"DALL'ERBA AL FORMAGGIO"

Asiago, 30 maggio 2009

# *Individuare la traccia che porta dal territorio al prodotto caseario*

*Parte II° - Le molecole markers nel latte e nel formaggio*

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Fondazione Edmund Mach

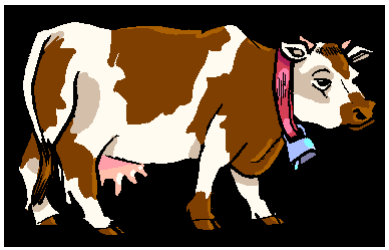
**Acidi grassi**

**CLA**

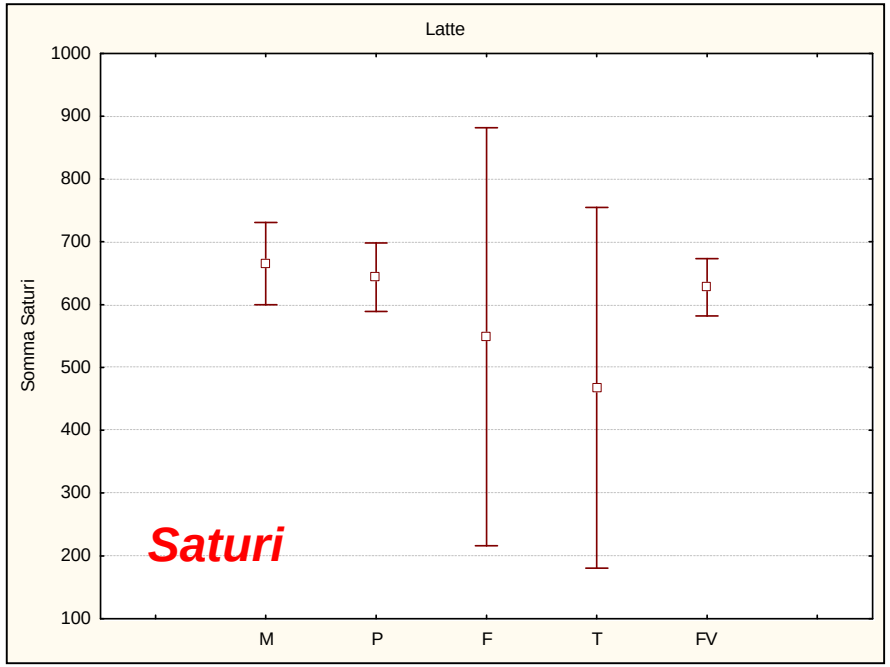
**Terpeni**

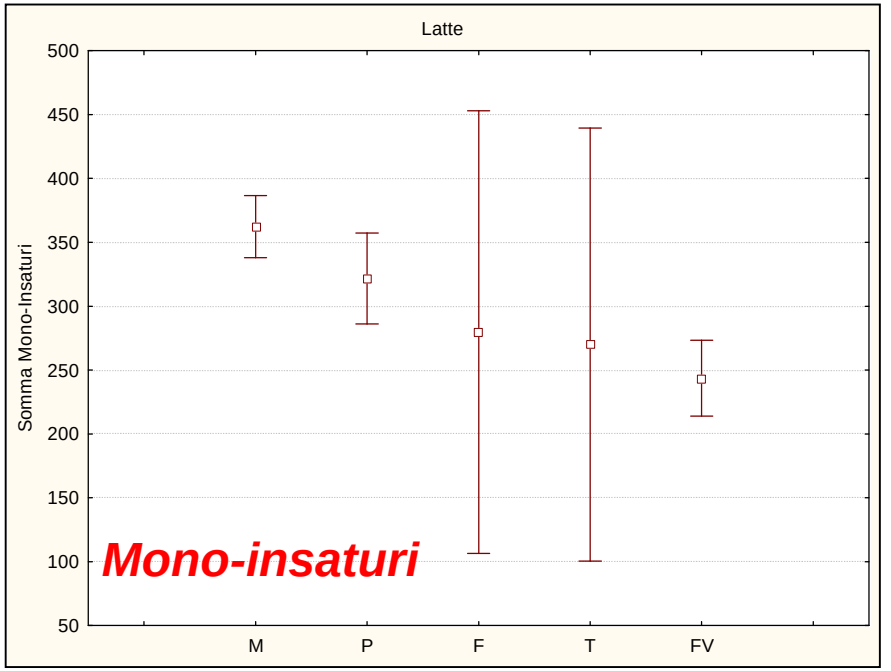
**Altri composti**
**(polifenoli, carotenoidi … ?)**

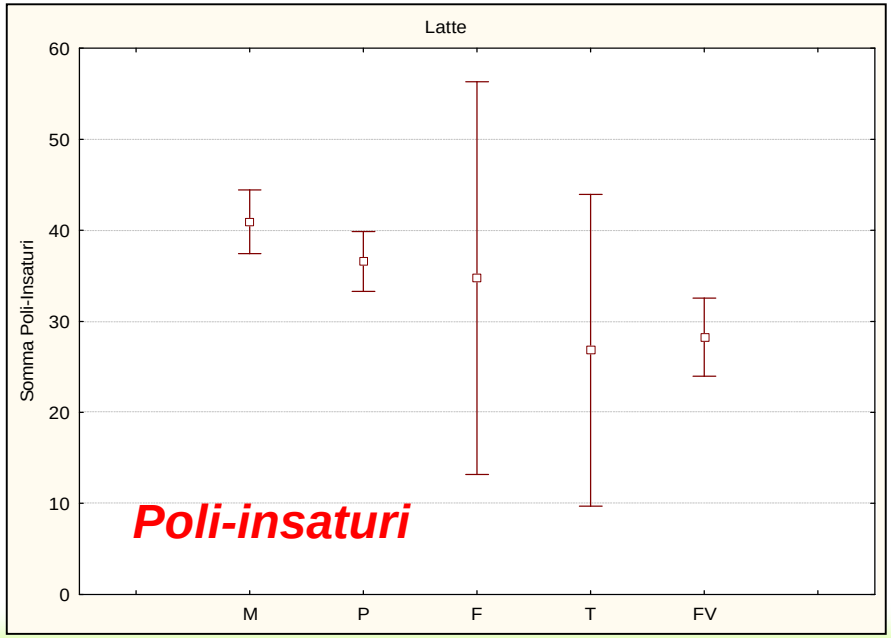
**Isotopi**

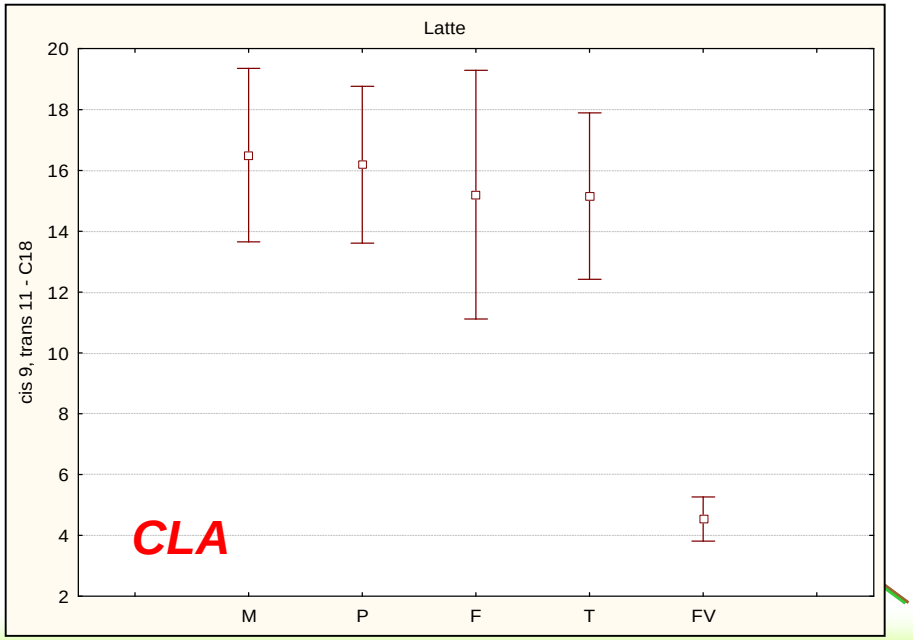


# Acidi grassi

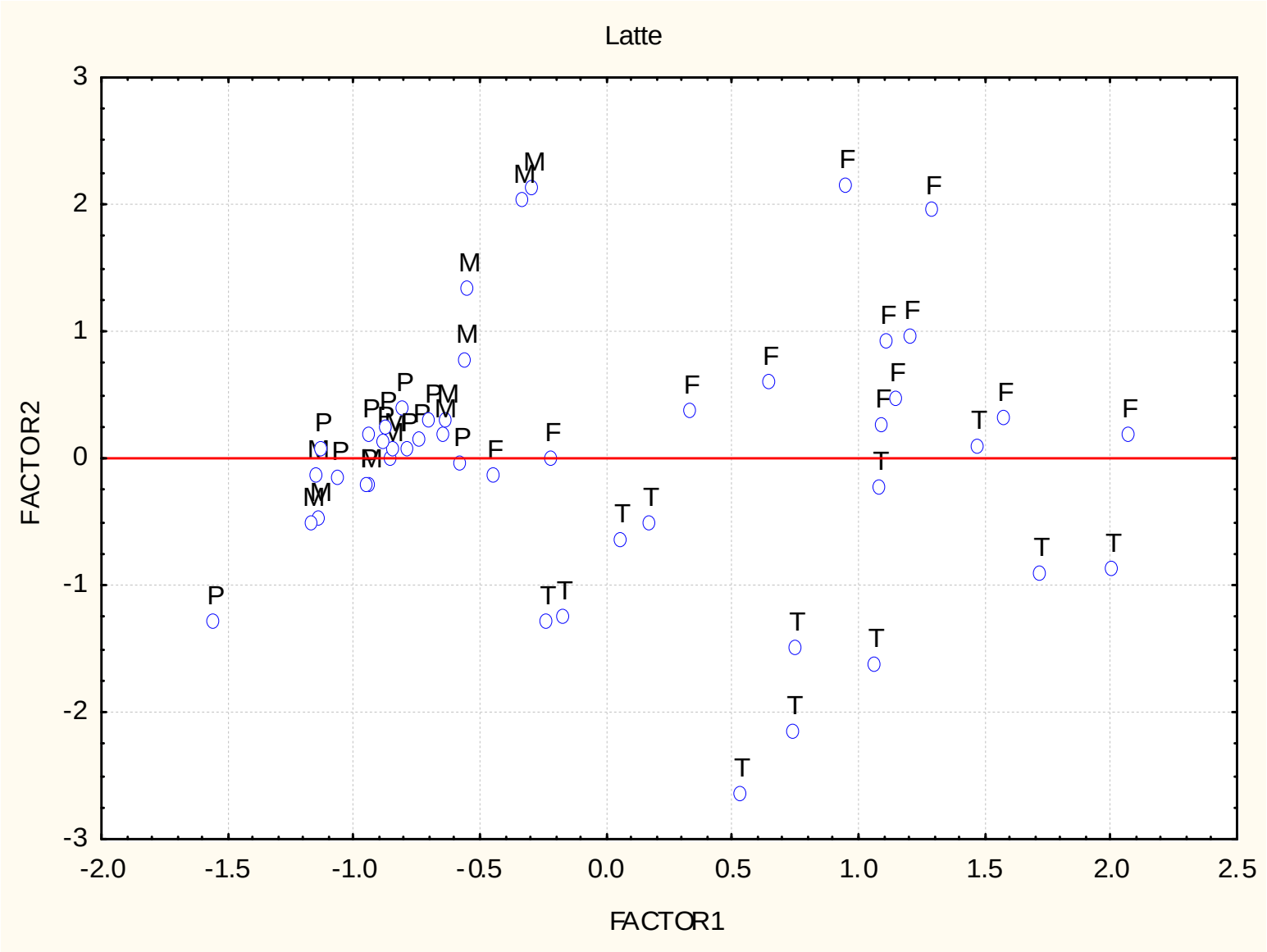


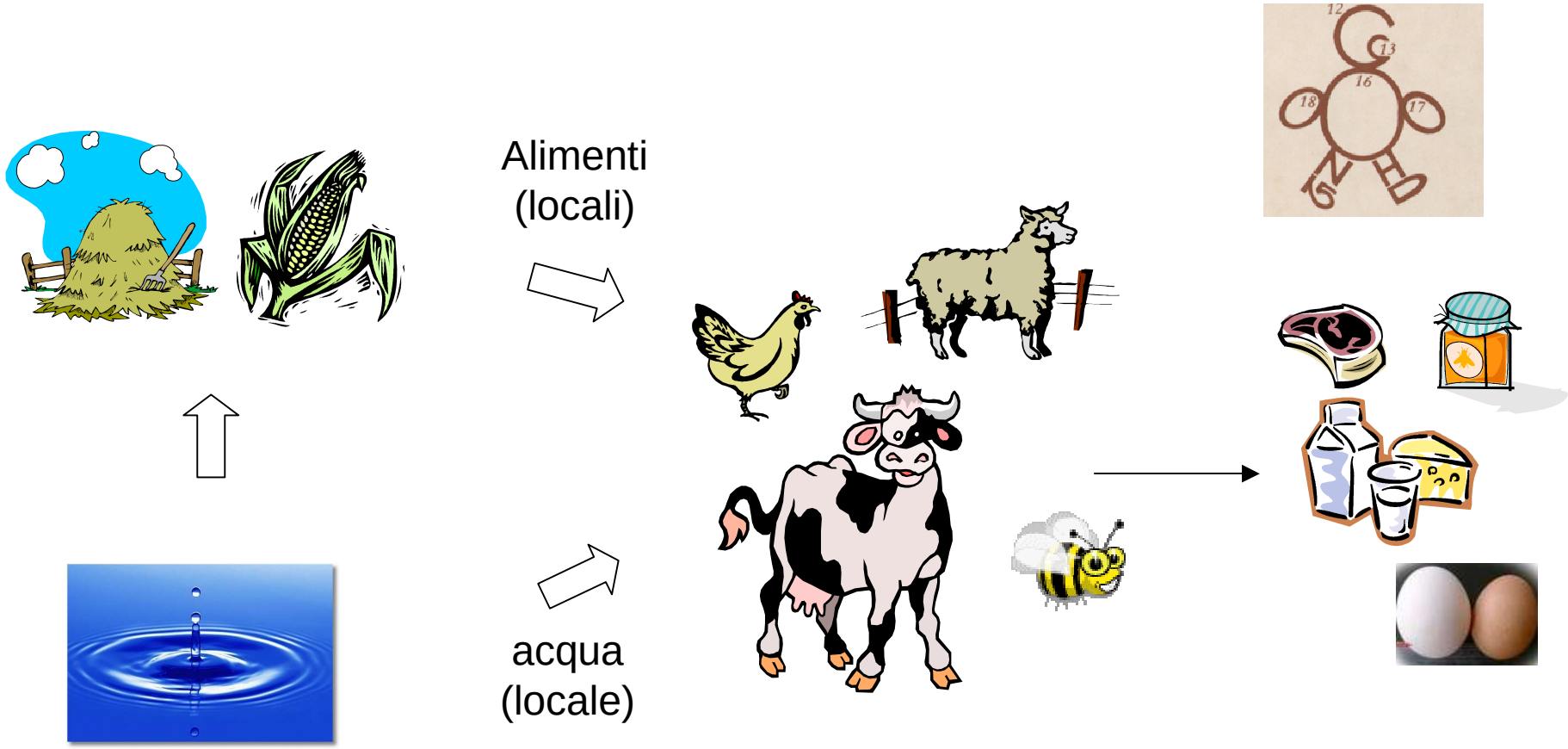



## *… ma dopo ANOVA e selezione variabili …*

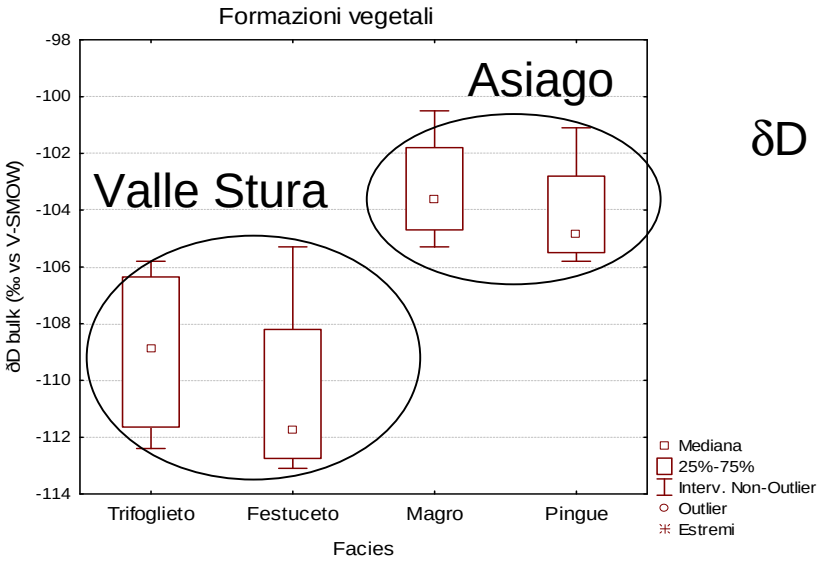



2 fattori (50% + 30% varianza spiegata)

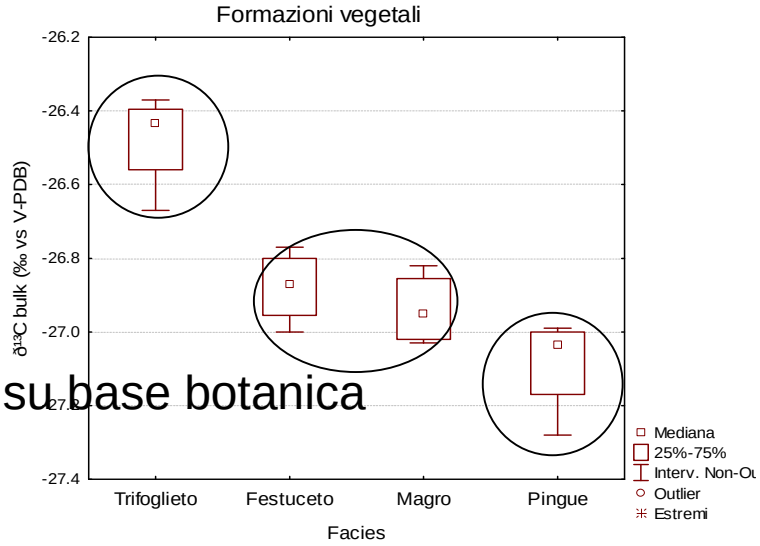
**…e i rapporti isotopici ?** La composizione isotopica dell'animale e dei prodotti animali deriva da quella di acqua e foraggio → fingerprint zona d'origine



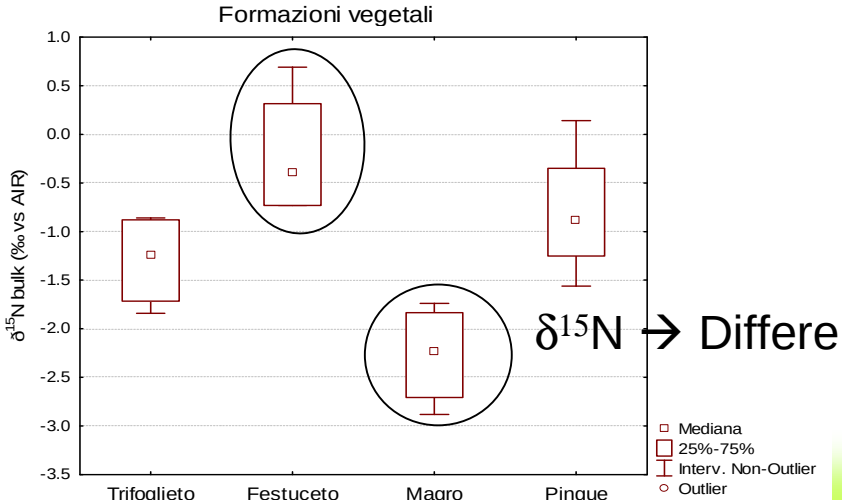
# Valutazione del contenuto di $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ e $\delta D$ delle matrici vegetali




$\delta D$ → Differenziazione su base geografica

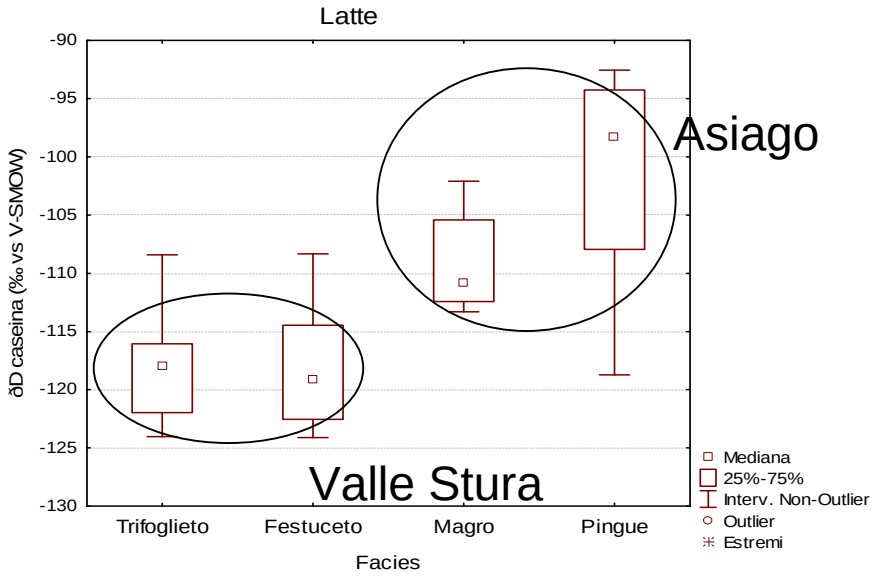


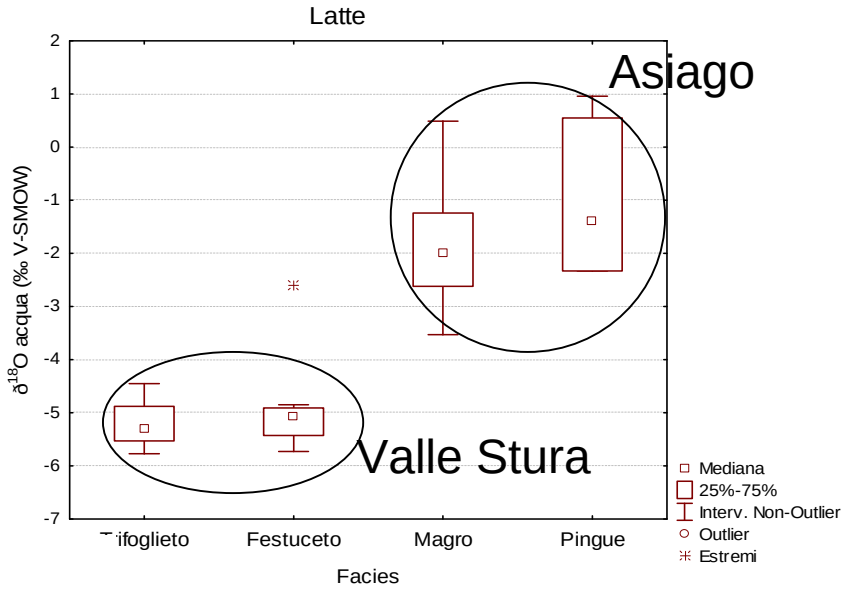

$\delta^{13}C$ → Differenziazione su base botanica

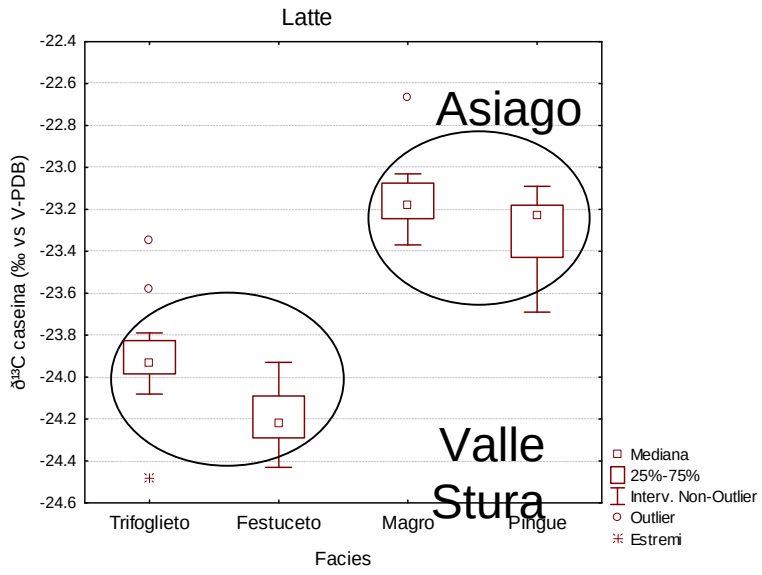



$\delta^{15}N$ → Differenziazione su base botanica

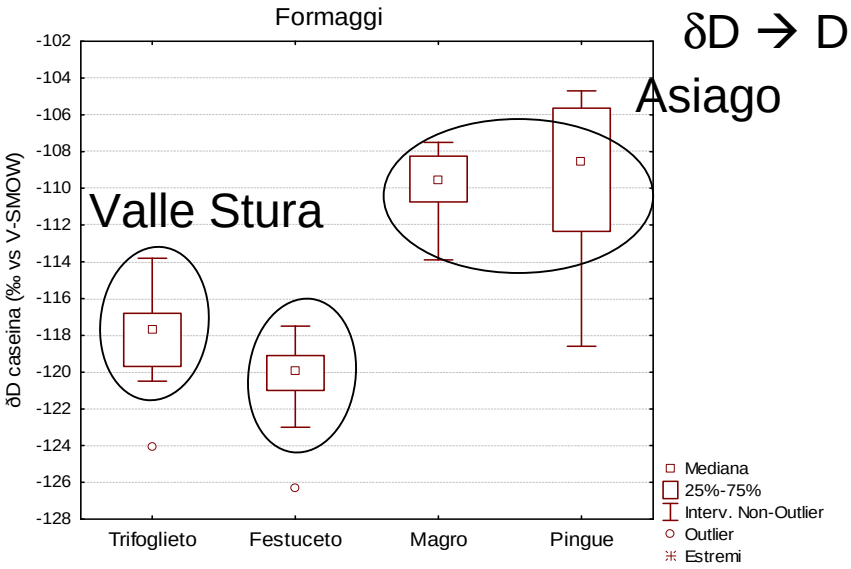
# Valutazione del contenuto di $\delta^{13}C$, $\delta^{15}N$ e $\delta D$ della caseina estratta da latte e del $\delta^{18}O$ dell'acqua del latte → differenziazione geografica



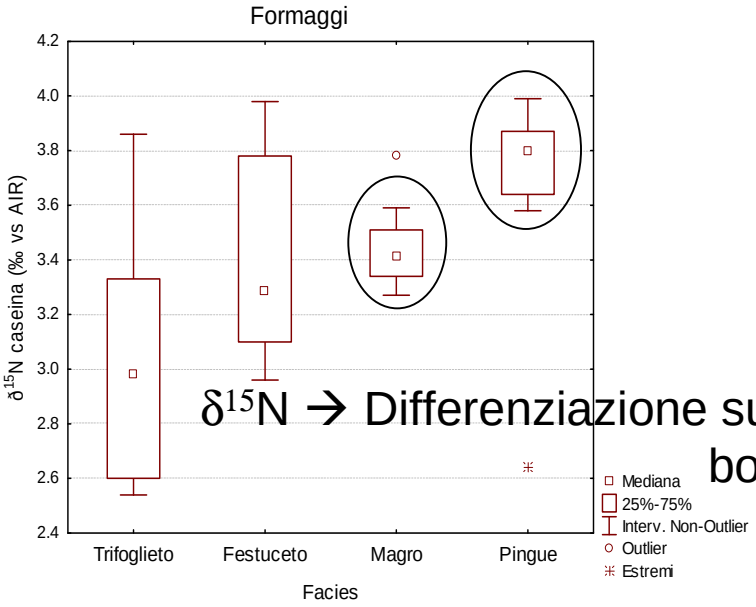



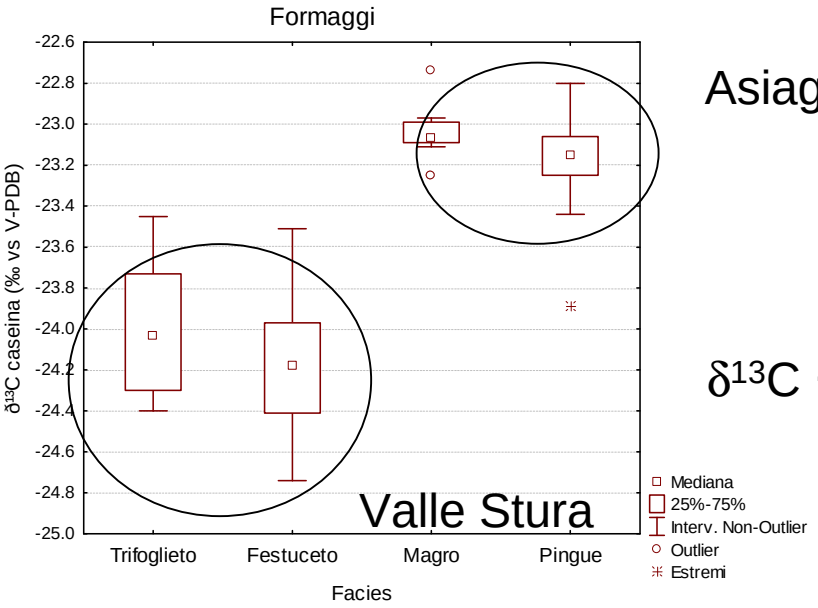
# Valutazione del contenuto di $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ e $\delta D$ della caseina estratta da formaggi




$\delta D$ → Differenziazione su base geografica

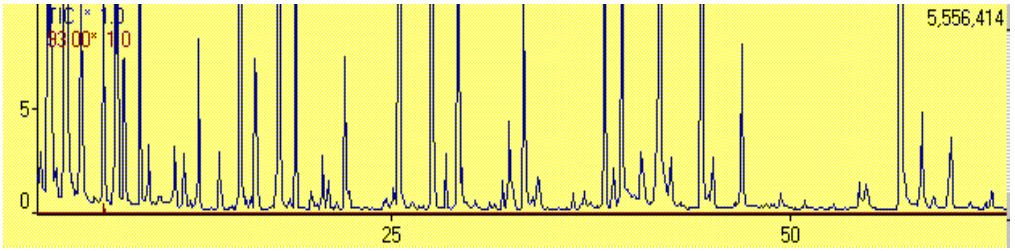


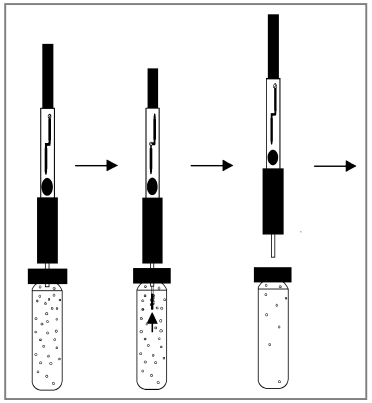

$\delta^{15}N$ → Differenziazione su base botanica

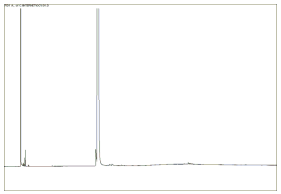


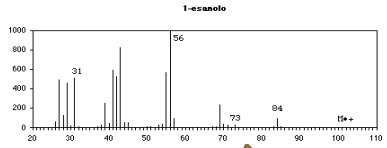

$\delta^{13}C$ → Differenziazione geografica

# … e i volatili ?


TIC
83.00* 1.0
5,556,414
5
0
25
50






1-esanolo
1000
800
600
400
200
0
20
30
40
50
60
70
80
90
100
110
31
56
73
84

# Biomarkers nel latte

| | LRI | Name | Vegetation Types | | | |
|---|---|---|---|---|---|---|
| **Monoterpenes** | | | FM | FP | F | T |
| 1 | 1008 | ⍺-Pinene | * | * | * | * |
| 2 | 1015 | ⍺-Thujene | * | * | * | * |
| 3 | 1046 | Camphene | * | * | * | |
| 4 | 1081 | β-Pinene | * | * | * | * |
| 5 | 1100 | Sabinene | * | * | * | |
| 6 | 1148 | β-Myrcene | * | * | * | * |
| 7 | 1160 | ⍺-Terpinene | * | * | | |
| 8 | 1175 | Limonene | * | * | * | * |
| 9 | 1188 | Cineole | * | * | * | * |
| 10 | 1227 | (Z)-⍺Ocimene | * | * | * | * |
| 11 | 1248 | *p* -Cymene | * | * | * | * |
| 12 | 1249 | Terpinolene | * | * | | |
| 13 | 1266 | Monoterpene n.i. **1**-[MW=136: 93(100)/121(96)/91(79)/77(51)/105(44)] | | * | | |
| 14 | 1427 | *cis* -Linalool oxide | * | * | * | * |
| 15 | 1464 | Menthone | * | * | | |
| 16 | 1464 | Dihydro myrcenol | * | * | * | * |
| 17 | 1481 | Camphor | | | * | * |
| 18 | 1537 | Pinocarvone | | * | | |
| 19 | 1541 | Linalool | * | * | * | * |
| 20 | 1560 | Bornyl acetate | * | * | * | * |
| 21 | 1585 | 4-Terpineol | * | * | | |
| 22 | 1627 | Menthol | * | * | * | * |
| 23 | 1638 | Pinocarveol | | * | | |
| 24 | 1675 | Terpinyl acetate | | | * | * |
| 25 | 1684 | ⍺-Terpineol | * | * | * | * |
| 26 | 1705 | Carvone | * | * | * | * |
| 27 | 1782 | Myrtenol | * | * | | |
| 28 | 1839 | Geranyl acetone | * | * | * | * |
| **Sesquiterpenes** | | | | | | |
| 1 | 1470 | Sesquiterpene n.i. **2**-[119(100)/105(93)/93(64)/161(39)] | * | * | | |
| 2 | 1572 | ⍺-Caryophyllene | * | * | * | * |
| 3 | 1653 | Cedrane | * | * | | |
| 4 | 1737 | Sesquiterpene n.i. **3**-[105(100)/119(87)/161(84)/134(74)/93(51)] | * | * | | |
| 5 | 2032 | Sesquiterpene n.i. **4**-[191(100)/119(76)/121(68)/135(44)/69(40)/79(36)/93(36)] | * | * | * | * |
| **Miscellaneous** | | | | | | |
| 1 | 1590 | ⍺-Cyclocitral | * | * | | |
| 2 | 1712 | Compound n.i. **1**-[41(100)/138(72)/83(67)/95(44)/109(35)/193(22)/165(9)] | * | * | | |
| 3 | 1830 | ⍺-ionone | | | * | |
| 4 | 1918 | ⍺-Ionone | * | * | * | |
| 5 | 2276 | Methyl dihydro jasmonate | * | * | | |

n.i.=non identificato

LRI=Indice di Ritenzione Lineare

*presenza del composto

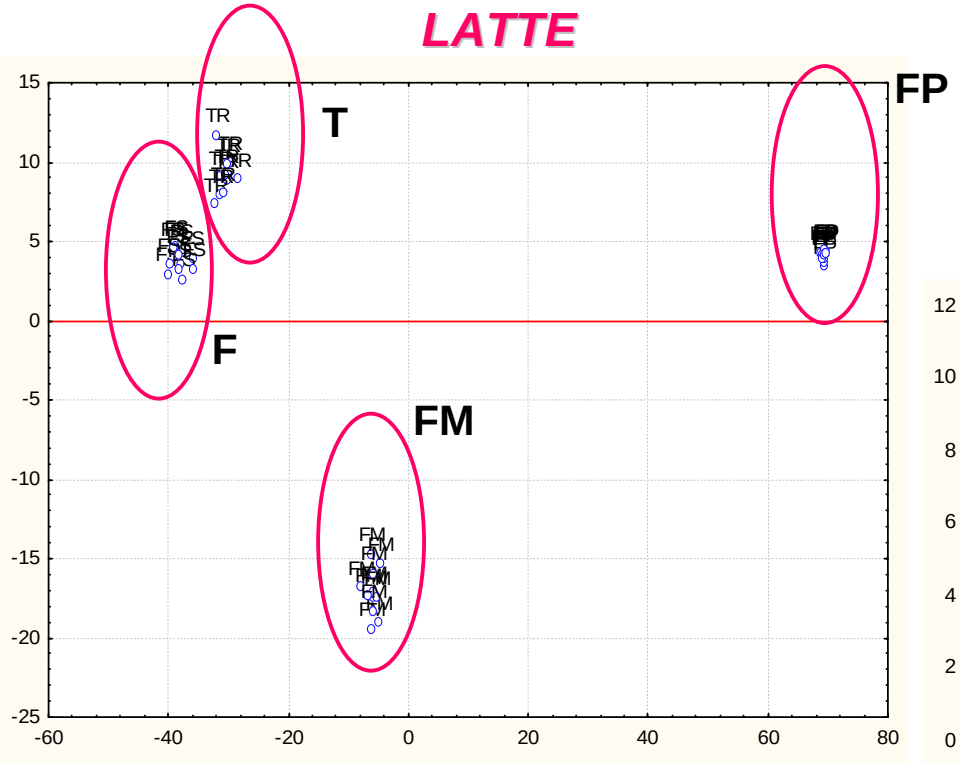
# Biomarkers nel formaggio

| | LRI | Name | Vegetation Types | | | |
|---|---|---|---|---|---|---|
| **Monoterpenes** | | | FM | FP | F | T |
| 1 | 1008 | α-Pinene | * | * | * | * |
| 2 | 1015 | α-Thujene | * | * | * | * |
| 3 | 1046 | Camphene | * | * | * | |
| 4 | 1081 | β-Pinene | * | * | * | * |
| 5 | 1100 | Sabinene | * | * | * | * |
| 6 | 1148 | β-Myrcene | * | * | * | * |
| 7 | 1160 | α-Terpinene | * | * | | |
| 8 | 1175 | Limonene | * | * | * | * |
| 9 | 1188 | Cineole | * | * | * | * |
| 10 | 1227 | (Z)-β-Ocimene | | | * | * |
| 11 | 1230 | γ-Terpinene | * | * | * | * |
| 12 | 1248 | *p* -Cymene | * | * | * | * |
| 13 | 1249 | Terpinolene | * | * | | |
| 14 | 1324 | *Exo* -2-hydroxy cineole | | | * | |
| 15 | 1437 | Menthone Isomer **1** | * | * | * | |
| 16 | 1464 | Menthone Isomer **2** | * | | | |
| 17 | 1464 | Dihydro myrcenol | * | * | * | * |
| 18 | 1481 | Camphor | * | * | * | * |
| 19 | 1541 | Linalool | * | * | * | * |
| 20 | 1546 | Monoterpene n.i. **2**-[MW=136: 93(100)/69(28)/121(24)/105(13)] | | * | * | |
| 21 | 1560 | Bornyl acetate | * | * | * | * |
| 22 | 1575 | Monoterpene n.i. **3**-[MW=136: 43(100)/93(67)/68(44)/107(29)/121(28)] | | * | | |
| 23 | 1585 | 4-Terpineol | * | * | | |
| 24 | 1627 | Menthol | * | * | * | * |
| 25 | 1675 | Terpinyl acetate | * | * | * | * |
| 26 | 1684 | α-Terpineol | * | * | * | * |
| 27 | 1705 | Carvone | * | * | * | * |
| 28 | 1768 | Monoterpene n.i. **4**-[MW=136: 121(100)/93(35)/79(27)] | | * | | * |
| 29 | 1771 | Dihydro carveol Isomer **1** | | * | | |
| 30 | 1782 | Myrtenol | | * | | |
| 31 | 1793 | Dihydro carveol isomer **2** | * | * | | |
| 32 | 1839 | Geranyl acetone | * | * | * | * |
| **Sesquiterpenes** | | | | | | |
| 1 | 1470 | Sesquiterpene n.i.**1**-[189(100)/105(93)/93(64)/161(39)] | * | | * | * |
| 2 | 1495 | Sesquiterpene n.i.**2**-[MW=204: 161(100)/133(55)/91(52)/148(51)/119(50)/175(44)] | | | * | |
| 3 | 1572 | β-caryophyllene | * | * | * | * |
| 4 | 1653 | Cedrane | * | * | | |
| 5 | 2010 | Isolongifolanone | | * | | |
| 6 | 2032 | Sesquiterpene n.i. **4**-[191(100)/119(76)/121(68)/135(44)/69(40)/79(36)/93(36)] | * | * | * | * |
| **Miscellaneous** | | | | | | |
| 1 | 1712 | Compound n.i. **1**-[41(100)/138(72)/83(67)/95(44)/109(35)/193(22)/165(9)] | * | * | | |
| 2 | 1918 | β-Ionone | * | * | * | * |

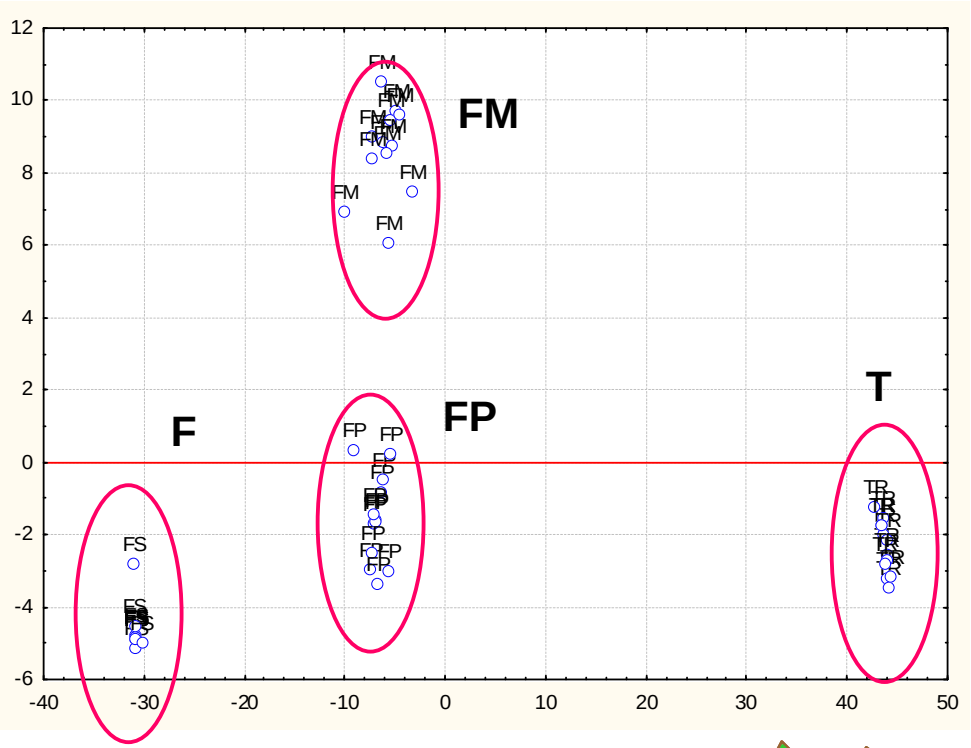
n.i.=non identificato
LRI=Indice di Ritenzione Lineare
*presenza del composto

# Analisi Discriminante Lineare

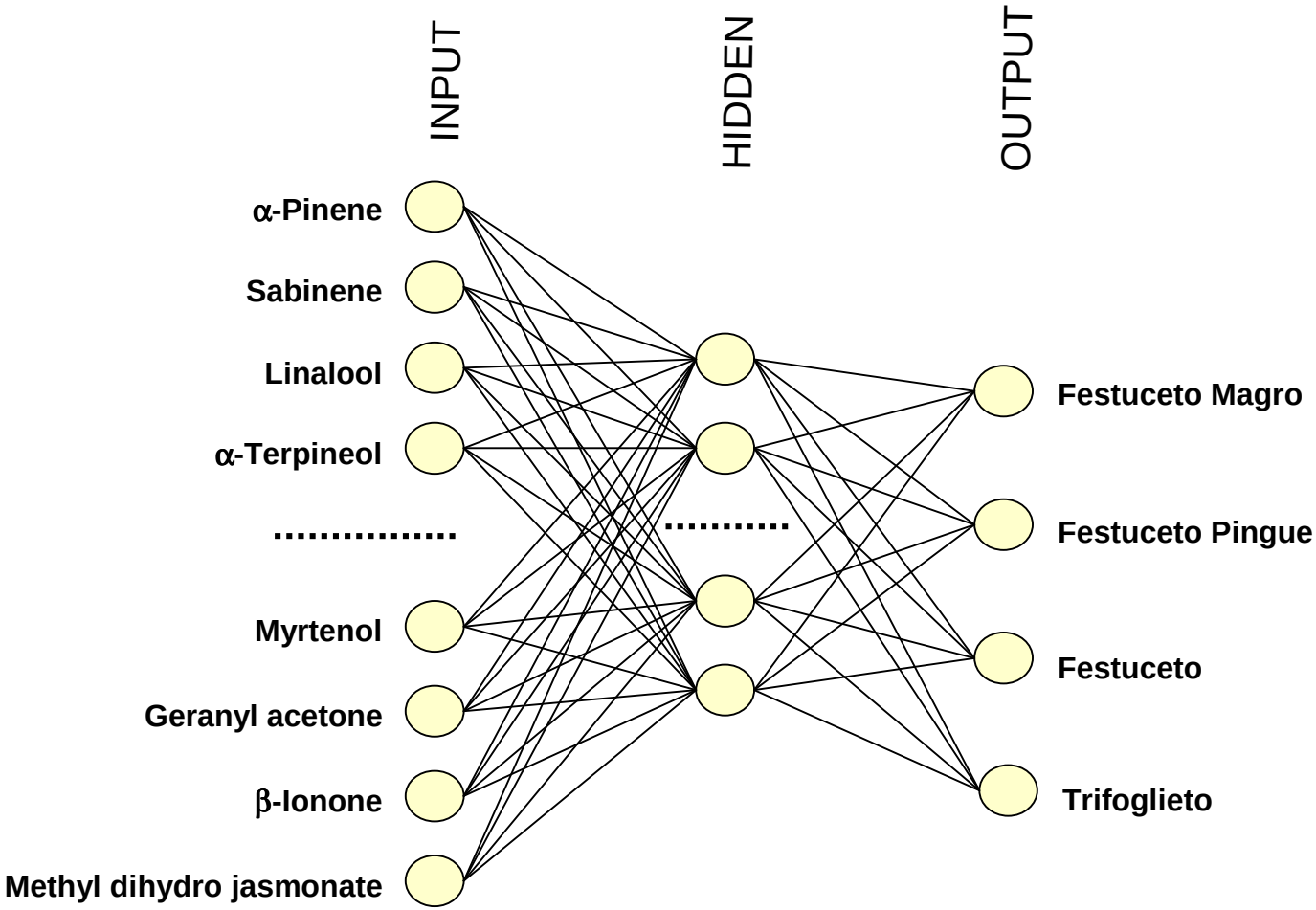
## LATTE




## FORMAGGIO



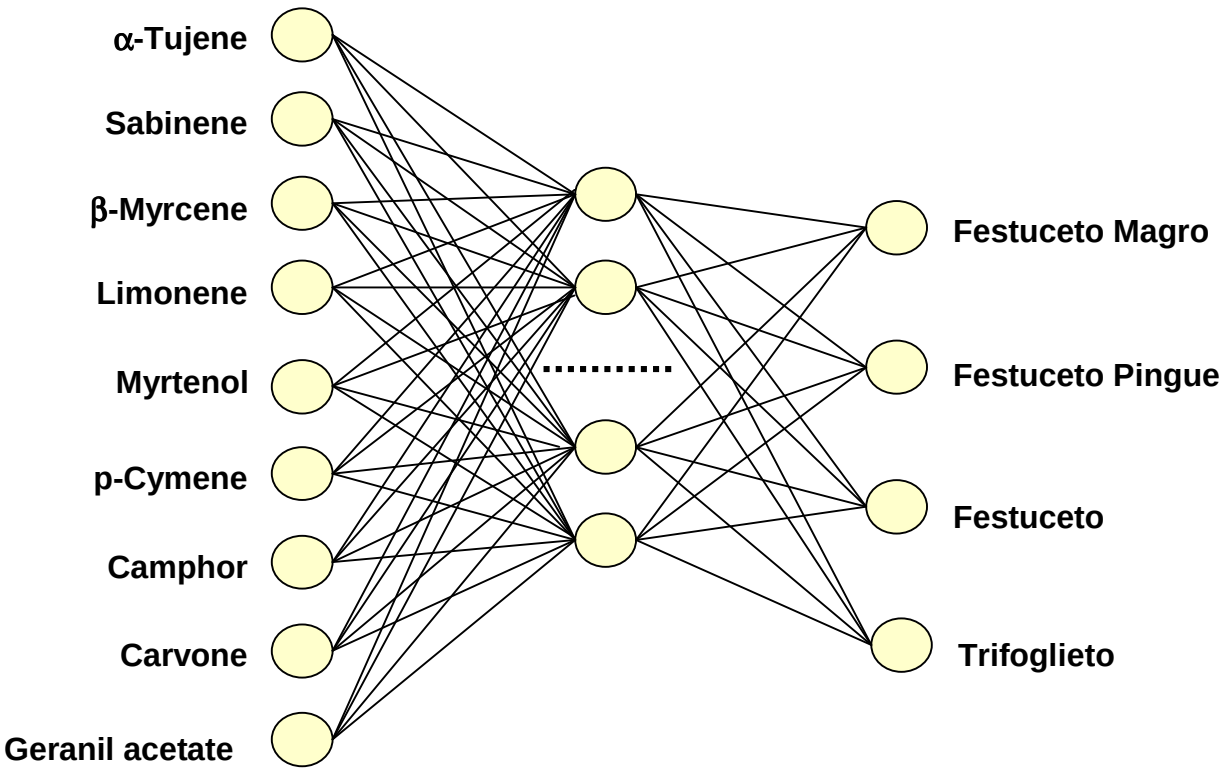
## Artificial Neural Network (ANN)




| *Formazioni* | *Latte* | *Formaggio* |
|---|---|---|
| *Festuceto magro* | 100 | 100 |
| *Festuceto pingue* | 98 | 95 |
| *Festuceto* | 100 | 95 |
| *Trifoglieto* | 98 | 100 |

## ANN

## Latte




| Festuceto | | |
|---|---|---|
| | 0 | 1 |
| 0 | 34 | 0 |
| 1 | 2 | 12 |

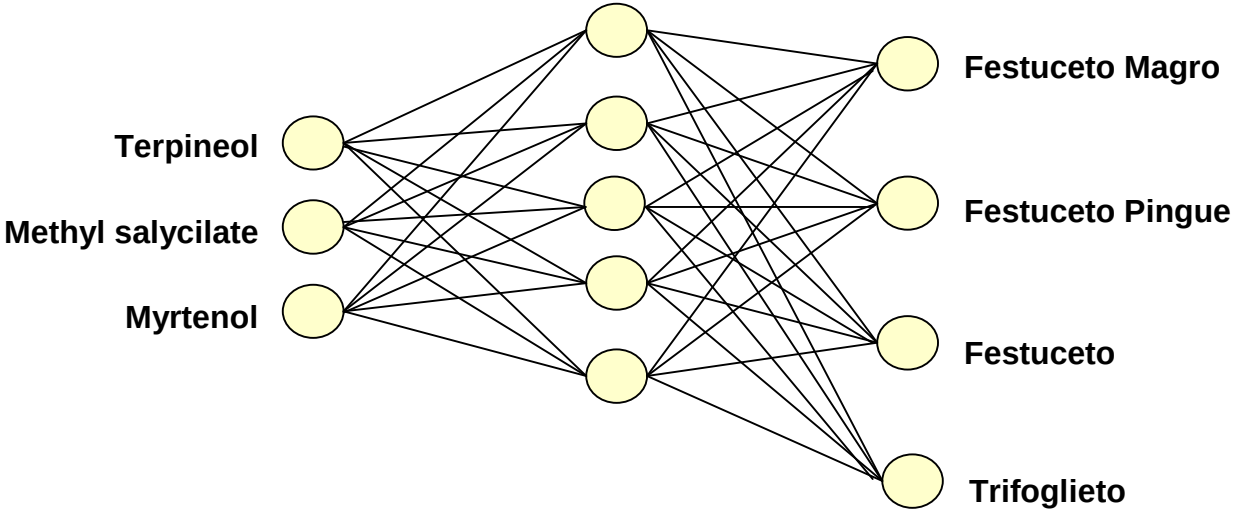
| Trifoglieto | | |
|---|---|---|
| | 0 | 1 |
| 0 | 35 | 0 |
| 1 | 1 | 12 |

| Magro | | |
|---|---|---|
| | 0 | 1 |
| 0 | 36 | 5 |
| 1 | 0 | 7 |

| Pingue | | |
|---|---|---|
| | 0 | 1 |
| 0 | 34 | 0 |
| 1 | 2 | 12 |

# ANN

## Formaggio




3 5 4

| Festuceto | | |
|---|---|---|
| | 0 | 1 |
| 0 | 30 | 2 |
| 1 | 5 | 10 |

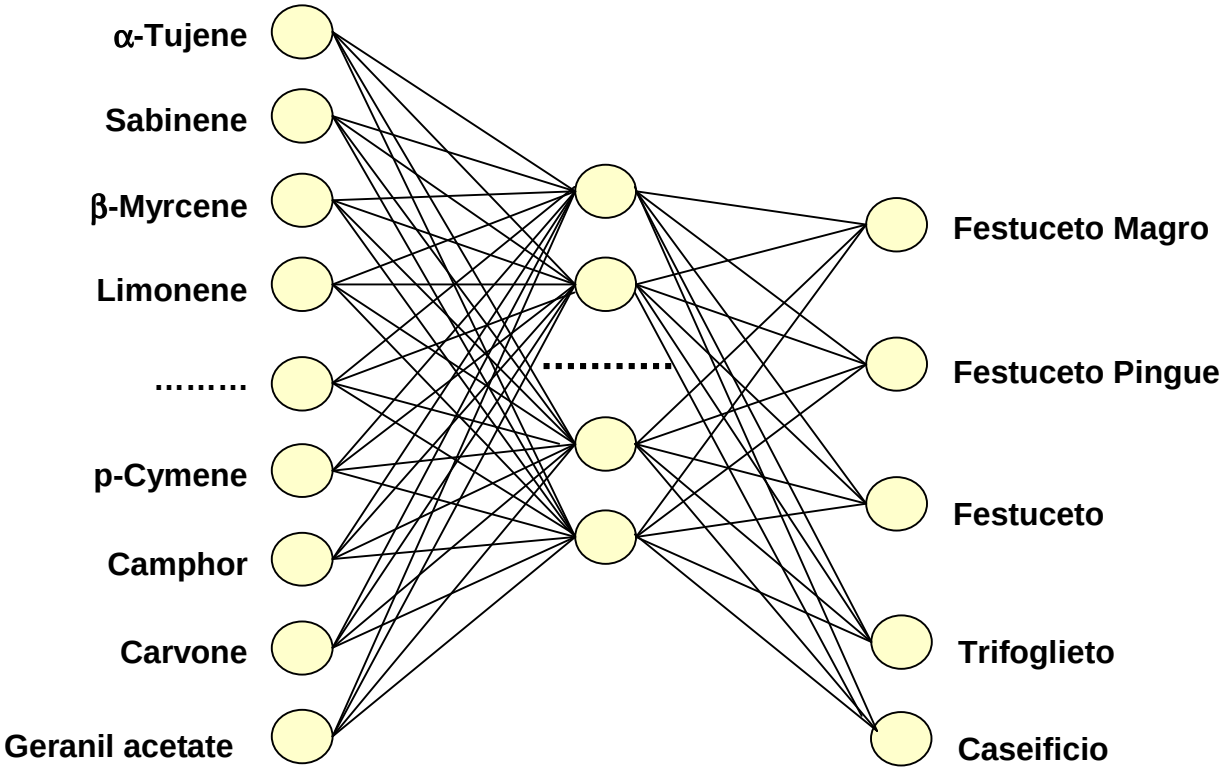
| Trifoglieto | | |
|---|---|---|
| | 0 | 1 |
| 0 | 33 | 5 |
| 1 | 2 | 7 |

| Magro | | |
|---|---|---|
| | 0 | 1 |
| 0 | 35 | 0 |
| 1 | 0 | 12 |

| Pingue | | |
|---|---|---|
| | 0 | 1 |
| 0 | 36 | 0 |
| 1 | 0 | 11 |

## ANN

## Formaggio Asiago



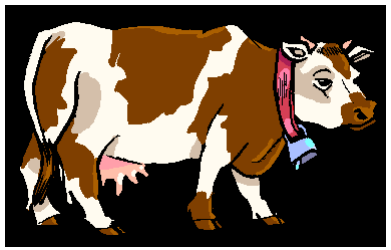
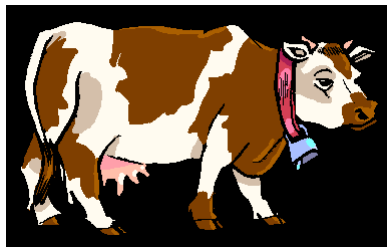
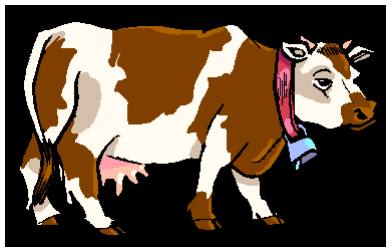

| | CAMP | T | P | V | F | FP | T | FM | CAS |
|---|---|---|---|---|---|---|---|---|---|
| F | 12 | 7 | 5 | | 4 | 1 | | | |
| FP | 12 | 8 | 4 | | | 4 | | | |
| T | 12 | 7 | 5 | | | | 5 | | |
| FM | 12 | 10 | 2 | | | | | 2 | |
| AS | 26 | 3 | | 23 | 3 | 7 | 2 | 8 | 5 |

```
' Insert this code into your VB program to fire the G:\archivio\latte 7 day network
' This code is designed to be simple and fast for porting to any machine.  Therefore all code and weights are inline without looping or data storage which might be harder to port between compilers.
Sub Fire_latte 7 day (inarray(), outarray())

 Dim netsum as double
 Static feature2(23) as double

' outarray(1) is f1
' outarray(2) is f2
' outarray(3) is f3
' outarray(4) is f4
' inarray(1) is a-Pinene
' inarray(2) is a-Thujene
' inarray(3) is Camphene
' inarray(4) is ?-Pinene
' inarray(5) is Sabinene
' inarray(6) is ?-Myrcene
' inarray(7) is Limonene
' inarray(8) is Cineole
' inarray(9) is (Z)-b-Ocimene
' inarray(10) is p-Cymene
' inarray(11) is Terpinolene
' inarray(12) is menthone_1
' inarray(13) is menthone_2
' inarray(14) is Dihydromyrcenol
' inarray(15) is Camphor
' inarray(16) is Linalool
' inarray(17) is b-caryophyllene
' inarray(18) is 4-Terpineol
' inarray(19) is Menthol
' inarray(20) is Cedrane
' inarray(21) is Terpinyl_acetate
' inarray(22) is Carvone
' inarray(23) is Myrtenol
' inarray(24) is Geranyl_acetone
' inarray(25) is b-Ionone

if (inarray(1)<1.370486E-02) then inarray(1) = 1.370486E-02
if (inarray(1)>0.2718873) then inarray(1) = 0.2718873
inarray(1) = (inarray(1) - 1.370486E-02) / 0.2581824

if (inarray(2)<0) then inarray(2) = 0
if (inarray(2)>2.364286E-02) then inarray(2) = 2.364286E-02
inarray(2) = inarray(2) / 2.364286E-02

if (inarray(3)<0) then inarray(3) = 0
if (inarray(3)>3.178289E-02) then inarray(3) = 3.178289E-02
inarray(3) = inarray(3) / 3.178289E-02

if (inarray(4)<0) then inarray(4) = 0
if (inarray(4)>0.1658355) then inarray(4) = 0.1658355
inarray(4) = inarray(4) / 0.1658355

if (inarray(5)<0) then inarray(5) = 0
if (inarray(5)>7.273432E-02) then inarray(5) = 7.273432E-02
inarray(5) = inarray(5) / 7.273432E-02

if (inarray(6)<0) then inarray(6) = 0
if (inarray(6)>3.112463E-02) then inarray(6) = 3.112463E-02
inarray(6) = inarray(6) / 3.112463E-02

if (inarray(7)<3.814849E-02) then inarray(7) = 3.814849E-02
if (inarray(7)>1.930329) then inarray(7) = 1.930329
inarray(7) = (inarray(7) - 3.814849E-02) / 1.89218

if (inarray(8)<0) then inarray(8) = 0
if (inarray(8)>0.1201577) then inarray(8) = 0.1201577
inarray(8) = inarray(8) / 0.1201577

if (inarray(9)<0) then inarray(9) = 0
if (inarray(9)>8.218862E-02) then inarray(9) = 8.218862E-02
inarray(9) = inarray(9) / 8.218862E-02

if (inarray(10)<0) then inarray(10) = 0
if (inarray(10)>0.5824084) then inarray(10) = 0.5824084
inarray(10) = inarray(10) / 0.5824084

if (inarray(11)<0) then inarray(11) = 0
if (inarray(11)>5.633711E-02) then inarray(11) = 5.633711E-02
inarray(11) = inarray(11) / 5.633711E-02

if (inarray(12)<0) then inarray(12) = 0
if (inarray(12)>6.688781) then inarray(12) = 6.688781
inarray(12) = inarray(12) / 6.688781
```



?

?

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| Formazione | Latte | Formaggio |
|---|---|---|
| (E)-b-Ocimene | x | x |
| (Z)-b-Ocimene | x | x |
| 4-Terpineol | x | x |
| 5,6-epoxy-β-ionone | | |
| α-Cadinene | | |
| α-caryophyllene | | |
| α-Copaene | | |
| α-cubebene | | |
| α-cubebene isomer | | |
| Ambrinol cis-alfa | | |
| α-Pinene | x | x |
| α-Terpinene | x | x |
| α-Terpineol | x | x |
| α-Thujene | x | x |
| β-caryophyllene | x | x |
| β-Cyclocitral | x | |
| Bicyclo germacrene | | |
| β-Ionone | x | x |
| Bornyl acetate | x | x |
| Bornyl acetate isomero | | |
| β-phellandrene | | |
| Cadalene | | |
| Calacorene | | |
| Calamenene cis | | |
| Calamenene trans | | |
| Camphene | x | x |
| Camphor | x | x |
| Cariophylla | | |
| Cariophyllene oxide | | |
| Carvacrolo | | |
| Carveol cis | | |
| Carveolo trans | | |
| Carvone | x | x |
| Cineol | x | x |
| Cis-nerolidol | | |
| Coumarin | | |
| δ-Amorphene | | |
| Dihydro carveol iso | | x |
| Dihydrocarvone trans | | |
| Dihydrocarvonec cis | | |
| Eugenol | | |
| Geranil acetone | x | x |
| Geraniol | | |

| Formazione | Latte | Formaggio |
|---|---|---|
| Germacrene D | | |
| Globulol | | |
| γ-Terpinene | | x |
| Helifolenol 1 | | |
| Isoeugenol | | |
| Lavandulol | | |
| Limonene | x | x |
| Limonene oxide cis | | |
| Limonene oxide trans | | |
| Linalool | x | x |
| Linalool oxide cis | x | |
| Linalool oxide trans | | |
| Methyl eugenol | | |
| Methyl salicilate | | x |
| Monoterpene n.i. 1 | | |
| Muurola-3,5-diene cis | | |
| Muurola-3,5-diene trans | | |
| Myrtenol | x | x |
| Nerol | | |
| Ocimene isomer 1 | | |
| p-Cymene | x | x |
| Perillaldeide | | |
| Phytol acetate | | |
| Pinocarvone | x | |
| p-Menth-3-en-9-ol | | |
| Sabinene | x | x |
| Sabinene hydrate | | |
| Sabinene hydrate isomer | | |
| Sesquiterpene n.i 1 | | x |
| Sesquiterpene n.i. 2 | | |
| Sesquiterpene n.i. 3 | | |
| Sesquiterpene n.i. 4 | | x |
| Sesquiterpene n.i. 5 | | |
| Sesquiterpene n.i. 6 | | |
| Spathulenol | | |
| Tau-cadinol | | |
| Terpinolene | x | x |
| Thymol 1 | | |
| β-Myrcene | x | x |
| β-Pinene | x | x |
| | Dihydromyrcenol | x |
| | Menthol | x |
| | Sesquiterpene n.i. 7 | |
| | Terpinyl acetate | x |
| | | Menthone |
| | | Menthone 2 |
| | | Cedrane |

# Conclusioni

'Sistema' alpeggio

Terpeni, Isotopi, Acidi grassi, ecc.

Analisi chimica

Analisi statistica

Modello matematico esportabile

Carta d'identità

Oggettivizzare la tipicità

Si può tutelare e difendere solo ciò che si conosce