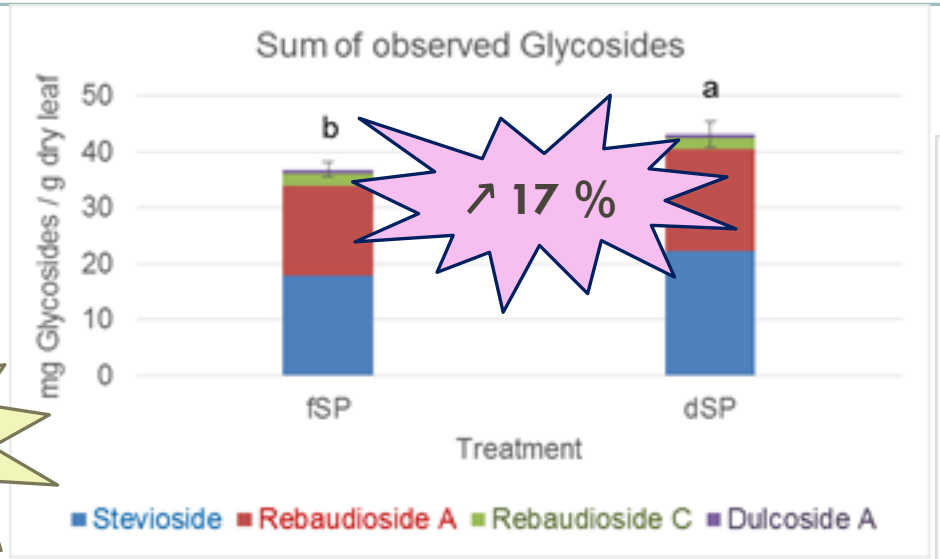
H = 78.36 %
fSP

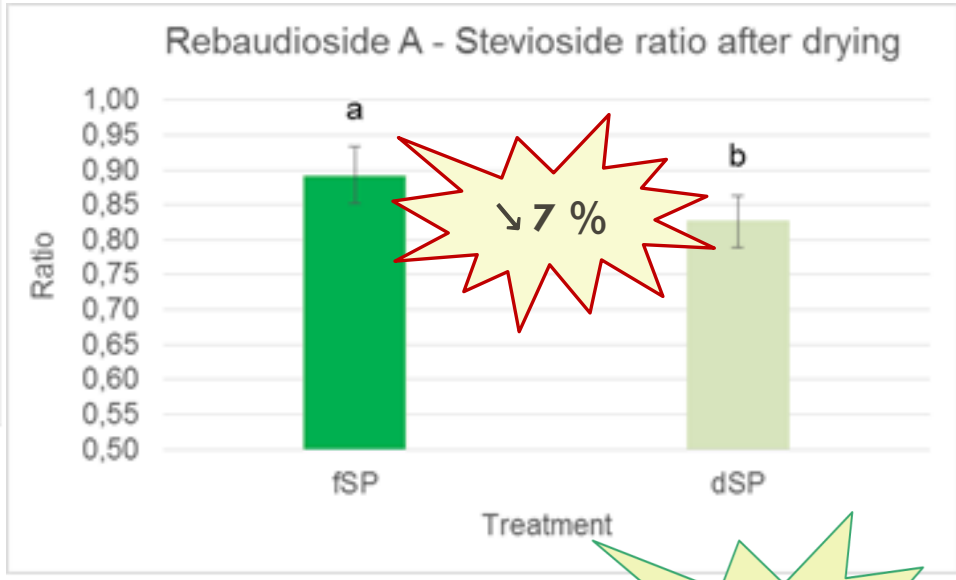
10.00 %
dSP

GLYCOSIDES

Heat abiotic stress ⇒ increased in ca. 17% **Sum of Glycosides** during drying reaching **43,06** mg/g dry leaves







Heat abiotic stress ⇏ Rebaudioside A: Stevioside ratio

- **decreased** in **7%**, could result in slight increase of bitter aftertaste

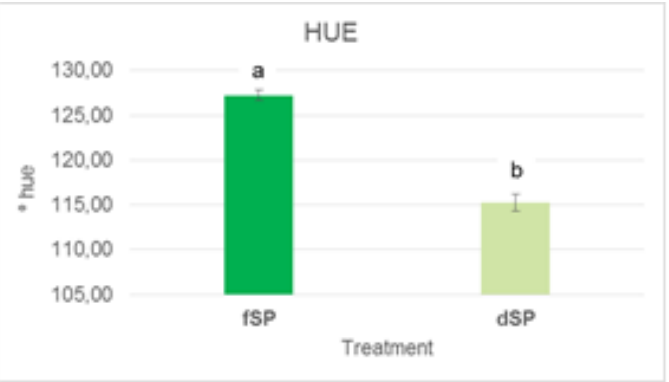
Stevioside increase as defense compound!

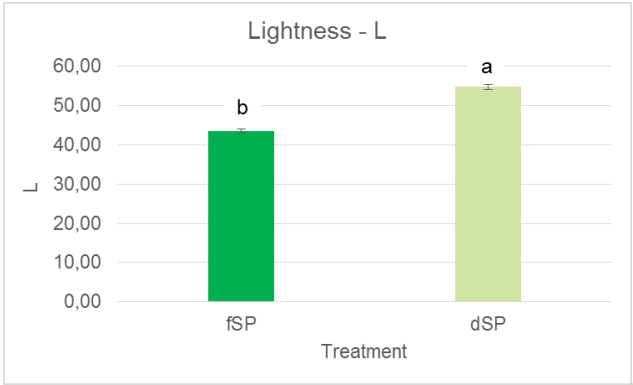
COLOR

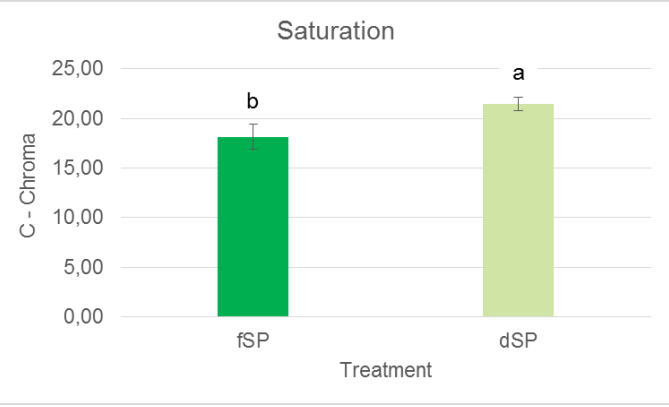
Color turned from **green** to **yellowish green**

Drying on lower temperature ⇒ **increase in ca. 26%** the **lightness:**

- Avoided enzymatic browning and
- lowered pigment deterioration

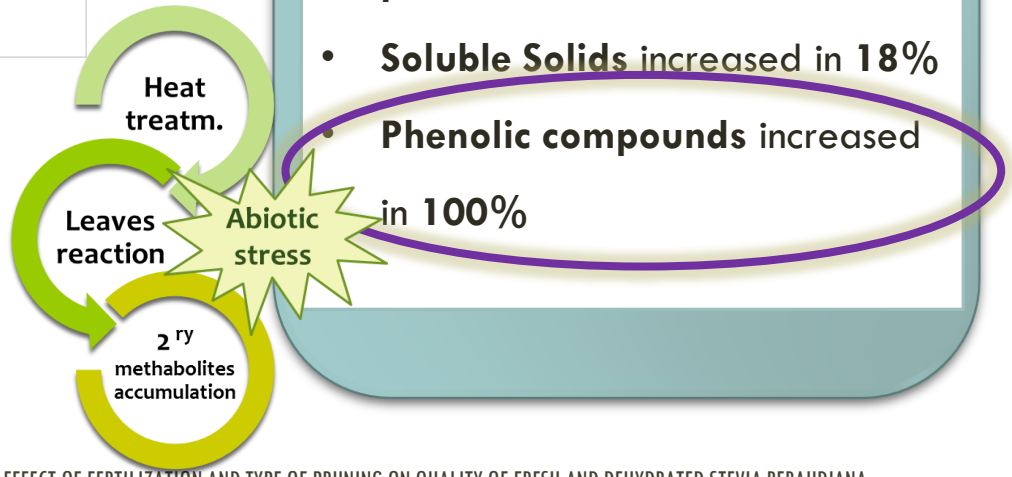






Still:

- **10% humidity**
- **pH** decreased in **4%**
- **Soluble Solids** increased in **18%**
- **Phenolic compounds** increased in **100%**



CONCLUSIONS

Severe pruning ⇒ **higher accumulation** of secondary metabolites **Stev, Reb A, Reb C, Dulc A,** regardless of the regime of fertilization.

Fertilization ⇏ ↗ Sum of Glycosides

Heat abiotic stress by Semi-Active Solar Drying:

- ⇒ increased sum of Glycosides during drying
- ⇒ increased Stevioside and lowered a portion of Rebaudioside A
- ⇒ Phenolic compounds hugely increased during drying

FUTURE PERSPECTIVES

Improvements should target scaling with controllable system that can respond to a complex process as accumulation of Stevia sweet compounds is.

- Investigate effects of **different drying regimes** (50, 60, 70°C) on phenolic compounds accumulation

3 Phase Integrated Dryer vs **heat bomb & solar energy**

HYBRID DRYERS

- If some **Individual antioxidant** can influence **bitterer aftertaste**

Thank You!