COME MISURARE LA QUALITÁ DEL CIBO: IL RUOLO DELLA RISONANZA MAGNETICA

DANIELE DEGL'INNOCENTI

LE -OMICHE E DINTORNI

GENETICA GENOMICA PROTEOMICA TRASCRITTOMICA EPIGENETICA METILOMICA NUTRIGENOMICA NUTRACEUTICA METAGENOMICA METABOLOMICA METABONOMICA

LA METABOLOMICA

La metabolomica è lo studio sistematico delle impronte chimiche uniche lasciate da specifici processi cellulari - nello specifico, lo studio dei loro profili metabolici a molecole piccole.

LA METABOLOMICA

La metabolomica fornisce informazioni che permettono di controllare l'origine degli alimenti e studiarne la qualità e gli effetti sul metabolismo di chi li assume

SPETTROSCOPIA E CHEMIOMETRIA

Il loro utilizzo combinato mediante analisi rapide e non "invasive" permette di

individuare le "impronte digitali" o "marker" di un alimento di alimenti provenienti da un'area geografica di alimenti ottenuti mediante lo stesso procedimento

e di riconoscerle nonostante le variazioni annuali o stagionali

e, in futuro, di risalire a frodi e sofisticazioni in tutti gli alimenti



Risonanza magnetica - NMR



NMR STATO LIQUIDO

¹H NMR Studies on Italian Balsamic and Traditional Balsamic Vinegars

ROBERTO CONSONNI*,† AND ALBERTO GATTI[‡]

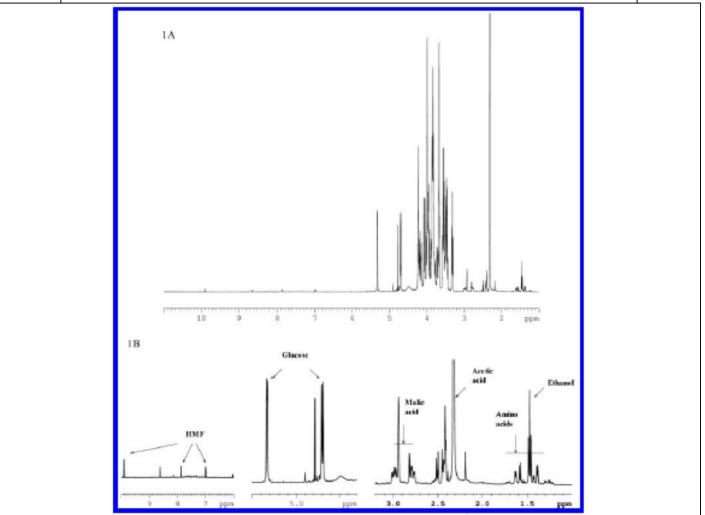
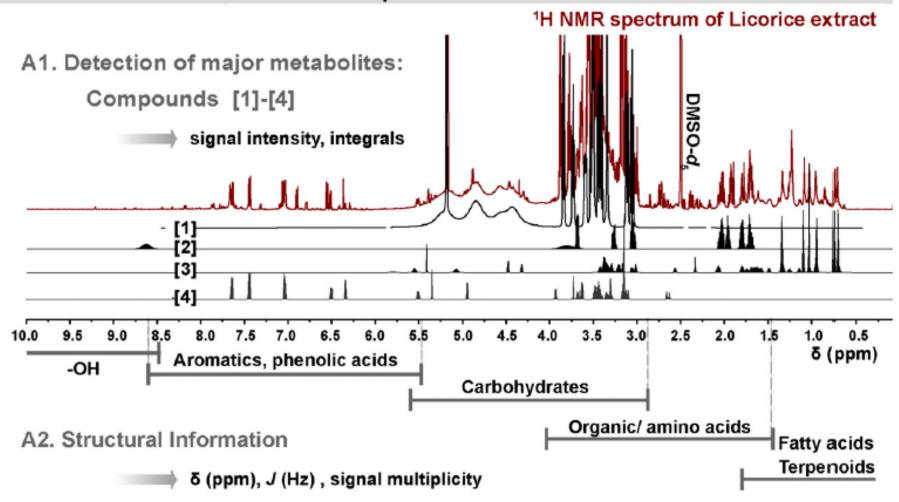


Figure 1. ¹H NMR spectra recorder with water suppression pulse program. (A) Typical spectrum of balsamic vinegar sample. (B) Expanded regions (aromatic, anomeric, and aliphatic regions, from left to right) with metabolite assignments.

A Observation of 1D ¹H NMR spectrum



High-Resolution NMR and Diffusion-Ordered Spectroscopy of Port Wine

Mathias Nilsson et al. - J. Agric. Food Chem. 2004

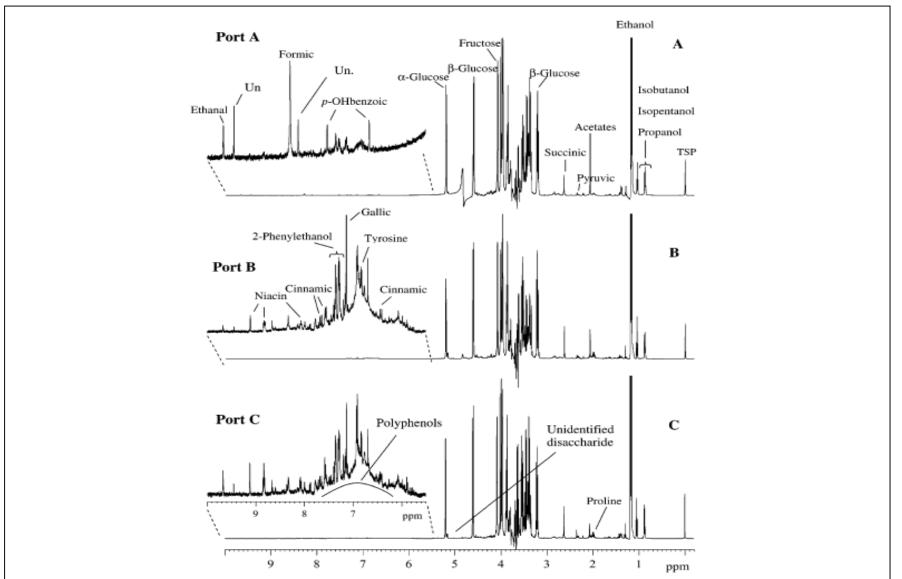


Figure 1. ¹H NMR spectra of (A) Port A (20 years old), (B) Port B (3 years old), and (C) Port C (1 year old), recorded with 128 transients. Some of the assigned resonances are indicated; signals marked "Un" remain unassigned.

DIFFERENZIAZIONE VINI SLOVENI CON SPETTRI NMR

Kosir et al. – Nationali Institute of Chemistry, Ljubliana, Slovenia (2000)

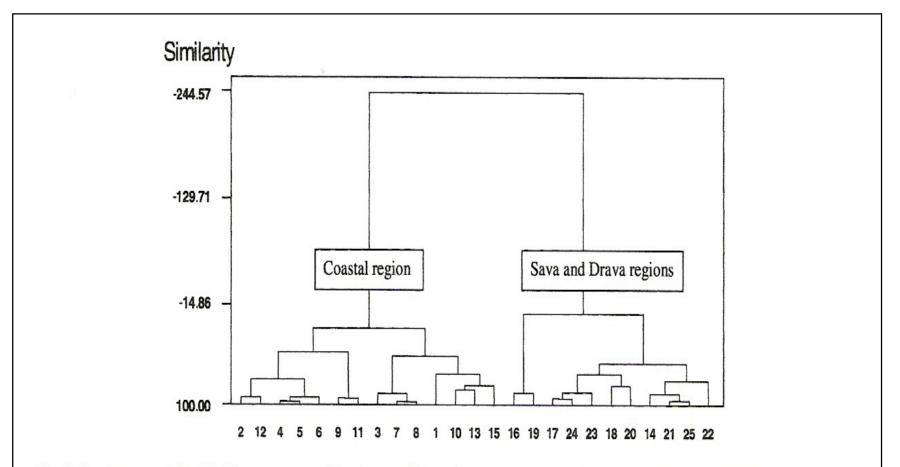


Fig. 9. Dendrogram of the 25 objects represented by three variables obtained by Ward's hierarchical clustering method. The numbers are the same sample identifiers as in Table 4.



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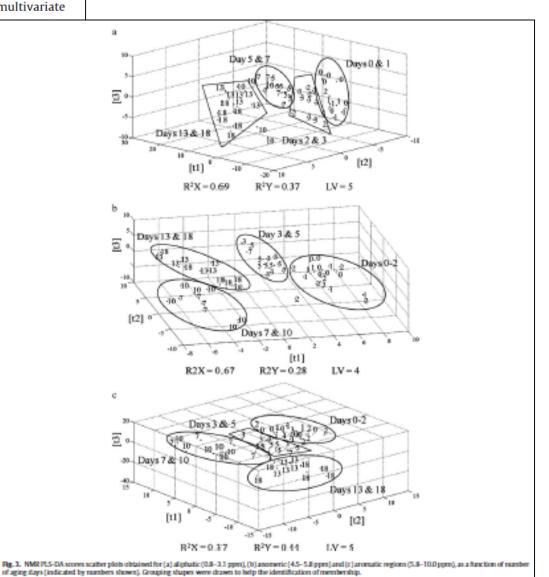


Probing beer aging chemistry by nuclear magnetic resonance and multivariate analysis

J.A. Rodrigues a, A.S. Barros b, B. Carvalho c, T. Brandão c, Ana M. Gil a,*

CICECO-Department of Chemistry, University of Aveiro, Campus de Santiago, 381 0-193 Aveiro, Portugal

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CUNCER, Bebidas de Portugal, Leça do Balio, 4466-955, S. Mamede de Infesta, Portugal





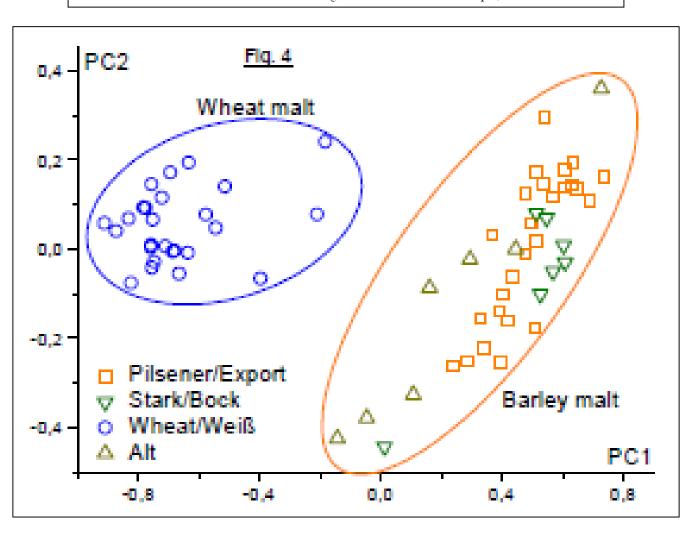
Quality Control of Beer using High-Resolution Nuclear Magnetic Resonance

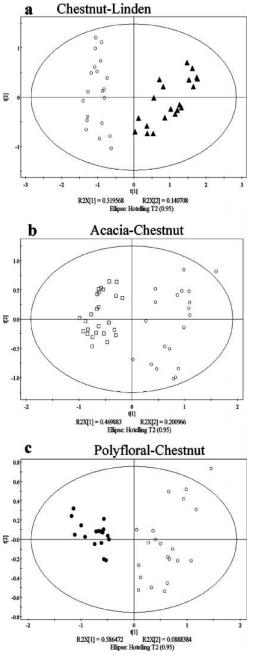


Spectroscopy and Multivariate Analysis

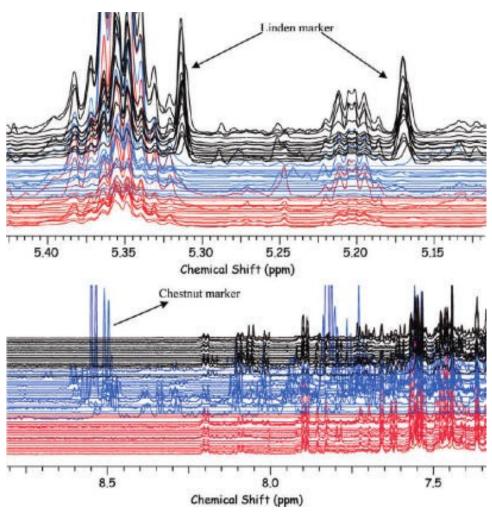
D.W. Lachenmeier¹, W. Frank¹, E. Humpfer², M. Spraul²

¹Chemisches und Veterinäruntersuchungsamt Karlsruhe ²Bruker BioSpin, Rheinstetten





MIELE E NMR Discriminazione dell'origine



NMR E MIELE Classificazione mieli italiani

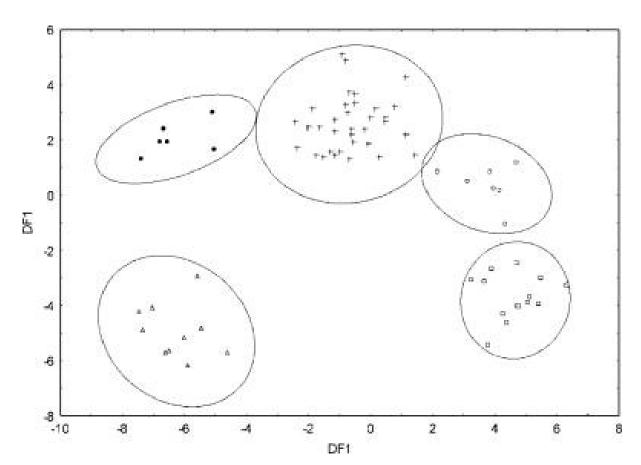


Figure 7. Score plot of the first two canonical functions for the data

set obtained by DMSO-d6
1H-13C HMBC spectrum
showing separation
of honeys in five different
clusters: polyfloral honeys (+),
eucalyptus
honeys (b), chestnut honeys (4),
citrus species honeys (O), and
robinia honeys (0).



LWT - Food Science and Technology



journal homepage: www.elsevier.com/locate/lwt

Identification of components of Brazilian honey by ¹H NMR and classification of its botanical origin by chemometric methods

Elisangela F. Boffo a,*, Leila A. Tavares b, Antonio C.T. Tobias c, Márcia M.C. Ferreira d, Antonio G. Ferreira a

ARSTRACT

The potential of NMR spectroscopy to differentiate honeys concerning to the nectar employed in its production was evaluated. The application of chemometric methods to ¹H NMR spectra has allowed to discriminate the honeys produced in the state of São Paulo, being identified the signals of responsible substances for the discrimination. Application of PCA and HCA methods to ¹H NMR data have resulted in the natural clustering of the samples. Wildflower honeys were characterized by higher concentration of phenylalanine and tyrosine. Citrus honeys showed higher amounts of sucrose than other compounds, while eucalyptus honeys had higher amount of lactic acid than the others. Assa-peixe honeys showed spectra similar to eucalyptus and citrus. Sugar-cane honeys showed some signals similar to eucalyptus and citrus honeys, but also showed the tyrosine and phenylalanine signals. Adulterated honeys showed 5-hydroxymethylfurfural, citric acid and ethanol signals. KNN, SIMCA and PLS-DA methods were used to build predictive models for honey classification. In the commercial honeys prediction KNN, SIMCA and PLS-DA models correctly classified 66.7; 22.2 and 72.2% of the samples, respectively.

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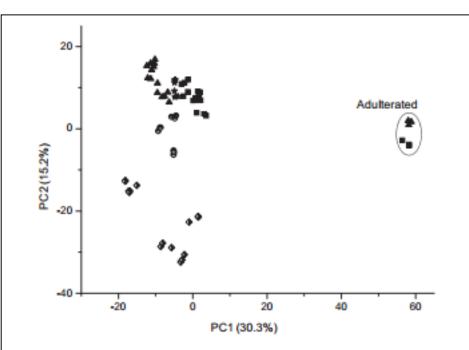


Fig. 2. PCA scores plot (PC1 × PC2) of all honey types analyzed by ¹H NMR (45.5% of the total variance): ♦ – wildflower; ▲ – eucalyptus; ■ – citrus; ⊕ – sugarcane; ★ – assa-peixe honeys.

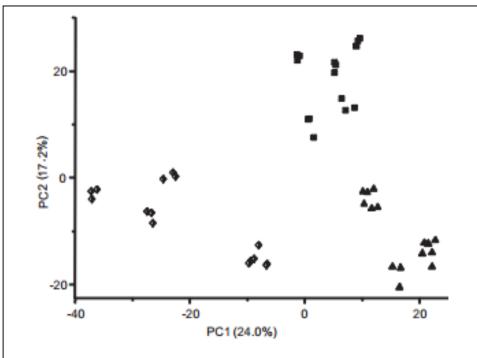


Fig. 4. PCA scores plot (PC1 x PC2) showing the discrimination between honey samples (41.2% of the total variance): → – Wildflower; ▲ – eucalyptus and ■ – citrus honeys.

Study of the Cultivar-Composition Relationship in Sicilian Olive Oils by GC, NMR, and Statistical Methods

Luisa Mannina,*,†,# Giacomo Dugo,‡ Francesco Salvo,‡ Lucia Cicero,‡ Giuliana Ansanelli,§ Cristina Calcagni,# and Annalaura Segre#

Dipartimento S.T.A.T., Facoltà di Scienze MM.FF.NN., Università del Molise, Via Mazzini 8, 86170 Isernia, Italy; Dipartimento di Chimica Organica e Biologica, Facoltà di Scienze MM.FF.NN., Università di Messina, Salita Sperone 31, 98166 Messina, Italy; C.R. ENEA-Trisaia, S.S. 106 Jonica, Km 419+500, 75025 Rotondella (MT), Italy; and Istituto di Metodologie Chimiche, CNR, 00016 Monterotondo Stazione, Roma, Italy

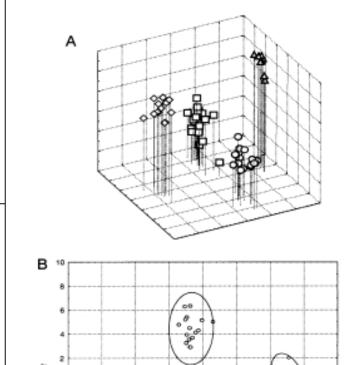


Figure 3. LDA of 60 Sicilian extra virgin olive oils based on 46 ¹³C peaks. (A) Three-dimensional plot obtained with the canonical scores for the three discriminant equations (roots 1, 2, and 3). (B) Two-dimensional plot with the canonical scores for the two discriminant equations (roots 1 and 2). Ellipses represent the 95% confidence regions for each group. Samples labeled with the same symbol come from the same cultivar: ○, NO, Nocellara; □, BI, Biancolilla; ◇, CE, Cerasuola; △, TI, Tonda Iblea.

Root 1

Characterization of Italian Extra Virgin Olive Oils Using ¹H-NMR Spectroscopy

Raffaele Sacchi,*.[†] Luisa Mannina,[‡] Paolo Fiordiponti,[§] Piero Barone,[∥] Livio Paolillo,[⊥] Maurizio Patumi,[‡] and Annalaura Segre[§]

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High-field (600-MHz) proton nuclear magnetic resonance (1 H-NMR) spectroscopy was applied to the analysis of 55 extra virgin olive oil samples from four Italian regions (Campania, Lazio, Sicily, and Umbria) and obtained from diffrent olive varieties. The multivariate statistical analysis (PCA, hierarchical clustering) performed on the normalized intensities of 1 H- NMR resonances due to minor components (β -sitosterol, n-alkenals, trans-2-alkenals, and other volatile compounds) allows a good classification of oil samples obtained from traditional varieties with respect to the region of origin (96% of oils correctly classified). Samples obtained from one new experimental cultivar (FS-17) were not correctly classified, indicating a strong contribution of olive variety on the chemical composition of virgin olive oils. The potential contribution and limits of NMR in the authentication of virgin olive oil geographical origin and variety are discussed.

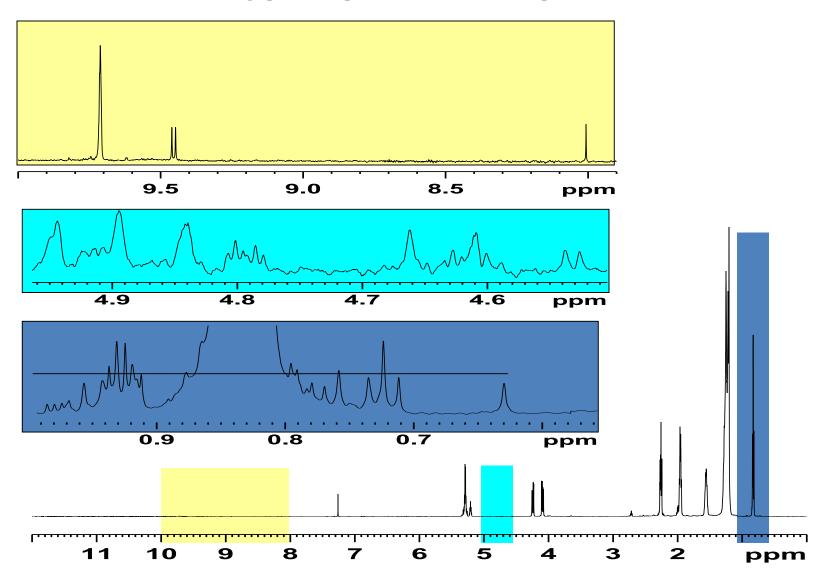
OLIO DI OLIVA: CARATTERIZZAZIONE ATTRAVERSO L'NMR AD ALTA RISOLUZIONE (¹H e ¹³C)

<u>Luisa Mannina</u>^{a,b}, Marco D'Imperio^a Anatoli Sobolev^b, Annalaura Segre^b

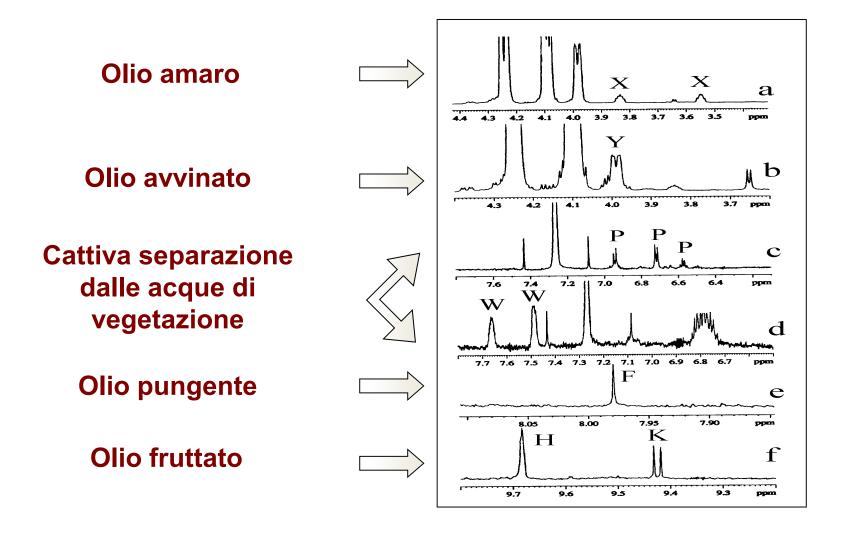
^a Università degli Studi del Molise, Isernia, Italy

b Istituto di Metodologie Chimiche, CNR, 00016 Monterotondo Stazione, Roma, Italy

SPETTRO PROTONICO DI UN OLIO DI OLIVA: COMPONENTI MINORI



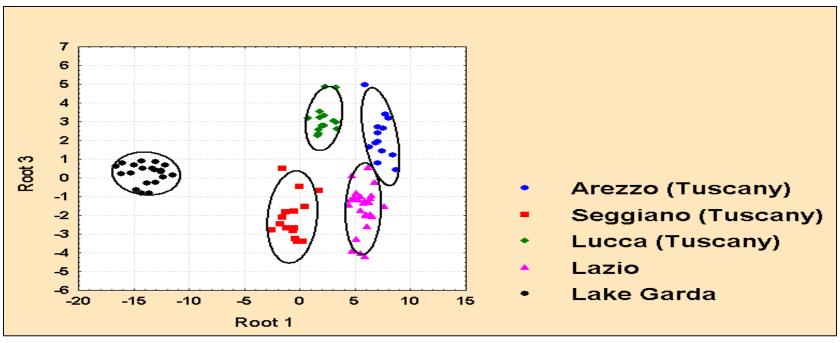
ATTRIBUTI SENSORIALI



CARATTERIZZAZIONE GEOGRAFICA (¹H): OLI DEL CENTRO-NORD



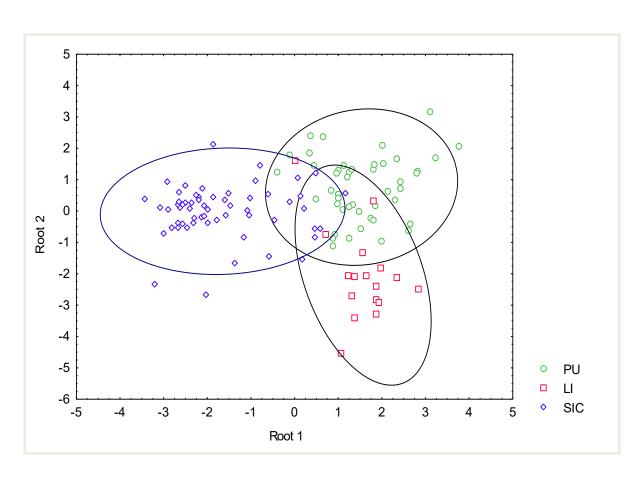
LDA



L.Mannina, M.Patumi, N.Proietti, D.Bassi, A.L.Segre, *Journal of Agriculture and Food Chemistry*, (2001), 49, 2687-2696

CARATTERIZZAZIONE GEOGRAFICA (¹H): EFFETTO DELL'ANNO

LDA

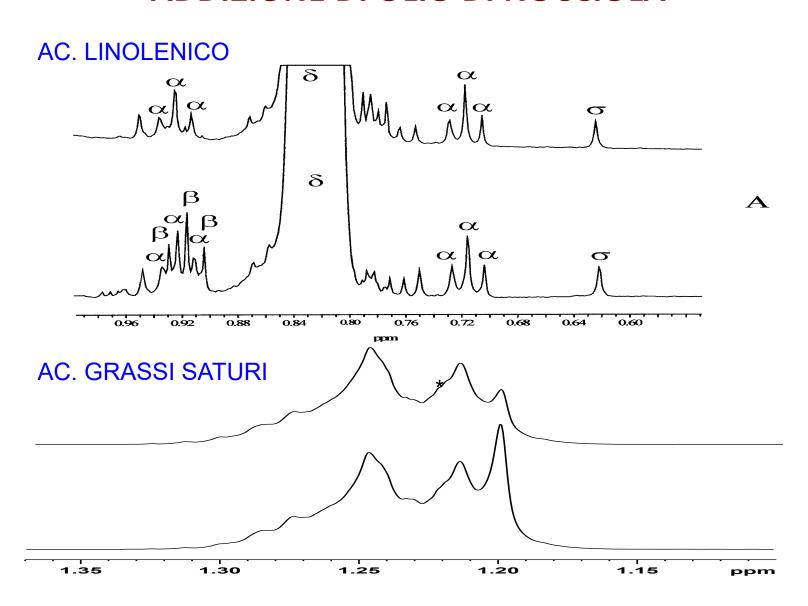




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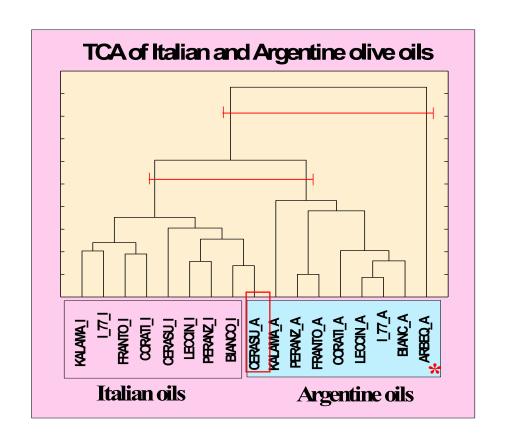
OLI PUGLIESI, LIGURI E SICILIANI

ADULTERAZIONE DELL'OLIO DI OLIVA: ADDIZIONE DI OLIO DI NOCCIOLA

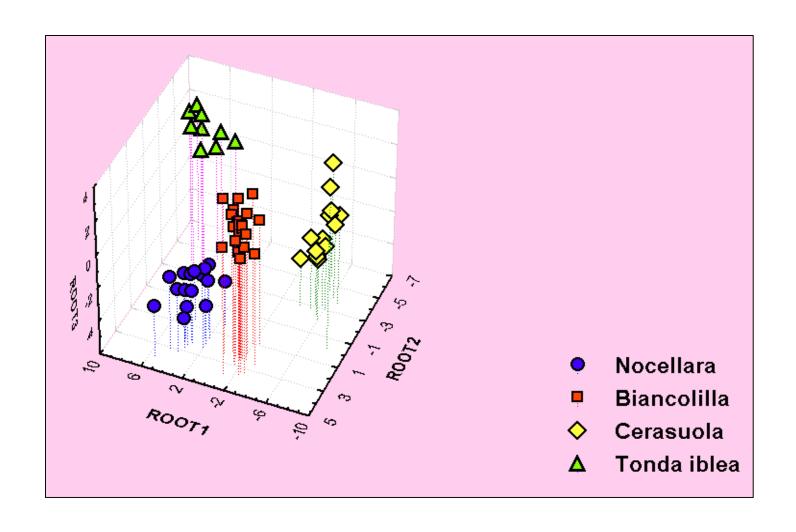


EFFETTO PEDOCLIMATICO (13C)

Argentina (Catamarca) Biancolilla (Sicilia) Cerasuola (Sicilia) Coratina (Puglia) Kalamata (Puglia) Peranzana (Puglia) Leccino (Lazio) I-77 (Umbria) Frantoio (Lazio) Arbequina



CARATTERIZZAZIONECC GENETICA (13C)





Classification of Edible Oils by Employing ³¹P and ¹H NMR Spectroscopy in Combination with Multivariate Statistical Analysis. A Proposal for the Detection of Seed Oil Adulteration in Virgin Olive Oils

GEORGIA VIGLI, ANGELOS PHILIPPIDIS, APOSTOLOS SPYROS, AND PHOTIS DAIS*

NMR Laboratory, Department of Chemistry, University of Crete, 714 09 Iraklion, Crete, Greece

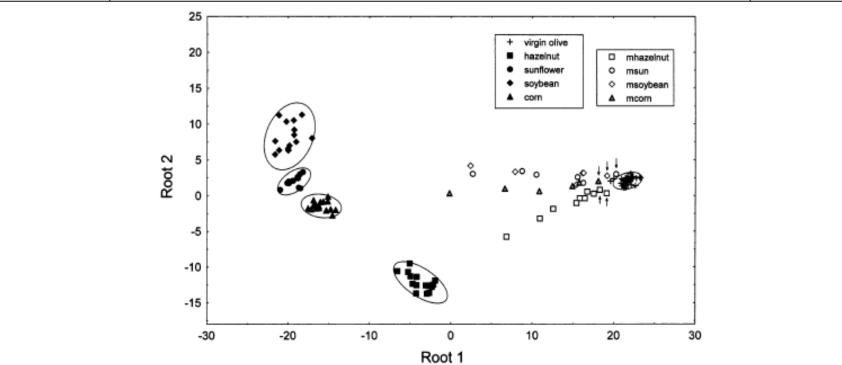
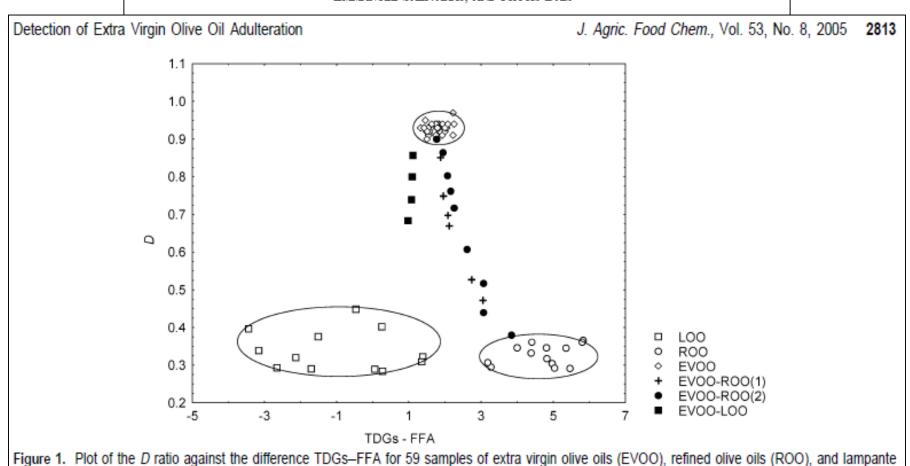


Figure 5. Plot of discriminant functions roots 1 and 2 for five types of edible oils. Virgin olive oil, hazelnut oil, corn oil, and sunflower oil are shown by crosses and solid symbols. Four sets of mixtures of 5, 10, 15, 20, 35, and 50% w/w of virgin olive oils with hazelnut (mhazelnut), sunflower (msun), soybean (msoybean), and corn (mcorn) oils and one set of mixtures of 5, 10, 15, and 20% of virgin olive oils with hazelnut oils (mhazelnut) are denoted by open symbols. Arrows indicate mixtures of 5% w/w of seed oils in virgin olive oils.



Detection of Extra Virgin Olive Oil Adulteration with Lampante Olive Oil and Refined Olive Oil Using Nuclear Magnetic Resonance Spectroscopy and Multivariate Statistical Analysis

GEORGIA FRAGAKI, APOSTOLOS SPYROS, GEORGE SIRAGAKIS, EMMANUEL SALIVARAS, AND PHOTIS DAIS*

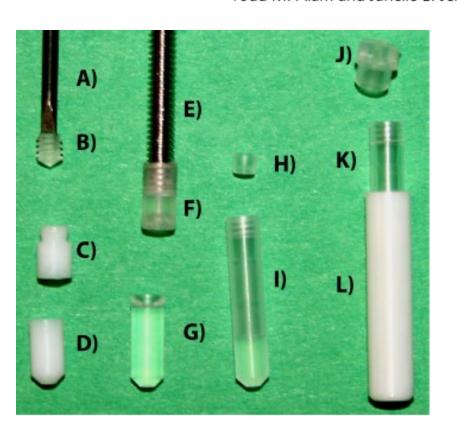


olive oils (LOO) (open symbols) and for the EVOO mixtures with the lower quality olive oils (solid symbols). Ellipses were drawn as an aid to the eye.

NMR STATO SOLIDO (SEMISOLIDO)

HR-MAS NMR Spectroscopy in Material Science

Todd M. Alam and Janelle E. Jenkins



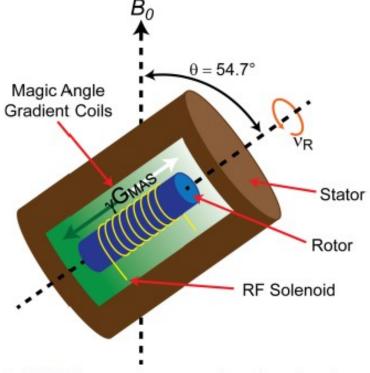
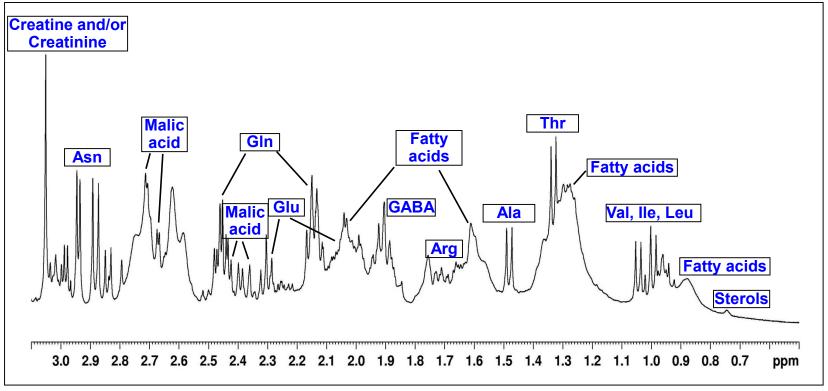


Figure 1. Schematic of a HR-MAS stator with a magic angle gradient along the rotor spinning axis.

CARATTERIZZAZIONE CON NMR:

Tracciabilità del peperone del Piemonte

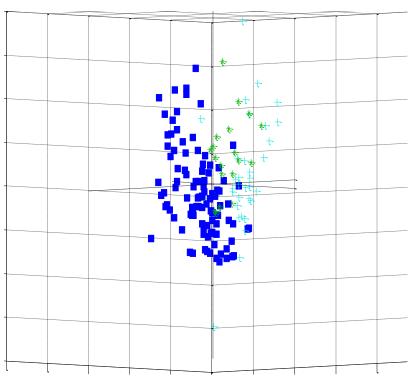


Spettro ¹H HRMAS-NMR di peperone liofilizzato; regione spettrale 0.70-3.10 ppm.

CARATTERIZZAZIONE CON NMR:

Peperone: distinzione della zona di origine

Modelli PLSDA per discriminare l'origine geografica all'interno della cultivar Cuneo: Torino vs Cuneo vs Sicilia



- **▲ Torino**
- Cuneo
- + Sicilia

Il modello riesce a predire:

- · l'85.7% della classe Torino;
- il 94.9% della classe Cuneo;
- il 100.0 %della classe Sicilia.

Proiezione dei campioni sulle prime tre variabili latenti.

Magu. Reson. Chem. (in press)

Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/mrc.1359



Is high-resolution magic angle spinning NMR a practical speciation tool for cheese samples? Parmigiano Reggiano as a case study

Laetitia Shintu,1 Fabio Ziarelli2 and Stefano Caldarelli1*

Received 6 August 2003; Revised 1 December 2003; Accepted 1 December 2003

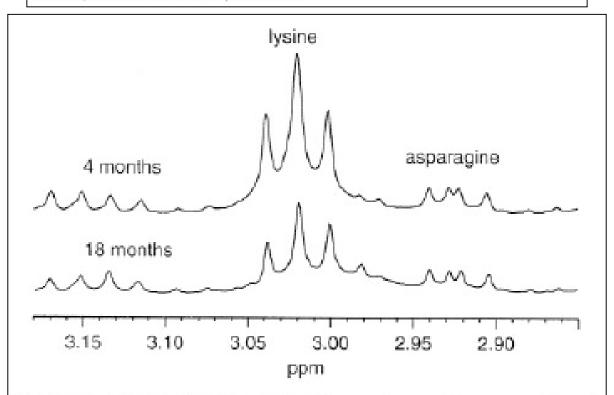


Figure 5. A portion of the HRMAS spectrum of two samples of Parmigiano Reggiano cheese with different ages. Top, 4 months old; bottom, 18 months old.

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Centre Régional de RMN, Université d'Aix-Marseille I and III, 13397 Marseille Cedex 20, France

Exploring High-resolution Magic Angle Spinning (HR-MAS) NMR Spectroscopy for Metabonomic Analysis of Apples

Martina Vermathen*a, Mattia Marzoratia, and Peter Vermathenb

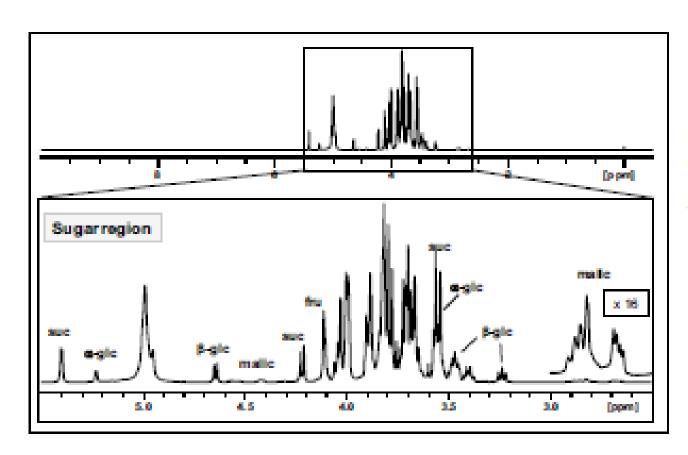


Fig. 2. ¹H HR-MAS NMR spectrum of apple tissue with an expansion of the sugar region (suc: sucrose, α-glc: α-glucose, β-glc: β-glucose, fru: fructose, malic: malic acid).

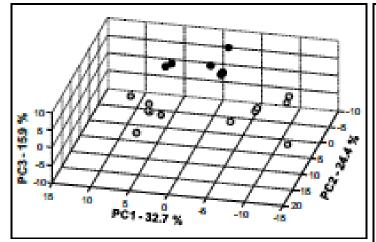


Fig. 7. 3D PCA scores plot PC1 vs PC2 vs PC3 for different apple cultivars. The PCA is based on 18 entries with each point representing the averaged spectrum obtained from 5 single spectra of one apple. Open circles: Golden Delicious, black: Rubens, grey: Braeburn.

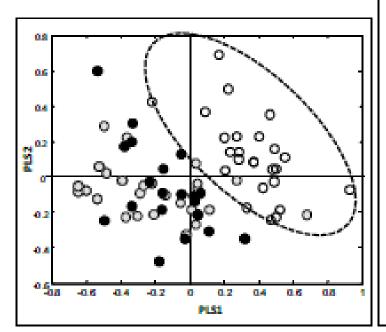


Fig. 8. Partial least squares discriminant analysis (PLS-DA) for applies Fig. 9. Load values for the first derived from different cultivation methods. Open circles: Bio, black: inte-the order of the ppm-scale. P1 grated production (IP), gray: low-input production (LI).P1

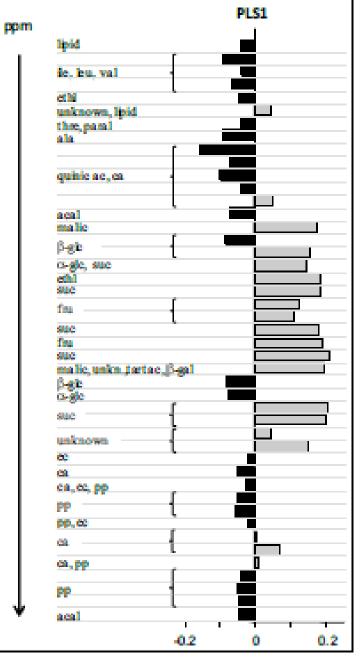


Fig. 9. Load values for the first PLS component and assigned buckets in the order of the ppm-scale.^[27]



Characterization of the Geographical and Varietal Origin of Wheat and Bread by Means of Nuclear Magnetic Resonance (NMR), Isotope Ratio Mass Spectrometry (IRMS) Methods and Chemometrics: A Review

Francesco Longobardi, Daniela Sacco, Grazia Casiello, Andrea Ventrella, Antonio Sacco*

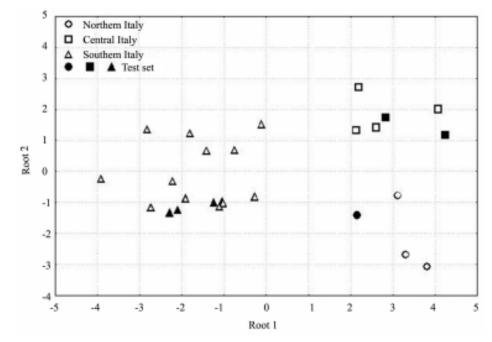


Figure 1. Plot of three geographical origins for wheat flours samples on the first two discriminant functions for spectroscopic data. Reprinted from Ref. [21]. Copyright (2002) with permission from AACC International.

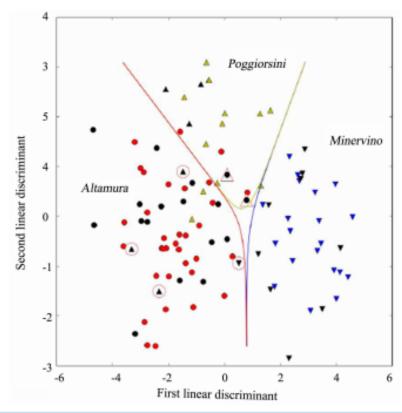


Figure 3. Linear discriminant analysis of a reduced number of Nuclear Magnetic Resonance (NMR) variables for the geographical origin classification. The red circle, blue down triangles and yellow up triangles represent, respectively, "Altamura", "Minervino" and "Poggiorsini" geographical classes in the training set. The same symbols in black represent the class assigned by the LDA model to the validation samples. Misassigned samples are surrounded by larger symbols representing the real geographical origin of the corresponding validation sample. Reprinted from Ref. [25]. Copyright (2010) with permission from John Wiley and Sons.



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Analytical Methods

Study of the suitability of HRMAS NMR for metabolic profiling of tomatoes: Application to tissue differentiation and fruit ripening

Estela María Sánchez Pérez a, María José Iglesias a,*, Fernando López Ortiz a, Isidro Sánchez Pérez b, María Martínez Galera b

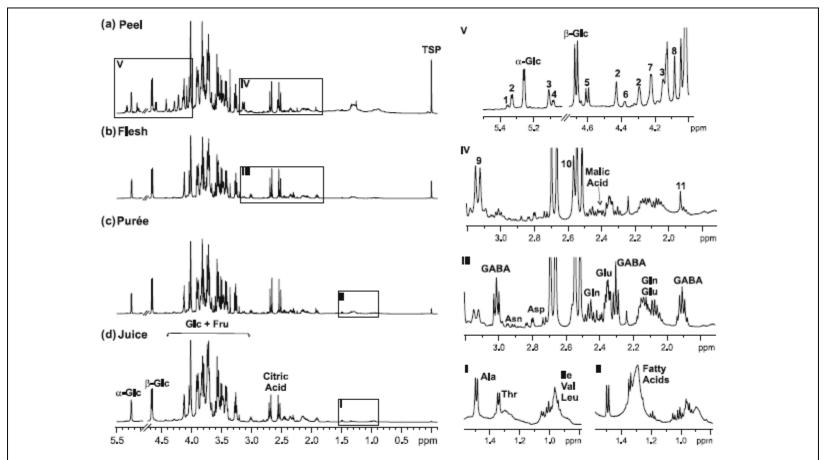


Fig. 2. ¹H HRMAS spectra of peel (a), flesh (b), purée (c) and ¹H NMR spectrum of juice (d) from mature red tomatoes. Resonances for selected metabolites are included (for labelling see Table 1).

Quantitative metabolic profiles of tomato flesh and seeds during fruit development: complementary analysis with ANN and PCA

Fabien Mounet,^a Martine Lemaire-Chamley,^a Mickaël Maucourt,^{a,b} Cécile Cabasson,^a Jean-Luc Giraudel,^c Catherine Deborde,^{a,b} René Lessire,^d Philippe Gallusci,^a Anne Bertrand,^a Monique Gaudillère,^a Christophe Rothan,^a Dominique Rolin,^a and Annick Moing^{a,*}

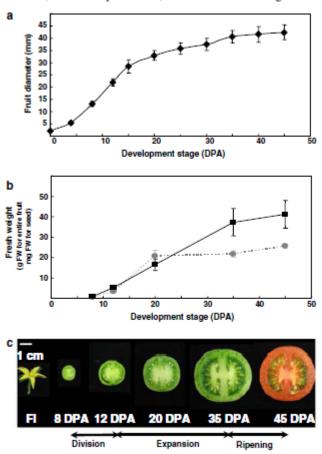


Figure 2. Growth and development of Aika Craig tomato fruits cultivated in a growth chamber. (a) Changes in fruit diameter. Mean of 12–36 fruits. Vertical bars represent standard deviations. (b) Changes in fruit fresh weight and seed fresh weight. Mean of 12–36 fruits. Vertical bars represent standard deviations. Black square, entire fruit; gray circle, seed. (c) Stages of fruit development from flower (FI) to mature fruit (45 DPA) separated in 3 phases of development characterized by cell division, cell expansion and fruit ripening.

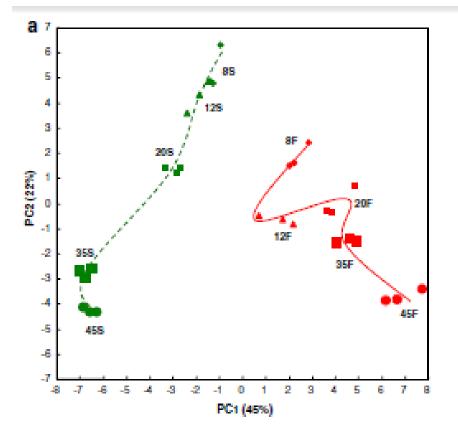
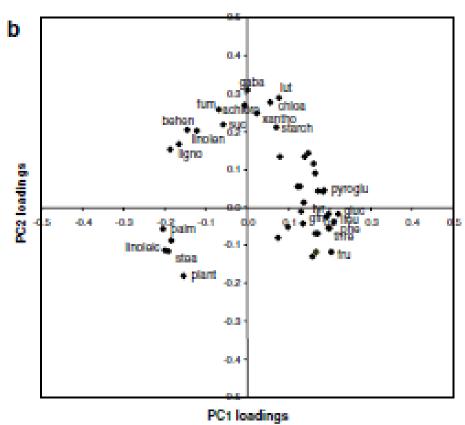
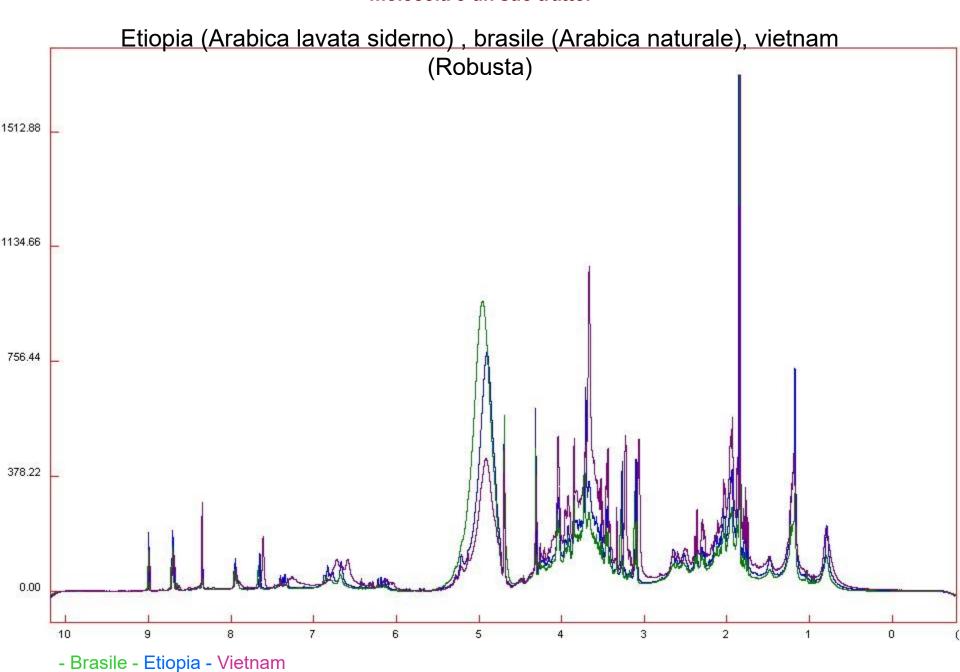


Figure 4. Principal component analysis (PCA) of absolute concentration of 44 metabolites issued from ¹H-NMR, GC-FID and LC-DAD analysis of tomato flesh (F) and seeds (S) at five stages of fruit development. (a) PCA scores plot. (b) PCA loadings plot. For each principal component, the 12 loadings with higher absolute value are indexed with the corresponding metabolite name. achloro, chlorogenic acid; behen, behenic acid; chloa, chlorophyll a; fruc, fructose; fum, fumaric acid; gaba, γ-aminobutyric acid; gln, glutamine; gluc, glucose; ileu, isoleucine; linoleic, linoleic acid; linolen, linolenic acid; ligno, lignoceric acid; lut, lutein; palm, palmitic acid; phe, phenylalanine; pyroglu, pyroglutamate; plant, planteose-like compound; stea, stearic acid; suc, sucrose; thre, threonin; tyr, tyrosine; xantho, xanthophyll.



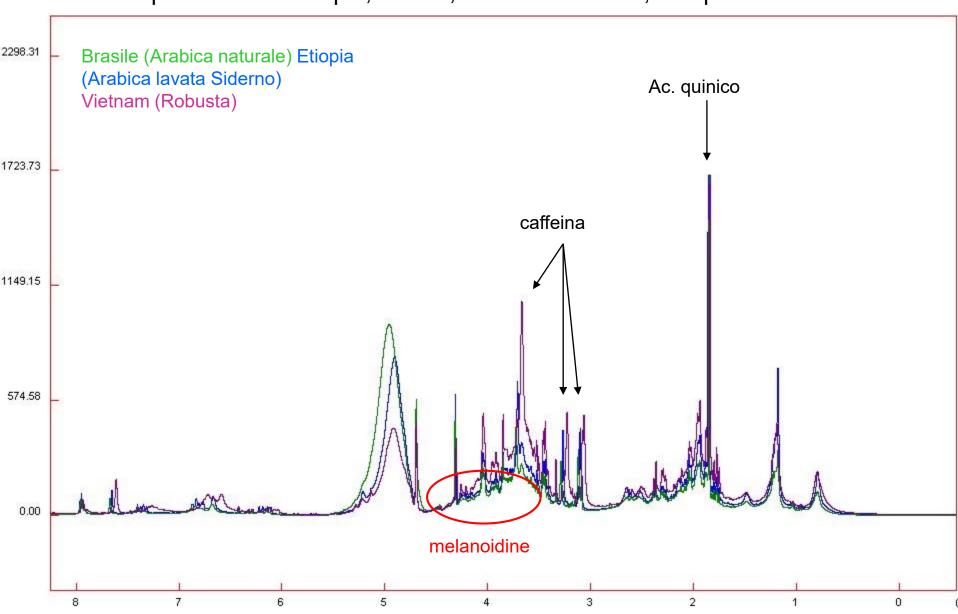
TECNICHE DI CONTROLLO DI QUALITÀ DEGLI ALIMENTI MEDIANTE NMR

SPETTRI OTTENUTI CON NMR (Nuclear Magnetic Resonance). Ogni picco rappresenta una molecola o un suo tratto.

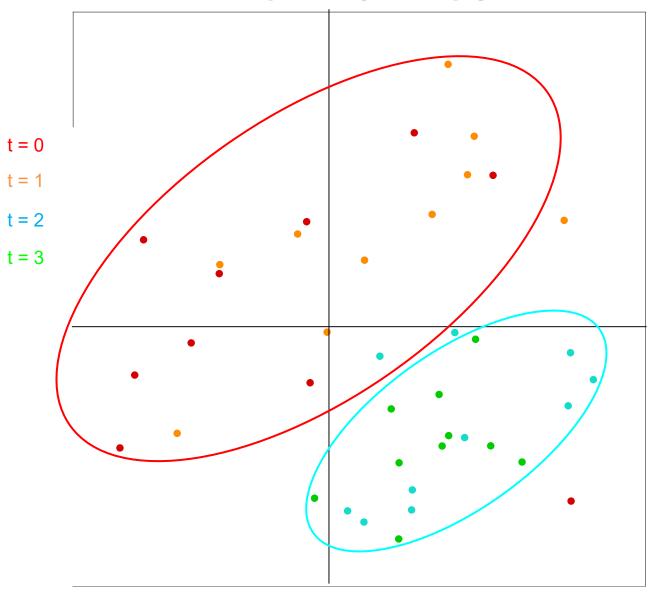


ZOOM SU UN TRATTO DI SPETTRO. MOLTI PICCHI POSSONO ESSERE RICONOSCIUTI (ASSEGNATI) A MOLECOLE NOTE

Spettri di caffè etiopia, brasile, vietnam: caffeina, ac. quinico

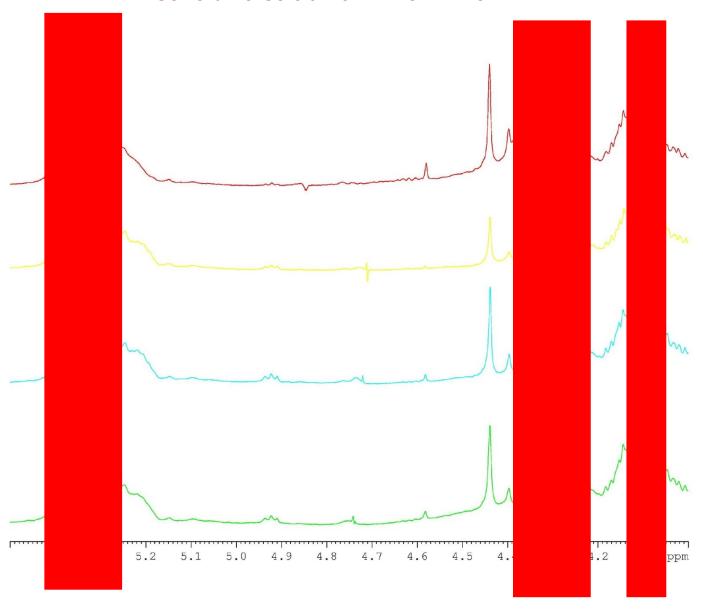


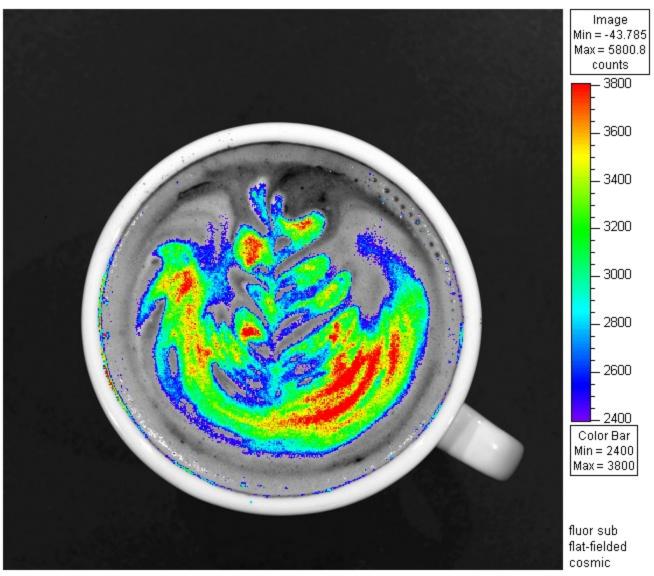
PC1 vs. PC3



I gruppi
individuati sono
due: il primo
costituito dagli
spettri T0 e T1,
il secondo da
quelli T2 e T3.

Le aree in rosso indicano alcune delle zone di spettro (metaboliti) utili per la discriminazione tra i gruppi: sono le molecole che sono diverse tra T0 + T1 e T2+T3



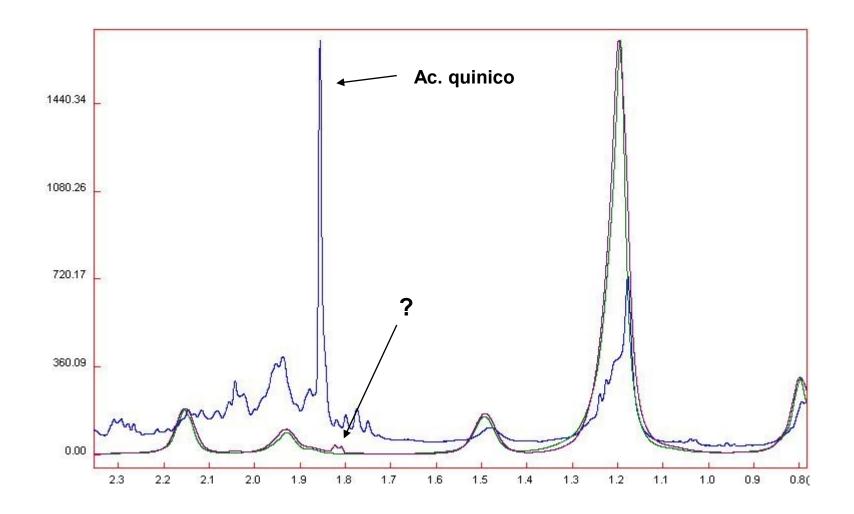


Click #FB20070920171514_001 Thu, Sep 20, 2007 17:16:06 Level=High, Em=GFP, Ex=GFP Bin:HR (4), FOV12.8, f4, 1s Camera: IVIS 23323, Spectral Instruments TE Series: cappuccino disegnato Experiment:

Label: Comment:

Analysis Comment:

Spettri di caffè 100% arabica, latte intero e relativo cappuccino: acido quinico





Sofia GmbH Rudower Chaussee 29 12489 Berlin GERMANY

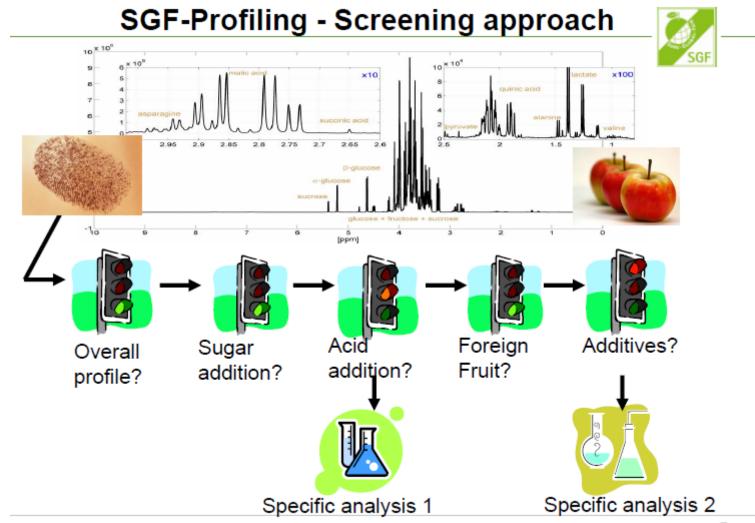


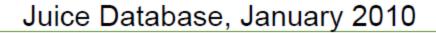
New Application Opportunities and further Development of SGF profiling Analyses



Dr. Susanne Koswig Technical Manager SGF/IRMA

www.sgf.org









Reference Juice Database (total 6560 samples)

| Type of Fruit | Quantity |
|-------------------|----------|
| Apple | 2591 |
| Orange | 1386 |
| Pineapple | 416 |
| Sour Cherry | 234 |
| Lemon | 225 |
| Raspberry | 187 |
| Grapefruit, white | 160 |
| Peach | 149 |
| Black currant | 128 |
| Pear | 109 |
| Mango | 101 |
| Other | 874 - |
| Total | 6560 |

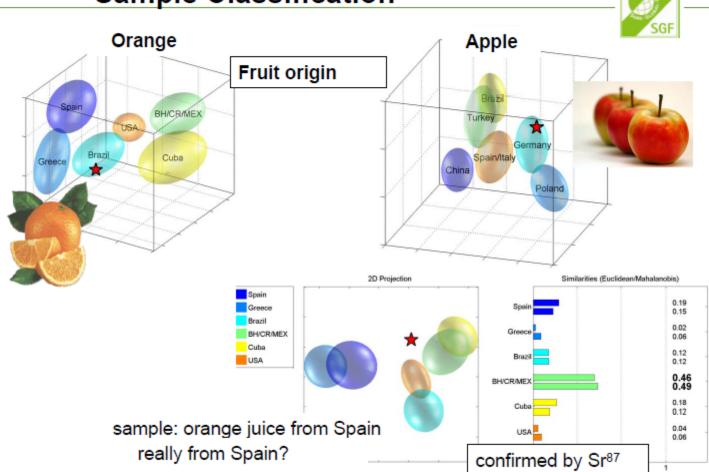
actual number of datasets: (April 2010)

7360 samples

| apricot | 101 |
|-----------------|-----|
| grapefruit red | 58 |
| pomegranate | 45 |
| grape white/red | 131 |
| sweetie | 11 |

database build up in the last years

Sample Classification

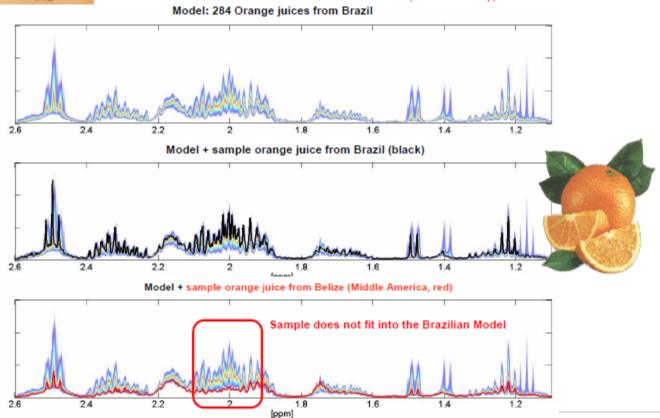




NMR Profile of Orange Juice



Expansion shows approx. 15% of the NMR Profile



NMR RICONOSCIMENTO DELL'ORIGINE CONVENZIONALE O BIOLOGICA



¹H NMR Profiling as an Approach To Differentiate Conventionally and Organically Grown Tomatoes

Monika Hohmann,*,†, Norbert Christoph,† Helmut Wachter,† and Ulrike Holzgrabe§

ABSTRACT: This study describes the approach of ¹H NMR profiling for the authentication of organically produced tomatoes (Solanum lycopersicum). Overall, 361 tomato samples of two different cultivars and four different producers were regularly analyzed during a 7 month period. The results of principal component analysis showed a significant trend for the separation between organically and conventionally produced tomatoes (p < 0.001 using the t test). Linear discriminant analysis demonstrated good discrimination between the growing regimens, and external validation showed 100% correctly classified tomato samples. Further validation studies, however, also disclosed unexpected differences between individual producers, which interfere with the aim of predicting the cultivation method, yet the results indicate significant differences between ¹H NMR spectra of organically and conventionally grown tomatoes.

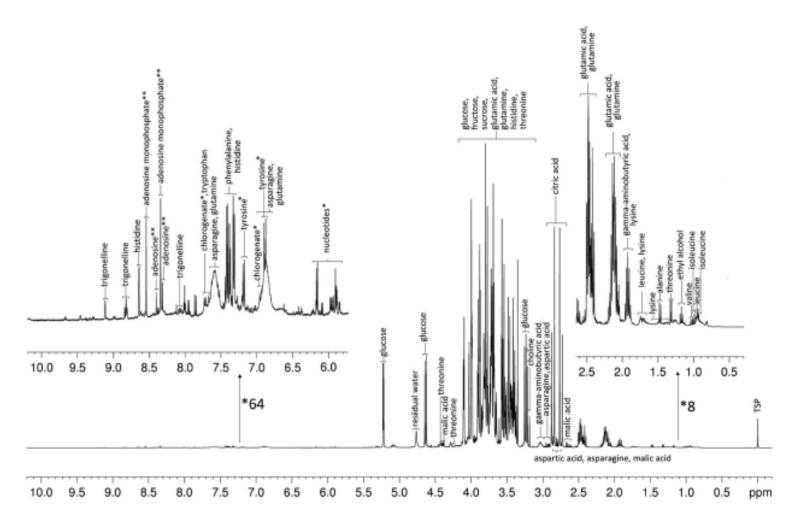


Figure 1. ¹H NMR spectrum of the aqueous phase of a tomato sample with an enlarged view on the spectral range from 0.5 to 2.6 ppm (*8) and from 5.8 to 10.0 ppm (*64), measured with a 400 MHz spectrometer. Signal assignments are based on reference spectra and the literature (*Mounet et al.; ⁴⁵ and **Le Gall et al. ⁵³).

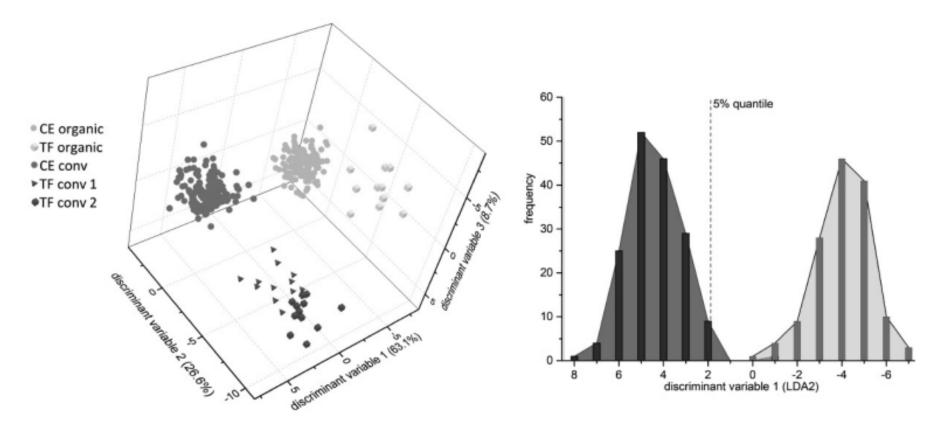


Figure 5. 3D scatter plot of discriminant variables 1, 2, and 3, with sphere symbols for CE samples, tetrahedral symbols for TF organic and TF conv 1, and cube symbols for TF conv 2: dark gray data points, conventional tomaotes; light gray data points, organic tomatoes (left side). Frequency histogram of the values of discriminant variable 1 obtained by LDA2: dark gray, conventional samples; light gray, organic samples (the auxiliary line shows the 5% quantile of the values of discriminant variable 1 for conventional tomato samples; right side).





Application of ¹H NMR Profiling To Assess Seed Metabolomic Diversity. A Case Study on a Soybean Era Population

George G. Harrigan,**,† Kirsten Skogerson,**,† Susan MacIsaac,[§] Anna Bickel,† Tim Perez,† and Xin Li†

ABSTRACT: ¹H NMR spectroscopy offers advantages in metabolite quantitation and platform robustness when applied in food metabolomics studies. This paper provides a ¹H NMR-based assessment of seed metabolomic diversity in conventional and glyphosate-resistant genetically modified (GM) soybean from a genetic lineage representing ~35 years of breeding and differing yield potential. ¹H NMR profiling of harvested seed allowed quantitation of 27 metabolites, including free amino acids, sugars, and organic acids, as well as choline, *O*-acetylcholine, dimethylamine, trigonelline, and *p*-cresol. Data were analyzed by canonical discriminant analysis (CDA) and principal variance component analysis (PVCA). Results demonstrated that ¹H NMR spectroscopy was effective in highlighting variation in metabolite levels in the genetically diverse sample set presented. The results also confirmed that metabolite variability is influenced by selective breeding and environment, but not genetic modification. Therefore, metabolite variability is an integral part of crop improvement that has occurred for decades and is associated with a history of safe use.

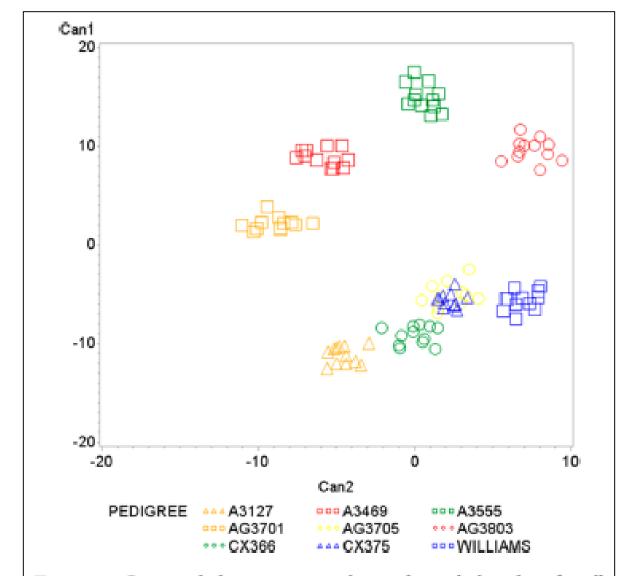


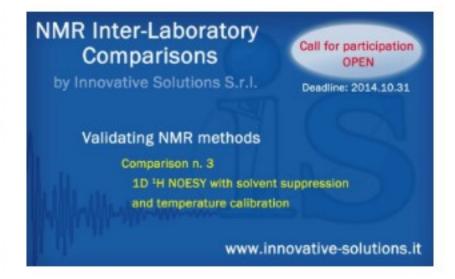
Figure 1. Canonical discriminant analysis of metabolite data for all nine varieties. On canonical 1 axis, the four older varieties (A3127, CX375, CX366, and Williams) can be distinguished from four of newer varieties (A3469, A3555, AG3701, and AG3803). AG3705 clustered with the older varieties and was shown (see text) to have some metabolic features similar to these.

NMR E INFRAROSSO

RICONOSCIMENTO
DELL'ORIGINE
CONVENZIONALE O
BIOLOGICA

NMR VALIDAZIONE DEL METODO COME ANALISI QUANTITATIVA





CIBO E SALUTE

LE QUALITÁ DEGLI ALIMENTI PER LA
PREVENZIONE
DELLE MALATIE CRONICHE NON
TRASMISSIBILI
E COME COADIUVANTI DELLE
TERAPIE MEDICHE

QUALITÁ DEGLI ALIMENTI

- Qualità nutrizionale: calorie; contenuto in nutrienti: zucchero, grassi, proteine, sali minerali, vitamine, fibre, ecc.
- Qualità organolettica: colore, fragranza, sapore, consistenza
- Qualità funzionale (o salutistica): (omega-6, omega-3), sostanze antitumorali (nutraceutici) contenuto in sostanze benefiche: antiossidanti, acidi grassi polinsaturi
- Qualità igienica: presenza di microrganismi patogeni (contaminazione microbica)
- Qualità sanitaria: presenza di sostanze nocive estranee o che si formano durante le trasformazioni industriali o durante la cottura: pesticidi, acidi grassi trans, antibiotici, ecc. (contaminazione chimica)
- Qualità etico-sociale: impatto delle pratiche di produzione agricola sulla salute dell'ambiente, benessere degli animali, salute e reddito degli agricoltori

QUALITÁ DEGLI ALIMENTI

Qualità funzionale o salutistica o....

EPIGENETICA

EPIGENETICA: LA DIETA DELLE MAMME INFLUISCE SULLA SALUTE DEI PICCOLI



Alimentare le mamme in gravidanza con cibi ricchi di donatori di metili (es. folati) modifica l'espressione del gene agouti (topolini gialli, obesi, iperinsulinemici, suscettibili ai tumori): 5 su 7 nati non esprimono il gene (Wolff et al. 1998, Dolinoy 1998)

ATTIVITA' DI ALCUNE ERBE AROMATICHE

ERBA AROMATICA COMPONENTI ATTIVITA'

Aglio Anice

Cardamomo

Chiodo di garofano

Coriandolo

Cumino

Fieno greco

Menta

Noce moscata

Pepe

Peperone Prezzemolo Rosmarino

Salvia Sedano Senape

Timo Zenzero allicina anetolo

cineolo

eugenolo linalolo

aldeide cuminica

trigonellina

mentolo sbinene, safrolo

piperina

capsaicina apiolo cineolo cineolo ftalidi

isotiocianato d'allile

timolo gingerolo stimolante la digestione, antisettico

stimolante la digestione

stimolante l'appetito e la digestione

stimolante l'appetito e la digestione, antisettico

stimolante la digestione

stimolante la digestione, calmante

stimolante l'appetito

stimolante l'appetito e la digestione, antisettico

stimolante digestivo, antisettico

stimolante digestivo

antidiarroico, antinfiammatorio, stimolante

stimolante l'appetito e la digestione, antisettico stimolante l'appetito e la digestione, antisettico stimolante la digestione, antisettico, calmante

stimolante la digestione, antisettico, antiossidante

stimolante la digestione

stimolante la digestione, antisettico, antiossidante

stimolante gastrico

COMPONENTI BIOLOGICAMENTE ATTIVI DI FRUTTA E VERDURA

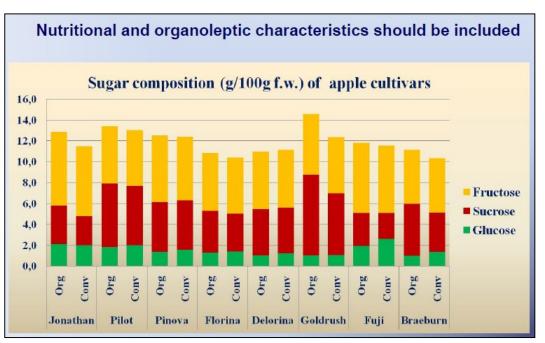
| ALIMENTO | PRINCIPIO ATTIVO | ATTIVITA' |
|----------------------|------------------------------------|---|
| Cipolla | composti della cisteina | anticolesterolici |
| | derivati sulfidilici | anticolesterolici |
| | flavonoidi | antiossidanti, antiaggregazione pistrinica |
| Agrumi | antocianine | antiossidanti |
| | flavoni e flavonoidi | antiossidanti |
| Brassicacee | sulforafano (isotiocianato) | anticanceroceno |
| | vitamina C | antiossidante |
| Carciofi | composti fenolici | antiossidanti |
| Carote | carotenoidi | antinfiammatori antiossidanti |
| Fragole | acido ellargico | anticolesterolico, anticancerogeno |
| Frutti di bosco | antocianine, polifenoli | antiossidanti, protezione del microcircolo |
| Legumi | polifenoli | anticancerogeni |
| Lattuga | flavonoidi | antiossidanti, antiaggregazione piastrinica |
| Mele | flvonoidi, ac. Clorogenico | antiossidanti |
| Miele | polifenoli, flavonoidi | antiossidanti |
| Olio d'oliva | tocoferoli, polifenoli, flavonoidi | antiossidanti |
| Pere, pesche, prugne | flavonoidi, antocianine, flavononi | antiossidanti |
| Pomodoro | flavononi, licopene | antiestrogeni, ipocolesterolizzanti, |
| | antiossidanti, | anticancerogeni |
| Riso | polifenoli, gamma-orizanolo | modulatori metabolismo lipidico |
| Soia | isoflavoni, genisteina | attività estrogena, anticolesterolici, antiosteoporosi |
| Uva | resveratrolo | inibizione proliferazione cellule tumorali |

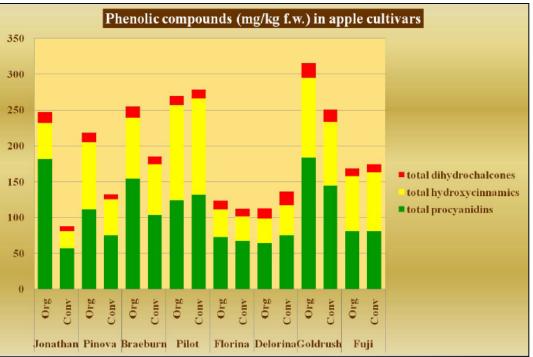
MiPAAF Bioqualia project: Organic farming, sustainability and biodiversity

Flavio Paoletti National Institute for Food and Nutrition Research (INRAN) Via Ardeatina, 546 – 00178 Rome Italy

INTERNATIONAL SCIENTIFIC SYMPOSIUM
BIODIVERSITY AND SUSTAINABLE DIETS
UNITED AGAINST HUNGER

3 - 5 November 2010, FAO Headquarters, Rome





Effects of seasonal changes in feeding management under part-time grazing on terpene concentrations of ewes' milk

Eunate Abilleira¹, Mailo Virto³, Ana Isabel Nájera¹, Marta Albisu², Francisco José Pérez-Elortondo², Juan Carlos Ruiz de Gordoa³, Mertxe de Renobales³* and Luis Javier R. Barron¹*

Table 1. Mean terpene content (µg/kg) of milks from C-flocks† (n=4) throughout the season

| | Indoor feeding | Transition feeding | Outdoor feeding | F test season/season*flock |
|----------------|-----------------------|-------------------------|-------------------|----------------------------|
| Limonene | 20-54±17-17 | 57-81±93-69 | 43·42±33·85 | NS# |
| β-Phellandrene | 11.61 ± 12.54 | 23-46±41-58 | 15-74±26-71 | NS |
| β-Pinene | 5-78±4-10 | $8-09 \pm 4-90$ | 19-76±21-27 | NS |
| α-Pinene | $3.02 \pm 3.41^{4.9}$ | $0.91 \pm 2.33^{\circ}$ | 6.60±5.08b | |
| Terpinolene | ND | 7-59±19-38 | ND | NS |
| a-Terpinene | ND | 3-40±8-71 | ND | NS |
| Myrcene | ND | 1.88 ± 4.83 | ND | NS |
| Camphene | ND | ND | 5·32±7·42 | NS |
| Total terpenes | 40.94±33-27 | 103-14±168-49 | 90.83 ± 82.26 | NS |

^{*}C-flocks: flocks grazing on cultivated private grasslands where ryegrass (Lollum perenne) and white clover (Trifolium repens) were predominant species

Table 2. Mean terpene content (µg/kg) of milks from NC-flocks† (n=5) throughout the season

| | Indoor feeding | Transition feeding | Outdoor feeding | F test season/season*flock |
|----------------------|---------------------|--------------------------|------------------------------|----------------------------|
| Limonene | 25·49±18·86 | 43.89 ± 47.07 | 95-71 ± 172-85 | NS‡ |
| β-Phellandrene | 15·54±12·43 | 23-34±39-25 | 53.88 ± 106.37 | NS |
| β-Pinene | 8.69 ± 6.47 | 13·36±12·08 | 38.97 ± 94.11 | NS |
| α-Pinene | 3.82 ± 2.09 | 2.32 ± 4.33 | 16.64 ± 24.80 | NS |
| Camphene | ND | 1.93 ± 3.65 | 7.58 ± 20.40 | NS |
| 3-Carene | ND | ND | 0.10 ± 0.48 | NS |
| Total monoterpenes | 33.54 ± 37.05 | 84.84 ± 97.95 | 212:83 ± 386:38 | NS |
| β-Caryophyllene | ND | ND | 127·72 ± 212·72 | ** |
| α-Humulene | ND | ND | 36.41 ± 72.30 | NS |
| a-Cubebene | ND | 4.46 ± 18.40 | ND | NS |
| Total sesquiterpenes | ND | 4.46 ± 18.40^{25} | 164·13 ± 224·09 ^b | |
| Total terpenes | 53.54 ± 37.05^a | 89·30±97·96 ^b | $376.95 \pm 392.50^{\circ}$ | ** |

^{*}NC-flocks: flocks grazing on non-cultivated community-owned grasslands consisted of herbaceous plants such as Trifolium repens, Festuca rubra and Agrostis capillaries, and also other non-graminoid plants and some shrubs

^{*}NS: not significant; * P < 0.05; ND: not detected

⁵a, b Means in a row followed by a different superscript letter were significantly different (P<0-05).</p>

^{*}NS: not significant; * P≤0.05; ** P≤0.01; ND: not detected

⁵a, b, c Means in a row followed by a different superscript letter are significantly different

DIPARTIMENTO DI SCIENZE NEUROSCIENZE, BIOMEDICINA E DEL MOVIMENTO

FOOD DISCOVERY: FRA MEDICINA E AGRICOLTURA

Daniele Degl'Innocenti

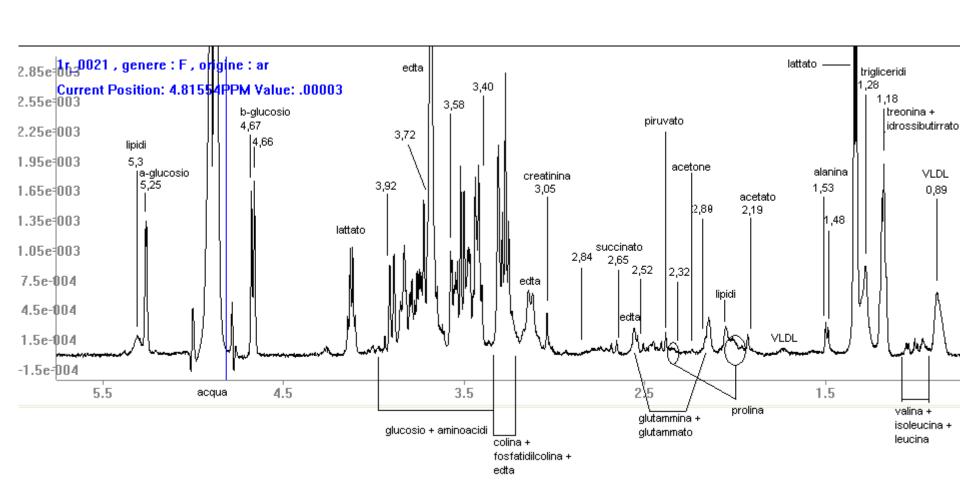
OLIO EXTRAVERGINE D'OLIVA DELLA PROVINCIA DI AREZZO

Effetti sul metabolismo

2009 - Ricerca dell'impatto di oli extravergini d'oliva sui metaboliti serici di animali da laboratorio

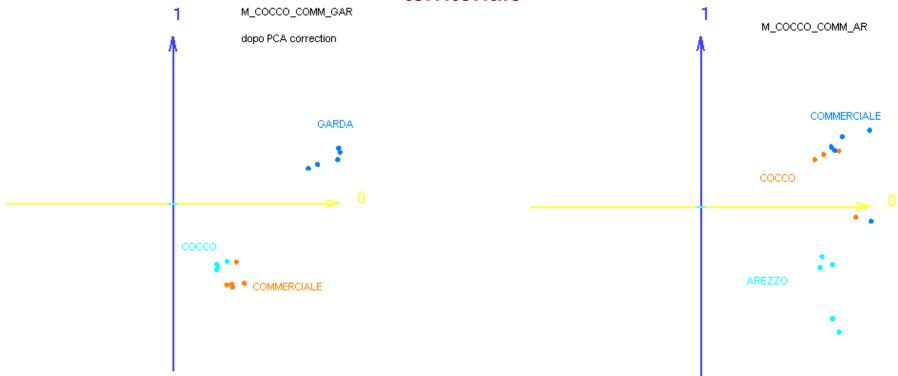
Ricerca dell'impatto di oli extravergini d'oliva sui metaboliti serici di animali da laboratorio

Esempio di tracciato NMR del siero di ratto



Ricerca dell'impatto di oli extravergini d'oliva sui metaboliti serici di animali da laboratorio

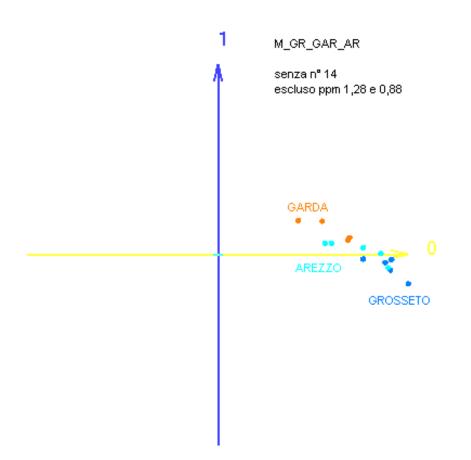
Analisi statistica: risultati dei trattamenti olio di cocco, commerciale e territoriale



Commento: l'olio di cocco e l'olio extravergine commerciale" inducono profili metabolici simili e differenti dagli oli extravergini d'oliva "territoriali"

Ricerca dell'impatto di oli extravergini d'oliva sui metaboliti serici di animali da laboratorio

Analisi statistica: risultati dei trattamenti di oli extravergini d'oliva territoriali



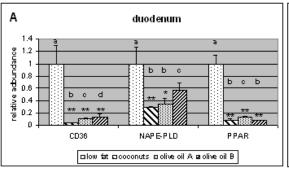
Commento: la comparazione diretta dei 3 oli extravergini d'oliva territoriali evidenzia profili metabolici simili ma distinti

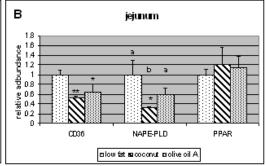


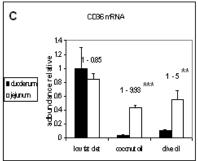
WORKING PACKAGE 6 Six foods

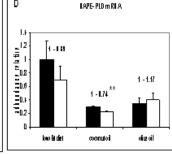
RISULTATI DELLA PCR QUANTITATIVA: CORSA SU GEL DI AGAROSIO 1,5 Carne Formaggio Oliva Margarina Castagna Cocco Pane Beta actin DNMT1 Castagna Formaggio Oliva Margarina Carne Cocco Pane Beta actin DNMT3a Castagna Formaggio Oliva Margarina Carne Cocco Pane Beta actin DNMT3b

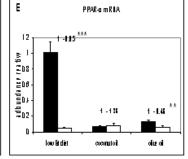
WORKING PACKAGE 5 Olive & Coconut oil

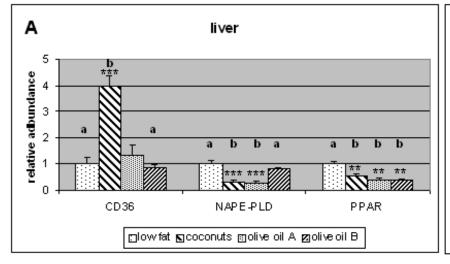


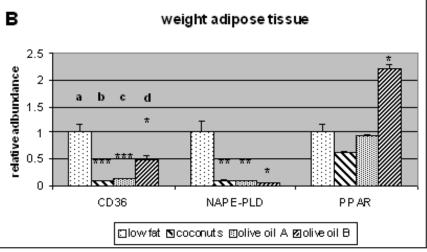














WORKING PACKAGE 6 Six foods

| TABELLA PUNTEGGI DI VALUTAZIONE DELL'ESPRESSIONE GENICA | | | | | | | |
|---|--|--------------|-----------|------|-------|----------|-----------|
| | Oliva | Carne | Formaggio | Pane | Cocco | Castagna | Margarina |
| DNMT1 | 6 | 2 | 4 | 4 | 2 | 1 | 2 |
| DNMT3a | 6 | 5 | 2 | 2 | 4 | 3 | 1 |
| DNMT3b | 6 | 6 | 6 | 6 | 5 | 1 | 1 |
| Totale | 18 | 13 | 12 | 12 | 11 | 5 | 4 |
| Media | 6,0 | 4,3 | 4,0 | 4,0 | 3,7 | 1,7 | 1,3 |
| Legenda: | 1 = espress | ione non ril | evata | | | | |
| | 2 = espressione molto bassa 3 = espressione bassa 4 = espressione media 5 = espressione buona 6 = espressione ottima | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Conclusioni

Da questo studio emerge la maggiore capacità dell'olio extravergine di oliva di indurre la metilazione del DNA in misura maggiore rispetto agli altri alimenti, fornendo la misura delle sue capacità protettive nei confronti del DNA. Anche altri alimenti, tra cui la carne di manzo di razza Chianina, il formaggio stagionato "Abbucciato" il pane con i suoi "Carboidrati" e anche l'olio di "Cocco", presentano in parte questa attività che, al contrario, è posseduta in minima parte dalla farina di castagne e dalla margarina. Tramite questa indagine di epigenetica si è trovato le conferme delle opposte interazioni che l'olio extravergine di oliva e la margarina hanno con l'organismo, fin nelle sue parti più intime come il DNA. Da questo studio emerge chiara l'importanza delle indagini epigenetiche per la valutazione nel lungo periodo dell'impatto di una alimento sull'organismo.

DIP. NEUROLOGIA, BIOMEDICINA E MOVIMENTO E VRM srl

JOINT PROJECT "INNUFISH"

Development of innovative methods to assess the nutritional quality of fish

RISULTATI AL 31/12/2016

DIP. NEUROLOGIA, BIOMEDICINA E MOVIMENTO E VRM srl

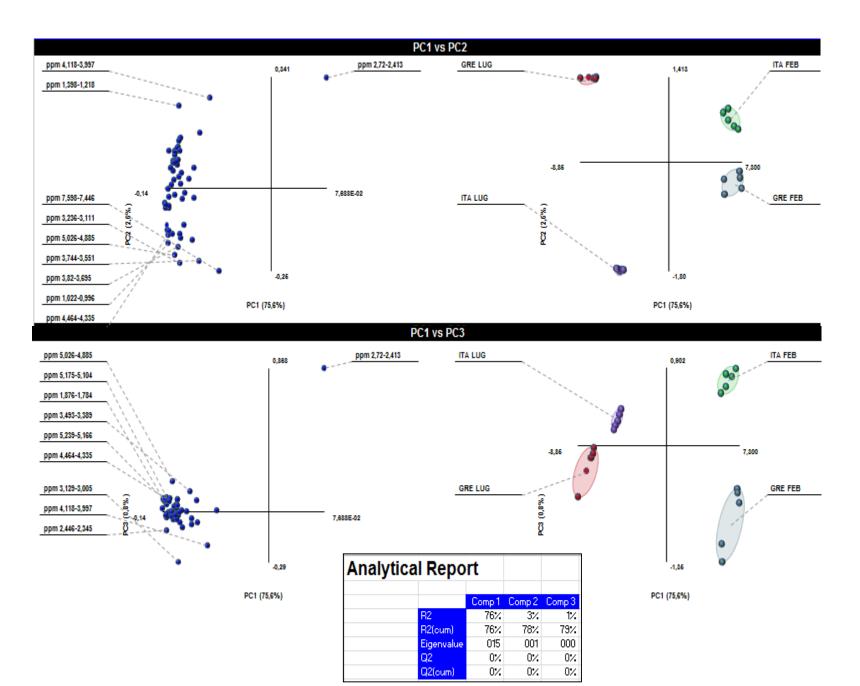
JOINT PROJECT "INNUFISH"

Development of innovative methods to assess the nutritional quality of fish

METABOLOMICA NMR SUGLI ALIMENTI



NMR - FASE ORGANICA - PLSEDA SU INTEGRALI



NMR – METABOLITI ASSEGNATI FASE ORGANICA

| | start | end | | |
|-------|-------|-------|---------|---|
| peak# | max | min | med | |
| 1 | 9,339 | 7,75 | 8,52725 | |
| 2 | 7,598 | 7,446 | 7,52008 | |
| 3 | 7,377 | 7,131 | 7,26058 | |
| 4 | 6,49 | 6,052 | 6,25633 | |
| 5 | 6,126 | 5,846 | 5,9709 | |
| 6 | 5,874 | 5,722 | 5,8066 | unsaturated x-1 acyl group |
| 7 | 5,766 | 5,562 | 5,67438 | |
| 8 | 5,446 | 5,353 | 5,39378 | acyl group |
| 9 | 5,358 | 5,285 | 5,3227 | CH=CH in UFA (di acidi grassi) |
| 10 | 5,29 | 5,233 | 5,26198 | Glyceryl-C2 in PC/PE/TG (-CHOCOR (glyceryl group)); CH2 in sn2 di triacilglicroli |
| 11 | 5,239 | 5,166 | 5,20428 | CH diacilglicerolo PE, PC |
| 12 | 5,175 | 5,104 | 5,13833 | |
| 13 | 5,114 | 5,028 | 5,07915 | |
| 14 | 5,053 | 4,955 | 5,0332 | unsaturated x-1 acyl groups |
| 15 | 5,026 | 4,885 | 4,9773 | |
| 16 | 4,464 | 4,335 | 4,39135 | 4,43-4,10 -CH2OCOR (glyceryl group); CH2OP di PC |
| 17 | 4,359 | 4,22 | 4,29643 | CH2 in posizione sn1 di diacilgliceroli di PE e PC |
| 18 | 4,211 | 4,085 | 4,14263 | Glyceryl-C1 in PC/PE/TG |
| 19 | 4,118 | 3,997 | 4,06315 | |
| 20 | 4,061 | 3,851 | 3,96488 | |
| 21 | 3,916 | 3,717 | 3,81788 | CH2 in sn3 di digliceridi di PC e PE |
| 22 | 3,82 | 3,695 | 3,73123 | CH2N di PC |
| 23 | 3,744 | 3,551 | 3,65988 | CH2N di PC |
| 24 | 3,597 | 3,466 | 3,52315 | |
| 25 | 3,493 | 3,389 | 3,4405 | |
| 26 | 3,415 | 3,223 | 3,33598 | -N(CH3)3 (phosphatidylcholine, PC); (CH3)3 N di PC |
| 27 | 3,262 | 3,181 | 3,22015 | |
| 28 | 3,236 | 3,111 | 3,1734 | |

NMR - METABOLITI ASSEGNATI FASE ORGANICA

| 29 | 3,129 | 3,005 | 3,0627 | -O-CH2-CH2-NH2 in PE; CH2N di PE |
|----|--------|-------|----------------|---|
| 30 | 2,887 | 2,826 | 2,854 | =CH-CH2-CH= in PUFA (except 18:2); CH2 di acidi praggi polinsaturi w3 |
| 31 | 2,83 | 2,786 | 2,8086 | other acyl groups |
| 32 | 2,79 | 2,732 | 2,765 | diunsaturated x-6 acyl groups; CH2 diallilici dell'acido linoleico |
| 33 | 2,72 | 2,413 | 2,5573 | |
| 34 | 2,446 | 2,345 | 2,3916 | DHA acyl group; CH2-2 e 3 DHA |
| 35 | 2,365 | 2,279 | 2,3169 | acyl group except for DHA acyl group |
| 36 | 2,288 | 2,241 | 2,2663 | Cholesterol-C4 |
| 37 | 2,243 | 2,13 | 2,1893 | acyl C2 |
| 38 | 2,111 | 2,061 | 2,0881 | CH=CH-CH2-CH=CH in PUFA (2,12-1,79 CH2 allylic to dis double bonds) |
| 39 | 2,084 | 2,069 | 2,0767 | |
| 40 | 2,096 | 2,058 | 2,067 | |
| 41 | 2,062 | 2,031 | 2,0476 | CH=CH-CH2-CH=CH in 18:1FA |
| 42 | 2,035 | 1,961 | 2,0051 | protoni allilici di tutti gli acidi grassi ecceto DHA |
| 43 | 1,876 | 1,784 | 1,8342 | |
| 44 | 1,747 | 1,662 | 1,7023 | -OCO-CH2-CH2- (EPA and ARA acyl groups); CH2-3 EPA |
| 45 | 1,668 | 1,519 | 1,6016 | acyl group except for DHA, EPA and ARA acyl groups; CH2-3 di tutti gli acidi grassi eccetto DHA e EPA |
| 46 | 1,398 | 1,218 | 1,3246 | |
| 47 | 1,42 | 1,197 | 1,304 | -(CH2)n- (acyl group) |
| 48 | 1,373 | 1,197 | 1,2539 | acyl C-4 to C (w3), saturated chains; (w2) CH2, saturated chain; isopropyl methyl; CH2 acidi grassi |
| 49 | 1,173 | 1,11 | 1,1438 | Cholesterol |
| 50 | 1,126 | 1,028 | 1,0741 | Cholesterol |
| 51 | 1,022 | 0,996 | 1,0085 | -CH3 (polyunsaturated x-3 acyl group); Terminal CH3 in w-3 polynsaturated FA chains |
| 52 | 0,998 | 0,945 | 0,9729 | CH3(C-21) in free cholesterol; 0,945-0,706 Terminal CH3 in FA chains except w-3 polynsaturated Fas |
| 53 | 0,929 | 0,913 | 0,9215 | CH3(C-21) in free cholesterol; 0,945-0,706 Terminal CH3 in FA chains except w-3 polynsaturated Fas |
| 54 | 0,917 | 0,905 | 0,9114 | CH3(C-21) in free cholesterol |
| 55 | 0,908 | 0,895 | 0,9025 | CH3(C-26+C-27) in total cholesterol + -CH3 in PUFA, |
| 56 | 0,899 | 0,839 | 0,873 | terminal methyl in alkyl chain |
| 57 | 0,793 | 0,752 | 0,7731 | Terminal CH3 in FA chains except w-3 polynsaturated Fas |
| 58 | 0,7 | 0,655 | 0,6786 | CH3(C-18) in total cholesterol (Cholesterol-CH3 (position 18)); CH3-18 colesterolo |
| 59 | -0,102 | 0,105 | 0,003 <u>5</u> | |

NMR – METABOLITI ASSEGNATI FASE ACQUOSA

| COMPOSTO | start | end | rif. Grafico | peak | rif |
|--------------|-------|-------|--------------|------|------------|
| niacinamide | 8,96 | 8,92 | d 28 p 39 | 2 | ppm 8,9455 |
| niacinamide | 8,732 | 8,705 | d 28 p 39 | 4 | ppm 8,7185 |
| carnosina | 8,607 | 8,59 | | 6 | ppm 8,6005 |
| ADP/ATP | 8,564 | 8,549 | d 28 p 28 | 8 | ppm 8,55 |
| formiato | 8,47 | 8,43 | | 10 | ppm 8,4575 |
| inosina | 8,375 | 8,33 | d 28 p 27 | 12 | ppm 8,357 |
| niacinamide | 8,276 | 8,21 | d 32 | 13 | ppm 8,246 |
| istidina | 8,021 | 8,008 | d 28 p 35 | 16 | ppm 8,0145 |
| carnosina | 7,886 | 7,86 | | 18 | ppm 7,858 |
| niacinamide | 7,622 | 7,57 | d 28 p 39 | 21 | ppm 7,6035 |
| triptofano | 7,56 | 7,51 | | 22 | ppm 7,5435 |
| fenilalanina | 7,4 | 7,354 | d 28 p 36 | 24 | ppm 7,3905 |
| fenilalanina | 7,356 | 7,308 | d 28 p 36 | 25 | ppm 7,336 |
| fenilalanina | 7,308 | 7,234 | d 28 p 36 | 26 | ppm 7,2745 |
| tirosina | 7,215 | 7,18 | d 28 p 33 | 27 | ppm 7,211 |
| tirosina | 7,225 | 7,149 | d 28 p 33 | 28 | ppm 7,1675 |
| tirosina | 6,923 | 6,87 | d 27 p 33 | 30 | ppm 6,908 |
| inosina | 6,126 | 6,08 | d 28 p 33 | 32 | ppm 6,108 |
| a-glucosio | 5,4 | 5,26 | d 26 p 30 | 35 | ppm 5,3275 |
| ADP/ATP | 4,6 | 4,533 | d 26 p 28 | 38 | ppm 4,5665 |
| inosina | 4,3 | 4,205 | | 42 | ppm 4,2575 |
| lattato | 4,147 | 4,08 | d 26 p 5 | 43 | ppm 4,117 |
| colina | 4,081 | 4,056 | | 44 | ppm 4,065 |
| lattato | 4,04 | 3,99 | | 45 | ppm 4,016 |
| fenilalanina | 3,99 | 3,97 | | 46 | ppm 3,9805 |
| tirosina | 3,97 | 3,95 | | 47 | ppm 3,9635 |
| creatina | 3,945 | 3,924 | d 26 p 20 | 48 | ppm 3,9345 |

NMR - METABOLITI ASSEGNATI FASE ACQUOSA

| | | 11710020117 | .,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |
|----------------|-------|-----------------|---|
| betaina | 3,887 | 3,868 | 51 ppm 3,8775 |
| a-glucosio | 3,868 | 3,847 | 52 ppm 3,856 |
| inosina | 3,843 | 3,822 | 53 ppm 3,8325 |
| isoleucina | 3,687 | 3,677 | 60 ppm 3,682 |
| isoleucina 💮 💮 | 3,654 | 3,639 d26 p1 | 63 ppm 3,6465 |
| valina | 3,639 | 3,62 d26p3 | 64 ppm 3,6295 |
| treonina | 3,619 | 3,595 d26p4 | 65 ppm 3,607 |
| glicina | 3,575 | 3,556 d26p24 | 66 ppm 3,5635 |
| taurina | 3,462 | 3,387 d26p23 | 69 ppm 3,4355 |
| prolina | 3,336 | 3,304 | 72 ppm 3,314 |
| TMAO | 3,286 | 3,256 d26p22 | 73 ppm 3,2695 |
| taurina | 3,248 | 3,225 d26p23 | 74 ppm 3,2365 |
| colina | 3,219 | 3,194 d 26 p 21 | 75 ppm 3,2065 |
| fenilalanina | 3,162 | 3,145 | 77 ppm 3,1505 |
| tirosina | 3,085 | 3,063 | 79 ppm 3,079 |
| oreatina 💮 💮 | 3,062 | 3,017 d 25 p 20 | 80 ppm 3,0395 |
| TMA | 2,942 | 2,895 d 25 p 19 | 81 ppm 2,914 |
| aspartato | 2,81 | 2,79 d25 p 17 | 82 ppm 2,806 |
| metionina | 2,645 | 2,516 | 86 ppm 2,547 |
| succinato | 2,577 | 2,48 d 25 p 14 | 87 ppm 2,5005 |
| ac malico | 2,416 | 2,405 d 25 p 13 | 89 ppm 2,4105 |
| prolina | 2,382 | 2,336 d 25 p 12 | 91 ppm 2,35 |
| metionina | 2,19 | 2,102 d 25 p 11 | 93 ppm 2,1485 |
| acetato | 2,026 | 1,914 d25p9 | 95 ppm 1,9065 |
| lisina | 1,79 | 1,704 | 96 ppm 1,757 |
| lattato | 1,376 | 1,286 d25p4 | 100 ppm 1,33 |
| isoleucina | 1,264 | 1,19 | 101 ppm 1,231 |
| valina | 1,063 | 1,032 d 25 p 3 | 102 ppm 1,0475 |
| valina | 1,006 | 0,983 d25p3 | 104 ppm 0,9945 |
| leucina 💮 💮 | 0,981 | 0,95 d25p2 | 105 ppm 0,9655 |
| isoleucina 💮 | 0,95 | 0,925 d25p1 | 106 ppm 0,9375 |

JOINT PROJECT «VACOOK»

NMR (Nuclear Magnetic resonance) o spettroscopia di risonanza magnetica nucleare

CONDIZIONI DI COTTURA:

BUSTA SOTTOVUOTO = pressione interna alla busta uguale alla pressione esterna; presenza di residui d'aria e quindi di ossigeno (condizioni di microaerofilia)

VASO SOTTOVUOTO = pressione interna notevolmente inferiore a quella esterna; presenza di residui d'aria e quindi di ossigeno (condizioni di microaerofilia)

BUSTA VAPORE

BUSTA ACQUA

BUSTA FORNO

ASPARAGO: RISULTATI SULLE SOSTANZE SOLUBILI IN ACQUA

Le sostanze riportate nel grafico sono quelle che determinano le differenze statistiche tra i diversi trattamenti

Legenda:

ACA: busta sottovuoto con cottura in acqua;

SCM_SV: busta sottovuoto con cottura al vapore;

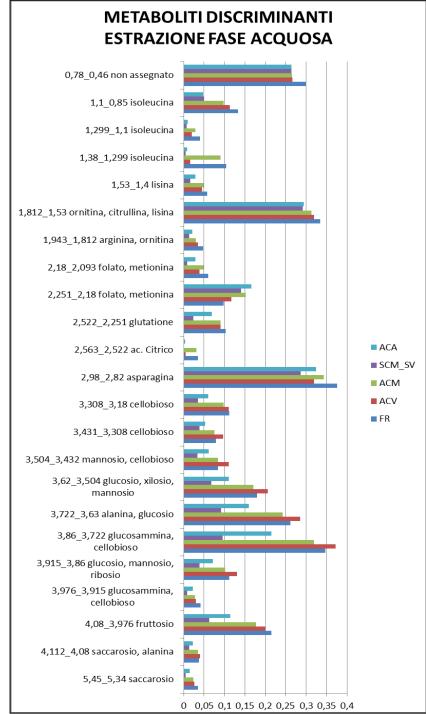
ACM: busta sottovuoto con cottura in forno a

microonde;

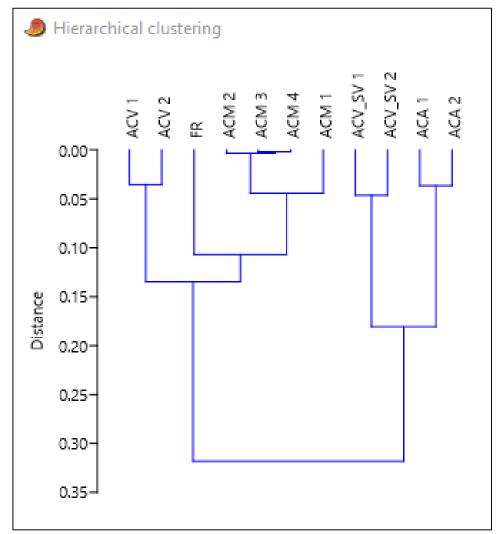
ACV: contenitore rigido sottovuoto con cottura in forno a

microonde;

FR: prodotto fresco



ASPARAGO: RISULTATI SULLE SOSTANZE SOLUBILI IN ACQUA



I trattamenti che si trovano più vicini al fresco (FR) sono la cottura in contenitore rigido al microonde (ACV) e quella in busta al microonde (ACM)

Legenda:

ACA: busta sottovuoto con cottura in acqua;

SCM_SV: busta sottovuoto con cottura al vapore;

ACM: busta sottovuoto con cottura in forno a microonde; ACV: contenitore rigido sottovuoto con cottura in forno a

microonde;

FR: prodotto fresco.

ASPARAGO: RISULTATI SULLE SOSTANZE LIPOSOLUBILI (GRASSI)

Le sostanze riportate nel grafico sono quelle che determinano le differenze statistiche tra i diversi trattamenti

Legenda:

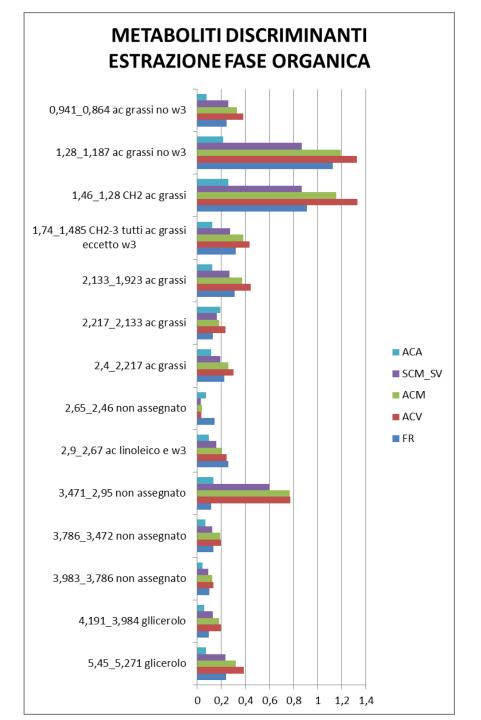
ACA: busta sottovuoto con cottura in acqua; SCM SV: busta sottovuoto con cottura al vapore;

ACM: busta sottovuoto con cottura in forno a

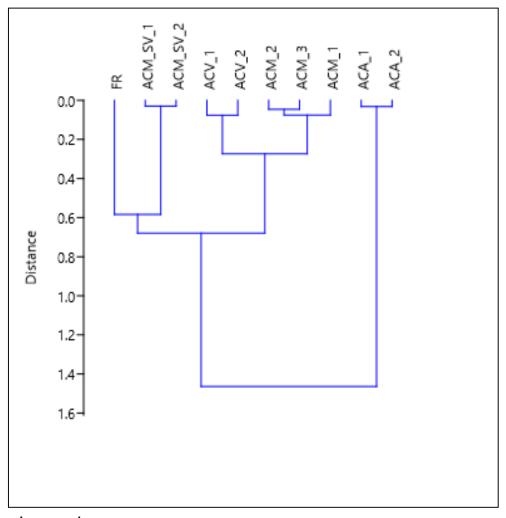
microonde;

ACV: contenitore rigido sottovuoto con cottura in forno a microonde;

FR: prodotto fresco



ASPARAGO: RISULTATI SULLE SOSTANZE LIPOSOLUBILI (GRASSI)



I trattamenti che si trovano più vicini al fresco (FR) sono la cottura in busta al vapore (ACM_SV), quindi quella in contenitore rigido al microonde (ACV) e quella in busta al microonde (ACM). Quella in busta in acqua (ACA) risulta essere la più modificata rispetto al prodotto fresco.

Legenda:

ACA: busta sottovuoto con cottura in acqua;

SCM_SV: busta sottovuoto con cottura al vapore;

ACM: busta sottovuoto con cottura in forno a microonde;

ACV: contenitore rigido sottovuoto con cottura in forno a microonde;

FR: prodotto fresco.

ORATA: RISULTATI (TUTTE LE SOSTANZE INSIEME)

Le sostanze riportate nel grafico sono quelle che determinano le differenze statistiche tra i diversi trattamenti

Legenda:

VASO: contenitore rigido sottovuoto con cottura in forno a microonde:

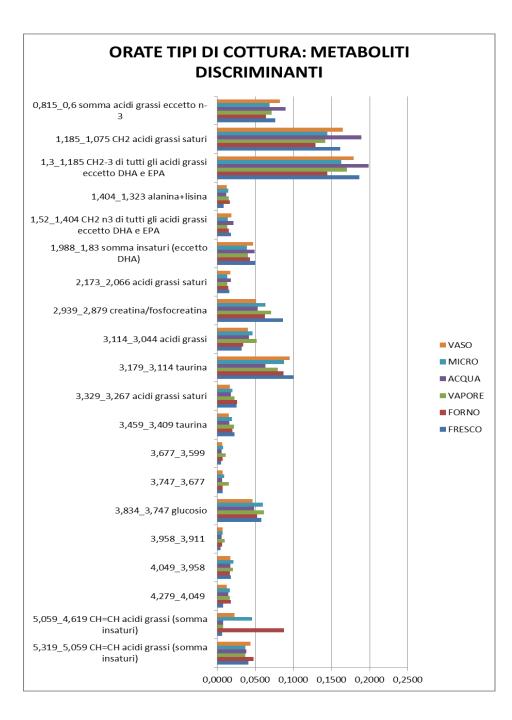
MICRO: busta sottovuoto con cottura in forno a microonde;

ACQUA: busta sottovuoto con cottura in acqua;

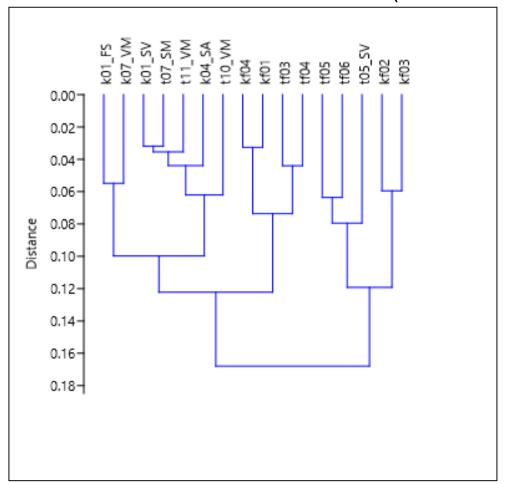
VAPORE: busta sottovuoto con cottura al vapore;

FORNO: cottura in forno tradizionale

FRESCO: prodotto fresco.



ORATA: RISULTATI (TUTTE LE SOSTANZE INSIEME)



Netta differenza tra orate crude e cotte (ad eccezione di un campione in busta sottovuoto cotto al vapore). La cottura che modifica maggiormente le sostanze contenute è quella in forno tradizionale. Quelle che modificano meno le sostanze contenute sono la cottura in contenitore rigido sottovuoto in forno a microonde e la cottura in busta sottovuoto al vapore e in acqua.

Legenda:

Kf04, kf01, tf03, tf04, tf05, tf06, kf02, kf03: prodotto fresco

K01_FS: busta sottovuoto in forno tradizionale;

K07_VM, t11_VM, t10_VM: contenitore rigido sottovuoto con cottura in forno a microonde:

K01_SV, t05_SV: busta sottovuoto con cottura a vapore;

T07_SM: busta sottovuoto con cottura in forno a microonde;

K04 SA: busta sottovuoto con cottura in acqua.

LA RISONANZA MAGNETICA può MISURARE LE QUALITÁ DEL CIBO Soprattutto quella

FUNZIONALE O NUTRACEUTICA O EPIGENETICA

GRAZIE DELL'ATTENZIONE