



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA



OPENDISTAL
20 SETTEMBRE

Applicazioni ingegneristiche nel settore agroalimentare

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Dipartimento di Scienze e Tecnologie Agro-ambientali

Chi siamo?

- Meccanica agraria

Prof. Ing. Angelo Fabbri



Prof. Luigi Ragni



Prof. Chiara Cevoli



Dr. Eleonora Iaccheri

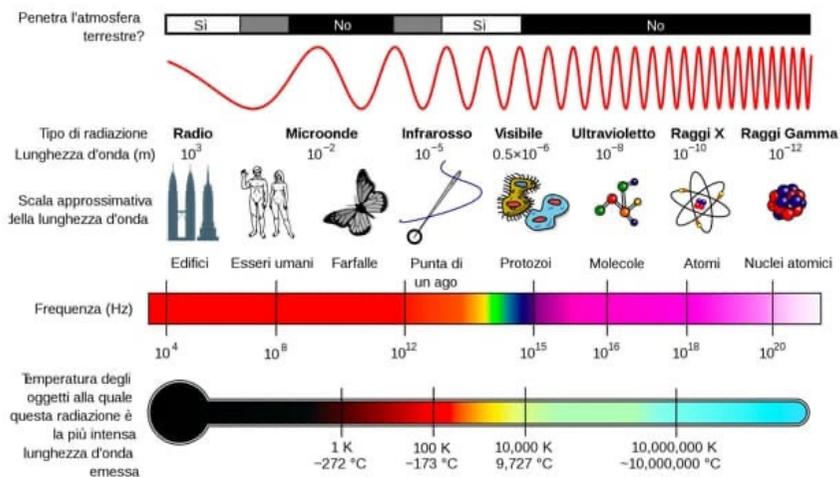


PRINCIPALI ATTIVITA'

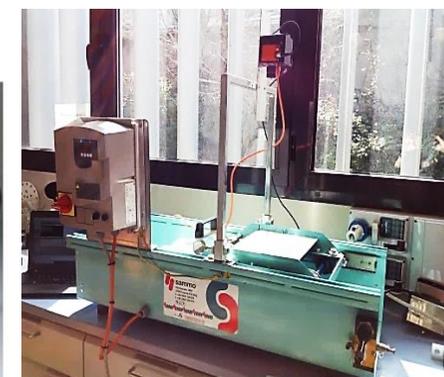
Metodi non distruttivi per la caratterizzazione dei prodotti agro-alimentari

Metodi di simulazione numerica applicati all'ingegneria agroalimentare

Metodi non distruttivi per la caratterizzazione dei prodotti agro-alimentari



-Spettroscopia FT-NIR e FT-MIR



-Metodi elettrici e dielettrici



L. Ragni et al. / Journal of Food Engineering 205 (2017) 25–33



Elaborazione statistica a mezzo di reti neurali e analisi multivariata



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✓ Messa a punto di un sistema di analisi d'immagine per la determinazione del colore interno dei kiwi rossi e gialli

```

python
# Python script for image analysis
import cv2
import numpy as np
import sys

# Load image
img = cv2.imread('image.jpg')

# Convert to H-Minolta
# ... (code for color conversion) ...

# Calculate statistics
mean_value = np.mean(hue)
sd = np.std(hue)

# Print results
print("Mean value, inner flesh: %f" % mean_value)
print("SD, inner flesh: %f" % sd)

```

Results of Hue in 0-360 scale for peeled samples

image: P7.jpg

** Mean and SD values (all samples) for conversion to H-Minolta

1) Conversion to H-Minolta, linear relation

Mean value, inner flesh: 106.2108
Mean value, centroid: 105.8022

SD, inner flesh: 3.5881
SD, centroid: 3.5881

2) Conversion to H-Minolta, quad relation

Mean value, inner flesh: 106.1898
Mean value, centroid: 105.7001

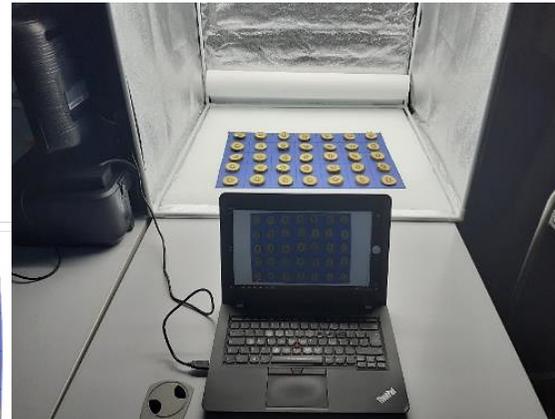
SD, inner flesh: 3.5458
SD, centroid: 3.5458

3) Percentage H>108, linear relation

17.1%

3) Percentage H>108 quad relation

17.1%



```

python
# Python script for image analysis
import cv2
import numpy as np
import sys

# Load image
img = cv2.imread('image.jpg')

# Convert to H-Minolta
# ... (code for color conversion) ...

# Calculate statistics
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sd = np.std(hue)

# Print results
print("Mean value, inner flesh: %f" % mean_value)
print("SD, inner flesh: %f" % sd)

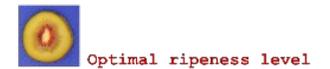
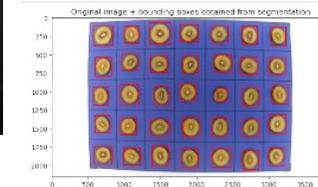
```



Results for image: kiwi7.jpg

Original number of slices = 35
Detected number of slices = 35

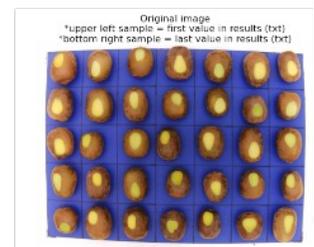
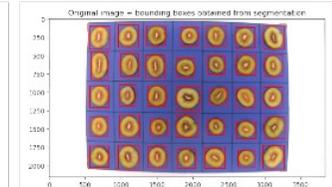
Number of slices with A/B < 2.5% = 10 (= 28.57%)
Mean A/B(%) = 4.17
Std Dev A/B(%) = 2.66



Results for image: kiwi3.jpg

Original number of slices = 35
Detected number of slices = 35

Number of slices with A/B < 2.5% = 0 (= 0.00%)
Mean A/B(%) = 18.19
Std Dev A/B(%) = 3.90

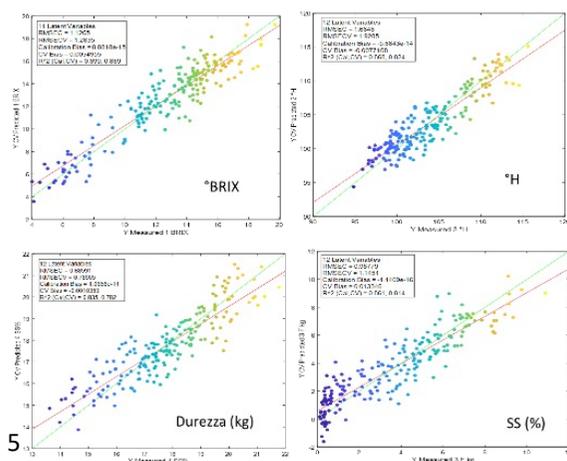
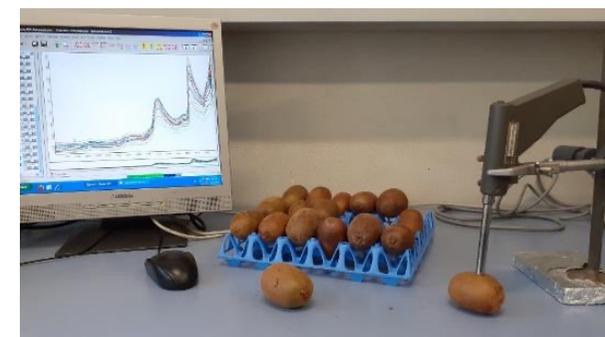
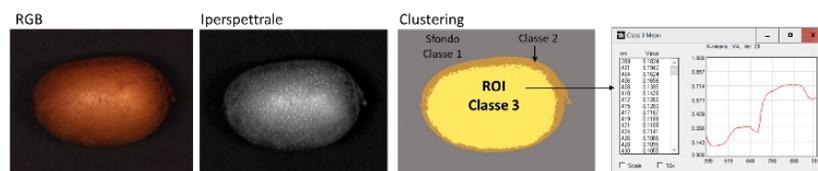


Valutazione delle potenzialità dell'iperspettrale imaging combinata a metodi statistici multivariati per la determinazione di parametri qualitativi di kiwi

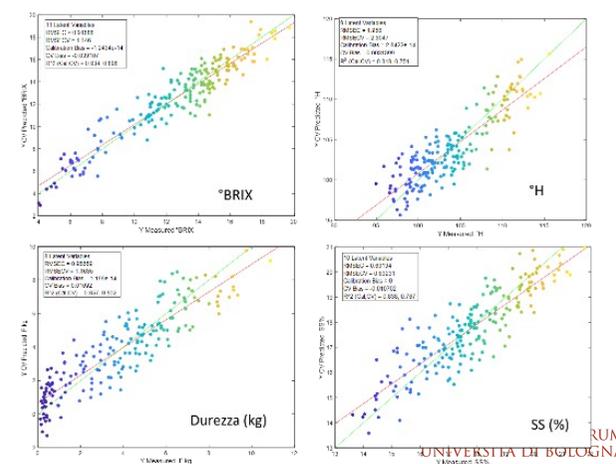


- ✓ Telecamera iperspettrale a matrice lineare push-broom, intervallo spettrale 400-1000 nm (Nano-Hyperspec VNIR, Headwall Photonics, Inc., Fitchburg, MA, USA)

- ✓ Spettrofotometro FT-NIR (MATRIX™ -F, Bruker Optics) in riflettanza diffusa nell'intervallo da 833 a 2500 nm (risoluzione 8 cm⁻¹).



	Range	R ² CV	RMSECV
°BRIX	NIR	0.898	1.14
	Vis/NIR	0.869	1.28
°H	NIR	0.751	2.31
	Vis/NIR	0.824	1.93
F(kg)	NIR	0.802	1.16
	Vis/NIR	0.814	1.14
SS(%)	NIR	0.767	0.83
	Vis/NIR	0.782	0.79



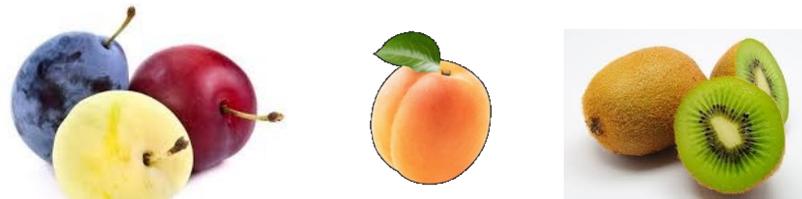
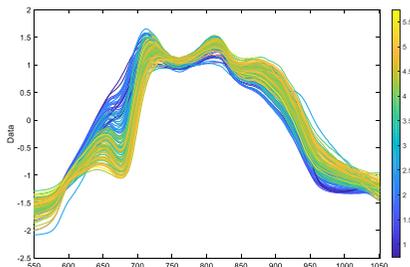
✓ Valutazione delle relazioni tra parametri qualitativi di tre tipologie di frutti (kiwi, albicocche e susine) e dati di tipo spettroscopico



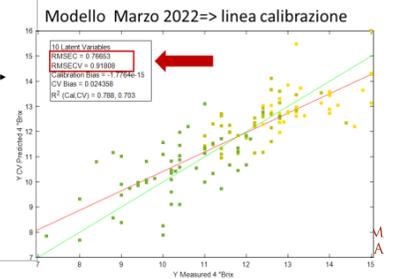
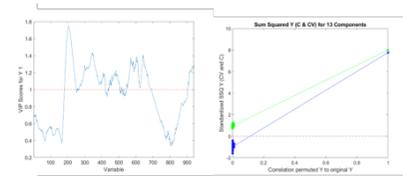
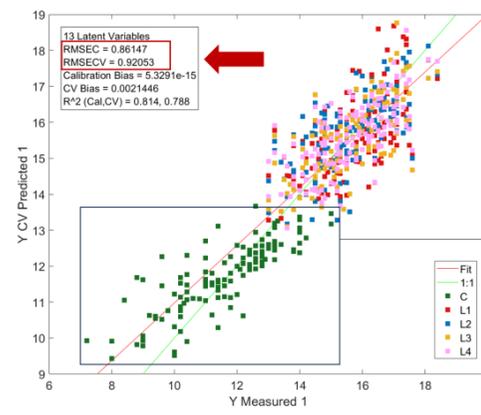
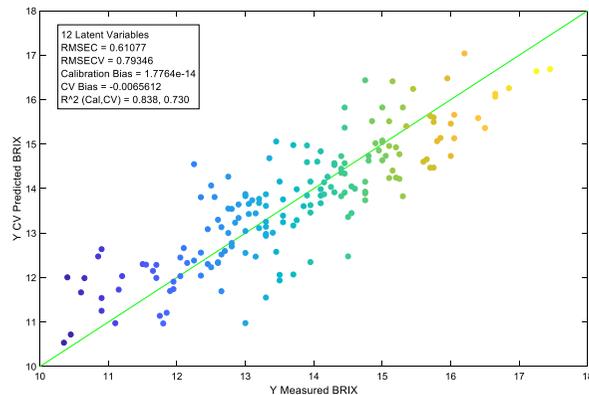
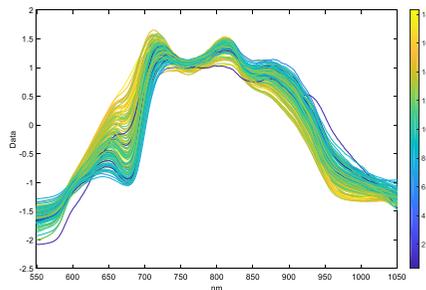
✓ Sviluppo di modelli statistici per la stima di parametri qualitativi dei kiwi partendo da dati spettroscopici provenienti da linee di lavorazione



Modelli PLS (range spettrale: 550 - 1050 nm)
Spettri colorati in funzione della durezza (kg)



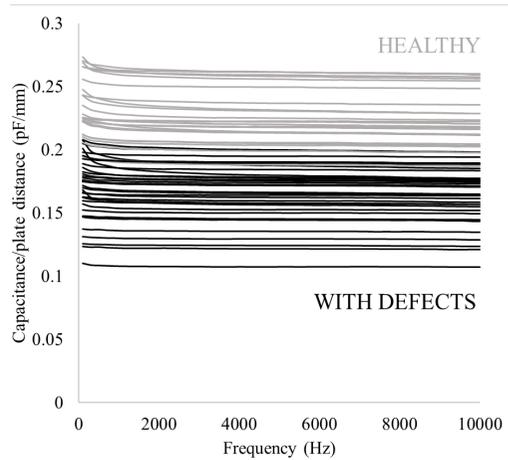
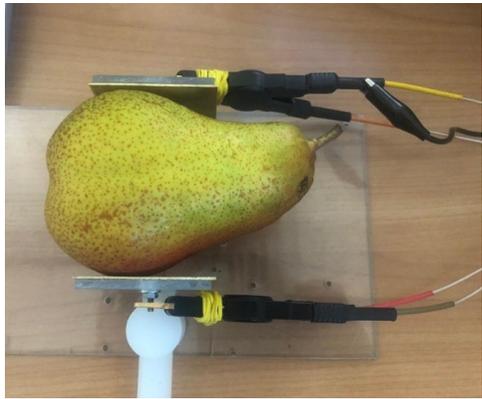
Spettri colorati in funzione del °Brix



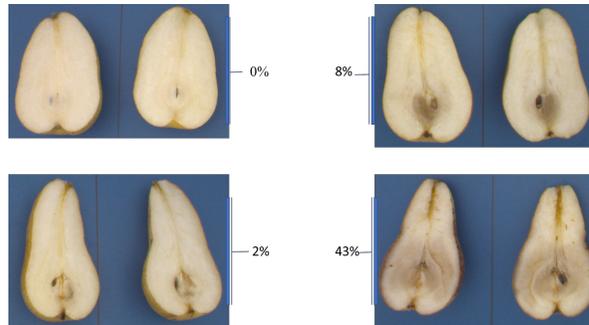
Rilevamento dell'imbrunimento interno delle pere FRED® durante la conservazione post-raccolta mediante una tecnica economica e non distruttiva.



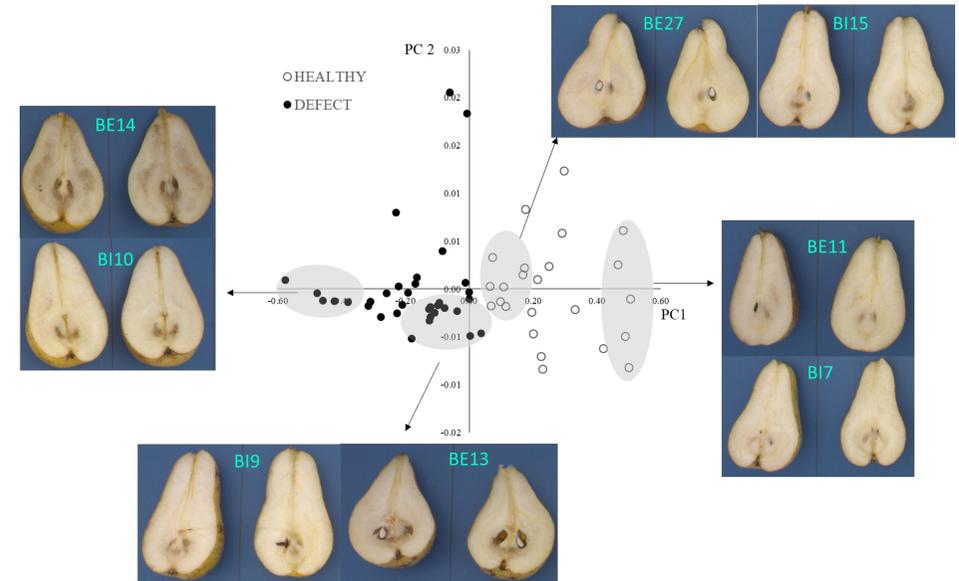
1. Metodo capacitivo rapido e non distruttivo



2. Analisi di immagine per il calcolo dei difetti interni



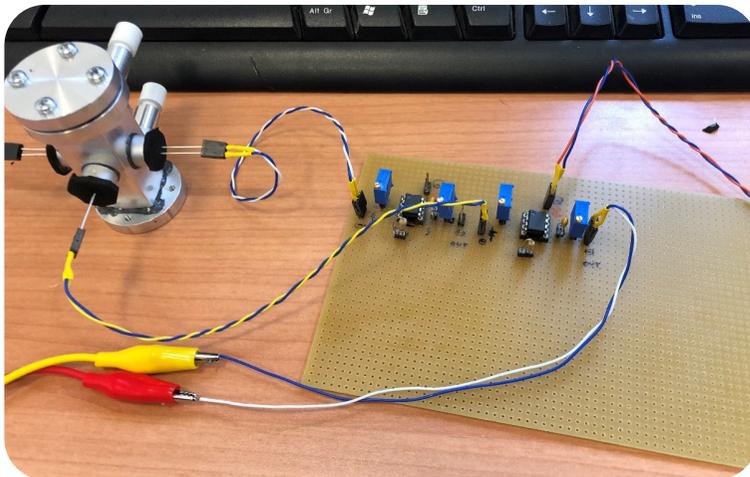
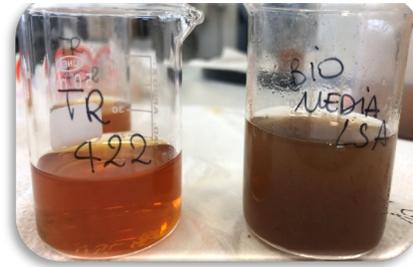
3. Classificazione dei campioni in difettati e sani



ENER-VITIS

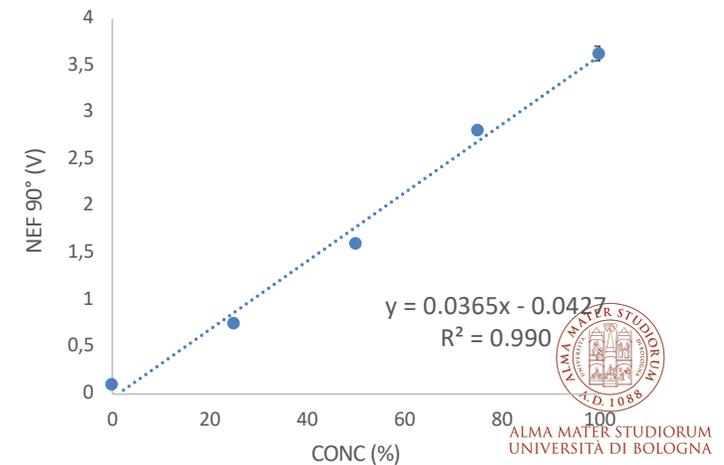
Sviluppo di un dispositivo economico e rapido, da implementare in linea, atto a determinare il grado di torbidità di mosti d'uva.

PROTOTIPO con doppia modalità di lettura



Il prototipo ottico è dotato di una sorgente di luce a led IR (picco di intensità a 890 nm) e due fotodiodi IR (picco di sensibilità a 900 nm). Il prototipo può effettuare una misura della torbidità in due modalità: in trasmissione, funzionando come turbidimetro e a 90° come nefelometro.

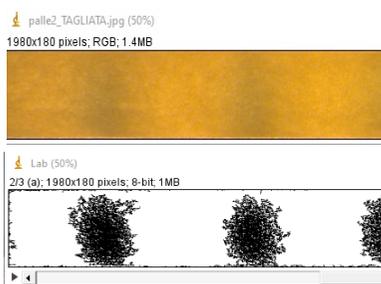
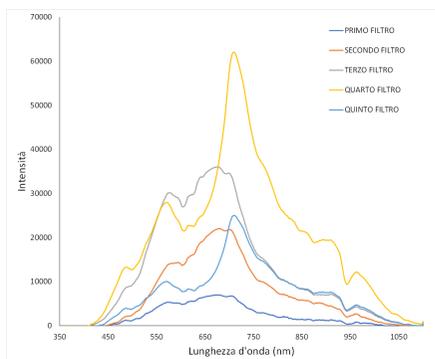
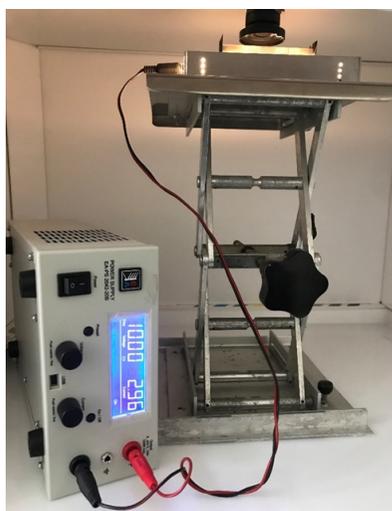
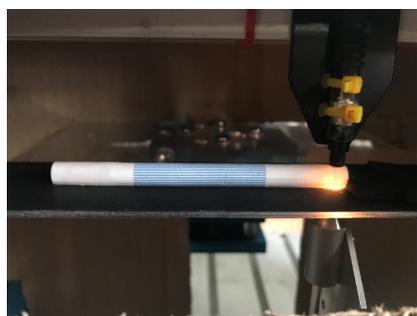
5 valori incrementali di torbidità.
0 corrisponde al mosto limpido
100 al mosto torbido
e 3 miscele al 25, 50 e 75%



Studio della risposta elettromagnetica dei singoli materiali e identificazione di oggetti interni

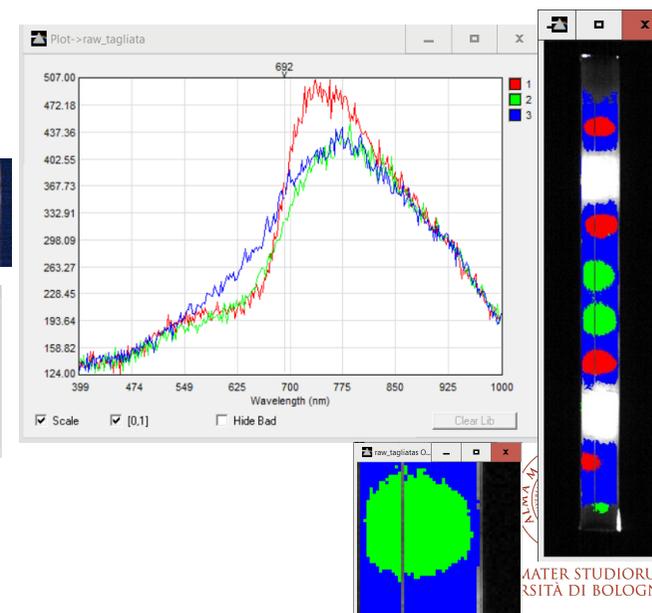
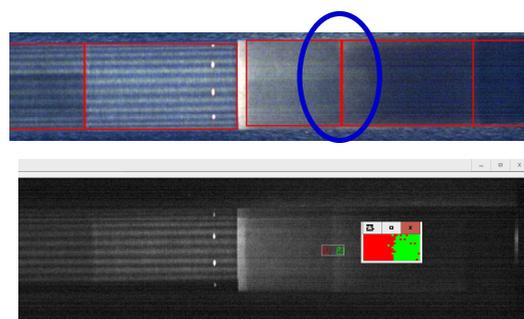


ANALISI DI IMMAGINE



Spettri caratteristici di ogni filtro.
9

CAMERA IPERSPETTRALE



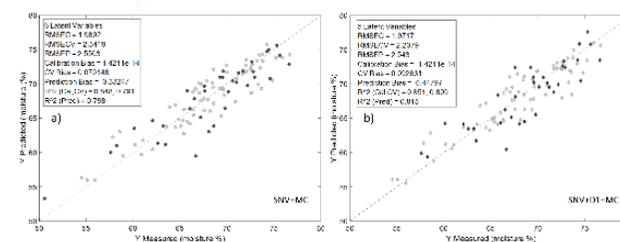
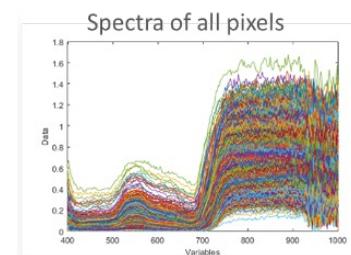
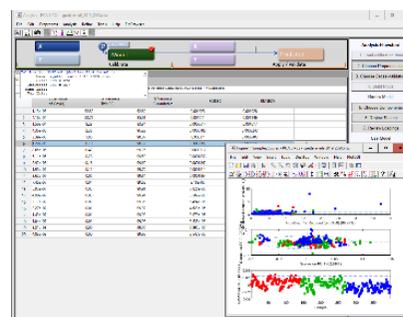
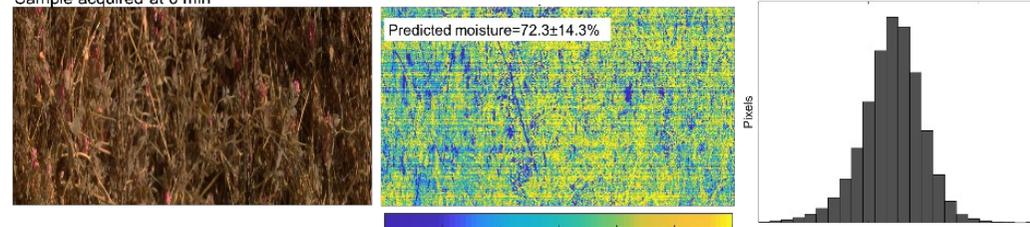
Studio di tecniche iperspettrali per la stima della qualità del condizionamento del foraggio



- HS camera 400-1000 nm
(Nano-Hyperspec VNIR, Headwall Photonics, Inc.)



Sample acquired at 0 min

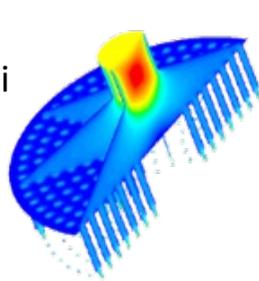


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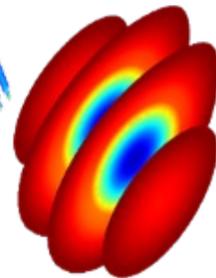
Metodi di simulazione numerica applicati all'ingegneria agroalimentare

- In particolare la simulazione numerica viene utilizzata per lo studio dei fenomeni termici, diffusivi e fluidodinamici che coinvolgono i processi di trasformazione e conservazione degli alimenti.

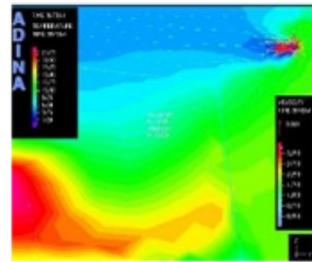
Estrusore di impasti



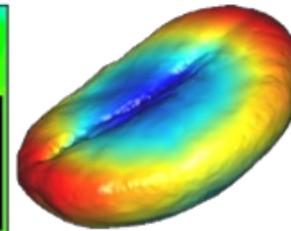
Diffusione CO₂ in uovo



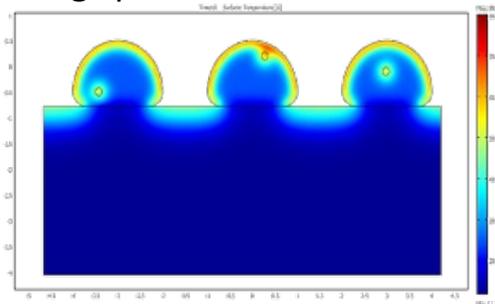
Distribuzione di temperatura in celle di conservazione



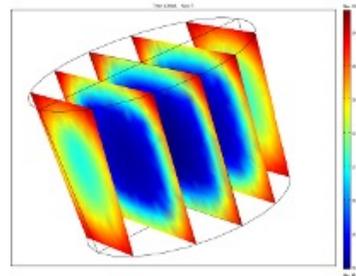
Essiccazione del caffè



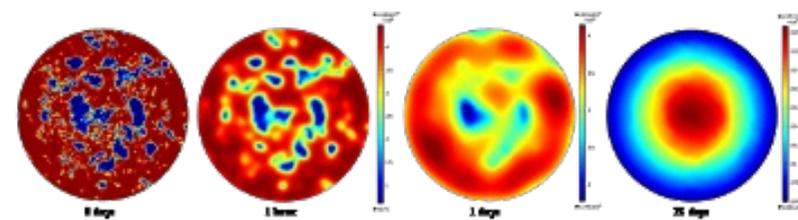
Temperatura in silo-bags per cereali



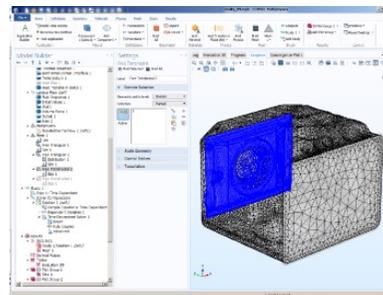
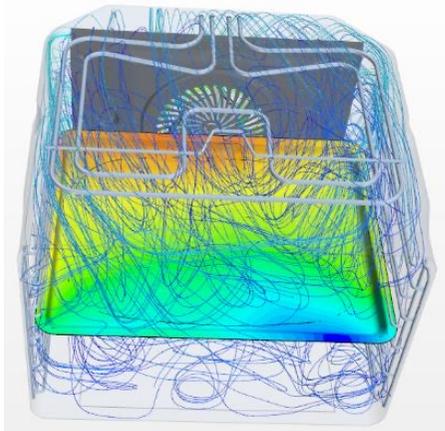
Temperatura in confezioni di frutta di IV gamma



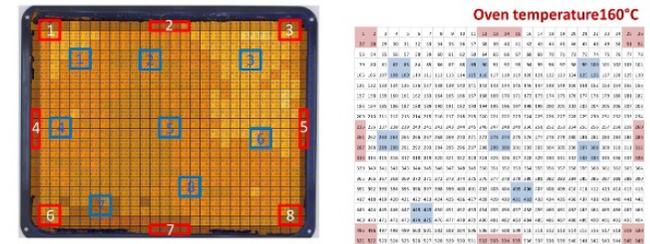
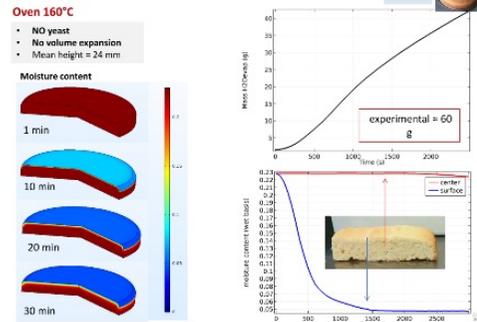
Stagionatura di insaccati



Simulazione numerica di forno a convezione con particolare riferimento alla ricerca di relazioni tra indici di brunitura di *flatcake* e parametri di processo

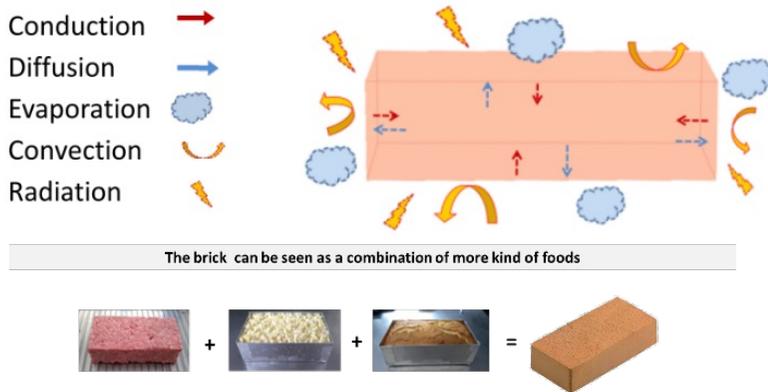


Step 2 - Model validation: calculated temperature and weight were compared with those obtained during cooking tests



L*		T(°C)		Integral	
	time (min)		time (min)		time (min)
WALL	16 21 26 36 46 65	WALL	16 21 26 36 46 65	WALL	16 21 26 36 46 65
1	82.0 76.8 65.2 51.5 40.8 33.2	1	108.1 115.2 117.8 124.4 129.7 133.8	1	352 1819 2353 3883 4857 5955
2	82.4 75.0 60.5 54.7 44.3 36.3	2	108.8 115.1 118.3 123.6 128.7 127.4	2	366 1510 2138 3408 4609 6077
3	82.6 75.8 61.5 56.2 41.8 32.5	3	111.5 115.3 123.2 125.2 126.5 130.3	3	394 1551 2182 3477 4742 7085
4	82.4 78.0 68.1 55.3 43.1 36.6	4	102.3 109.7 120.5 129.6 128.3 129.1	4	400 1419 1993 3111 4433 5254
5	83.0 80.0 68.9 55.4 46.3 26.7	5	100.1 105.2 109.7 115.6 112.7 120.7	5	589 1359 1950 3143 4313 6498
6	75.3 89.1 59.4 42.6 36.4 25.5	6	106.8 112.8 114.5 112.1 125.6 127.3	6	390 1470 2056 3186 4255 5808
7	68.5 62.6 37.8 32.5 22.3 22.0	7	107.6 114.5 116.7 125.3 129.2 118.5	7	540 1480 2093 3130 4643 5917
8	72.7 65.1 53.9 42.8 36.8 24.4	8	103.0 111.3 115.6 124.2 126.2 132.4	8	523 1456 2044 3191 4539 6013
CENTER		CENTER		CENTER	
1	83.3 78.3 68.0 57.5 48.3 37.8	1	104.4 111.4 112.0 118.8 123.6 129.8	1	344 1481 2056 3287 4482 6792
2	84.4 74.8 64.6 55.6 48.3 42.7	2	107.1 111.7 112.0 118.5 123.6 124.4	2	396 1498 2059 3284 4489 6724
3	84.4 81.9 72.0 61.7 51.4 40.3	3	107.8 110.7 110.8 117.1 123.8 122.8	3	396 1498 2053 3170 4508 5663
4	83.2 78.9 68.8 58.2 48.7 41.2	4	106.9 110.3 111.0 118.0 123.0 122.3	4	529 1481 2061 3164 4461 6679
5	83.1 74.3 64.4 56.6 49.9 43.7	5	107.5 112.0 112.0 119.0 122.0 123.6	5	539 1475 2054 3196 4504 6243
6	84.3 80.1 71.2 59.5 50.4 41.1	6	107.8 112.3 111.0 118.0 121.1 128.2	6	346 1483 2060 3190 4483 6716
7	79.6 71.5 60.0 51.7 45.2 39.9	7	107.7 112.4 114.6 123.0 123.3 124.6	7	340 1486 2079 3125 4548 5823
8	83.7 76.5 67.1 58.2 50.4 43.8	8	102.7 102.6 110.1 117.8 119.5 113.3	8	538 1478 2030 3101 4396 5048

✓ Relation between the standard test for energy consumption (brick test) and food cooking



VS

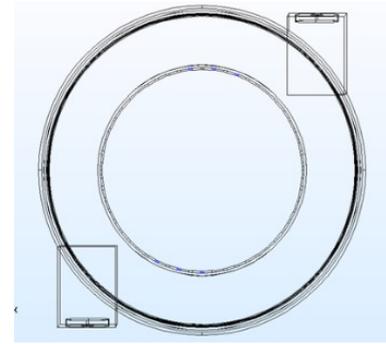
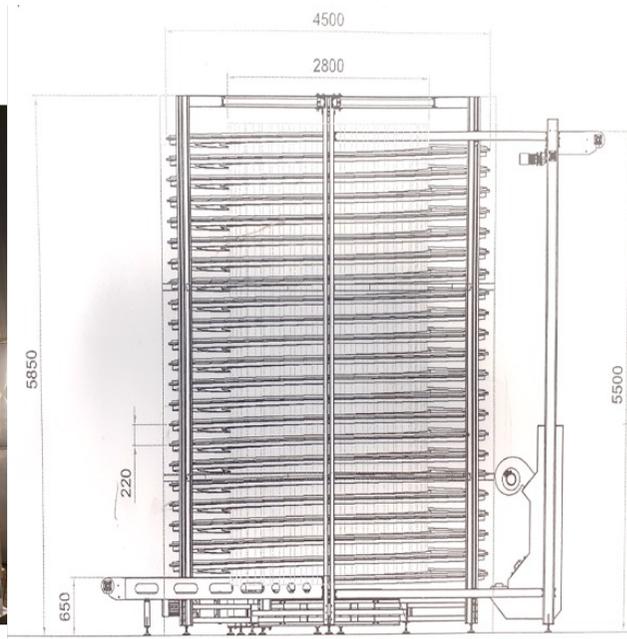
• Minced meat

• Palm cake

• Potato

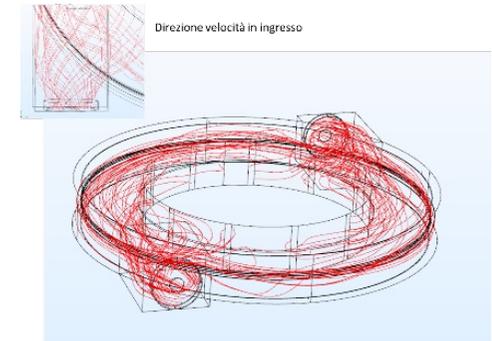
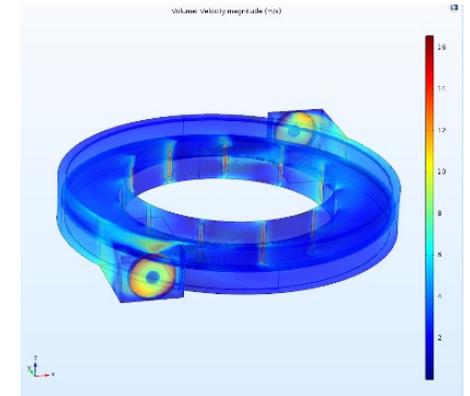
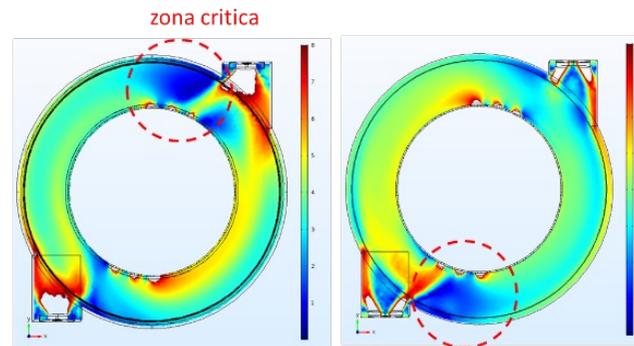
JDIDORUM SOLOGNA

Sviluppo di modelli CFD per l'ottimizzazione di un impianto industriale di essiccamento di frutta ad aria calda.

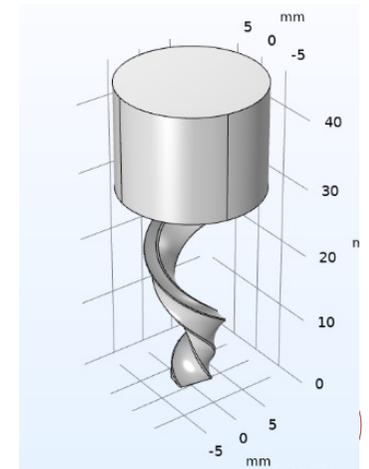
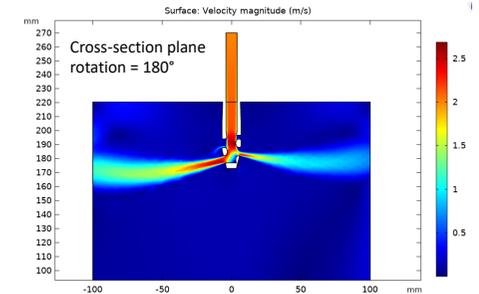
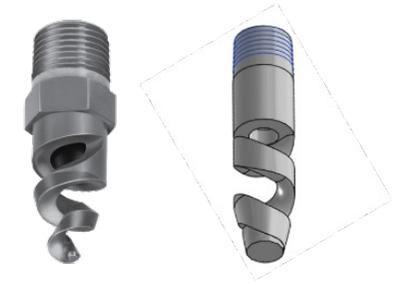
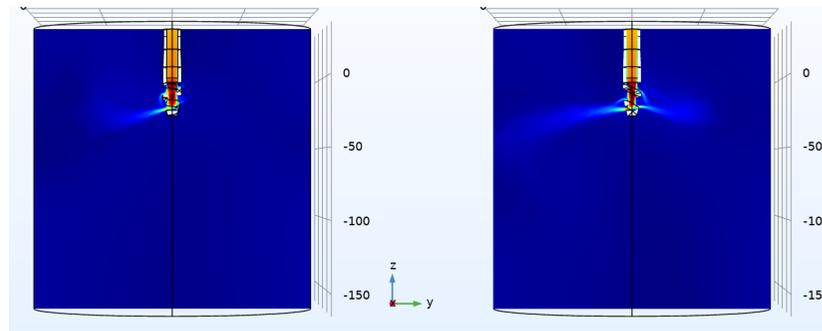
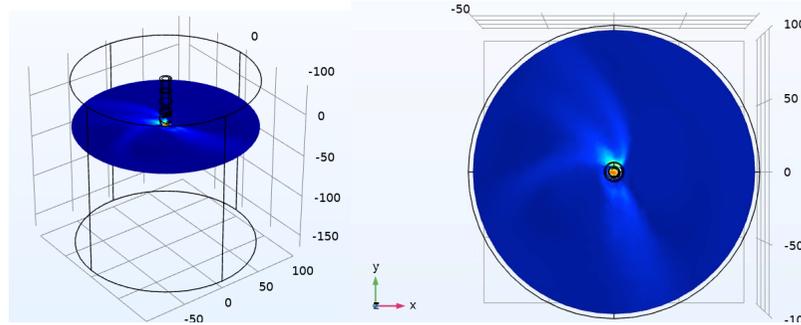


1° ripiano

2° ripiano



Sviluppo di modelli CFD parametrici in grado di descrivere il campo di velocità, pressione e temperatura dei getti di acqua al variare della configurazione degli ugelli (e.g cilindrico/conico) e delle condizioni di flusso dell'acqua in ingresso (pressione/velocità in ingresso).





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