

DEEP FRYING OIL WITH LOW SATURATED FATTY ACIDS FOR FAST FOOD RESTAURANTS: KINETICS OF PHYSICO-CHEMICAL PARAMETERS DURING FRYING AGEING

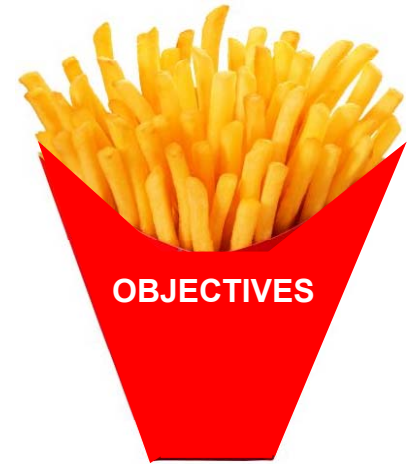
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Arab Tehrani, E, Fanni, J.



LIBio

Laboratory of Engineering

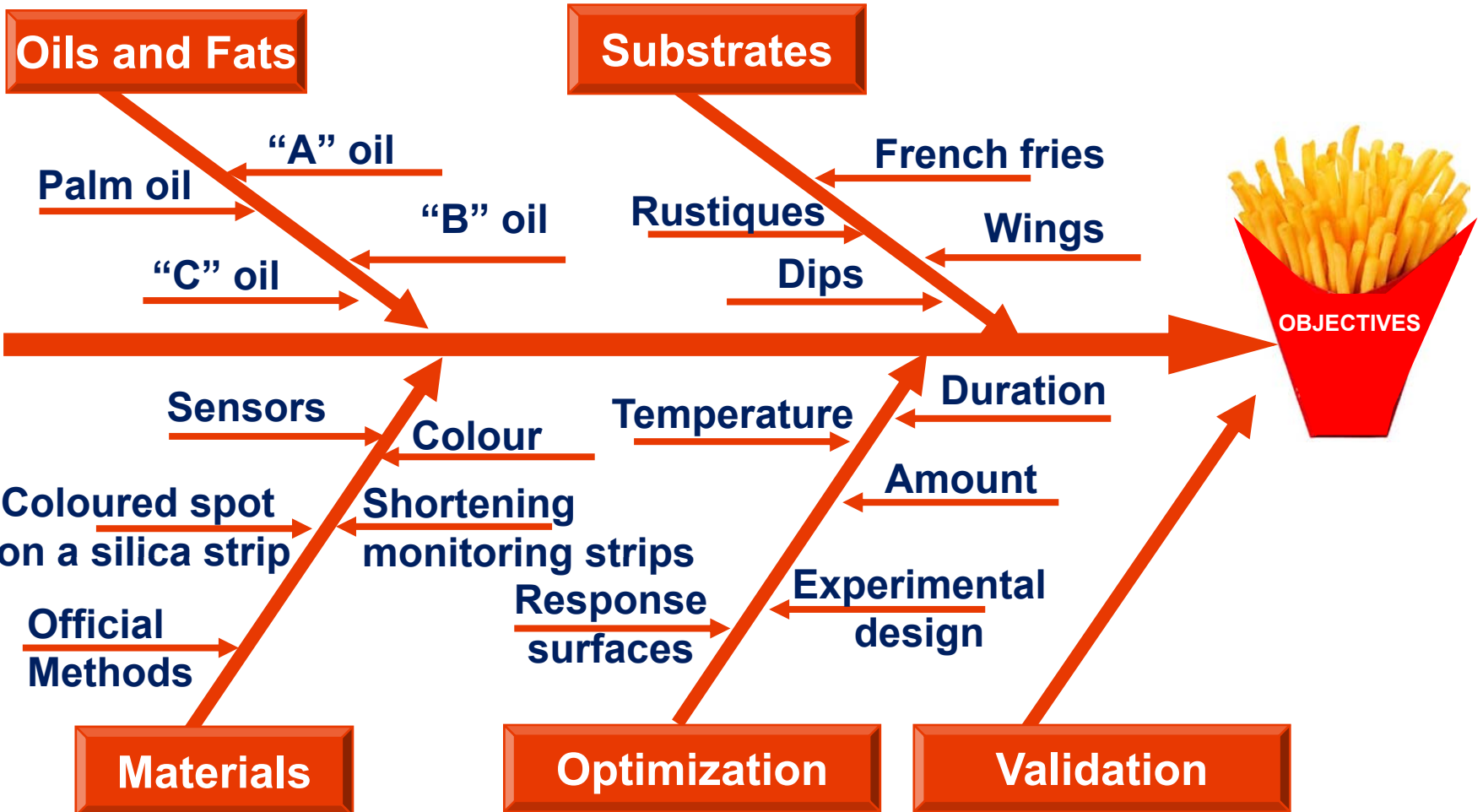




The aim of this study was to find a new frying oil

- ✓ **More stable than palm oil**
- ✓ **French fries with an healthier nutritional profile**
- ✓ **No modification of the textural properties of French fries**
- ✓ **While keeping the same hedonic properties**





Substratum



PHYSICO-CHEMICAL METHODS

Lipid extraction

Oil was extracted according to Soxhlet and Bligh and Dyer methods.

Peroxide value: AOAC 965.33, 1997

Iodine value: NF EN ISO 3961, 1999

Free fatty acids (FFA): NF EN ISO 660 1999)

Fatty acid composition by GLC

Lipid extracts were transesterified to FAME (BF₃ MeOH)

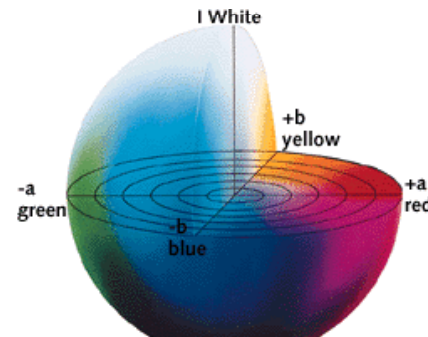


Total polar materials (TPM): AOAC 1998

2.5 g oil was dissolved in 20 ml of petroleum / diethyl ether mixture and drained through a silica gel column

Colour measurements:

Colour was measured using a Datacolor International model 200



QUALITY OF COOKING OILS: COMPARISON OF DIFFERENT MEASURING DEVICES

Rapid test based on color reaction (presence of FFA): 3M LRSM

Determination of TPM based on changes in the dielectric constant :
Testo 265 ; Ebro FOM 310

Chemical test with a migration of a colored spot on a silica strip: 3M
PCT 120



Fatty acid profile of precooked French fries

Fatty acid	
Lauric acid (C12:0)	0.21 ± 0.03
Myristic acid (C14:0)	1.30 ± 0.03
Palmitic acid (C16:0)	45.28 ± 1.45
Palmitoleic (C16:1)	0.15 ± 0.01
Stearic acid (C18:0)	4.11 ± 1.16
Oleic acid (C18:1n-9)	37.64 ± 1.22
Linoleic acid (C18:2n-6)	9.82 ± 0.25
α -linolenic acid (C18:3n-3)	0.41 ± 0.01
Arachidonic acid (C20:0)	0.40 ± 0.02
Eicosenoic acid (C20:1)	0.11 ± 0.01

Dry matter (g / 100 g)	38.0 ± 1.0
Lipid content (g/100 g dry /wet basis)	14.5 ± 0.4 6.6 ± 0.5



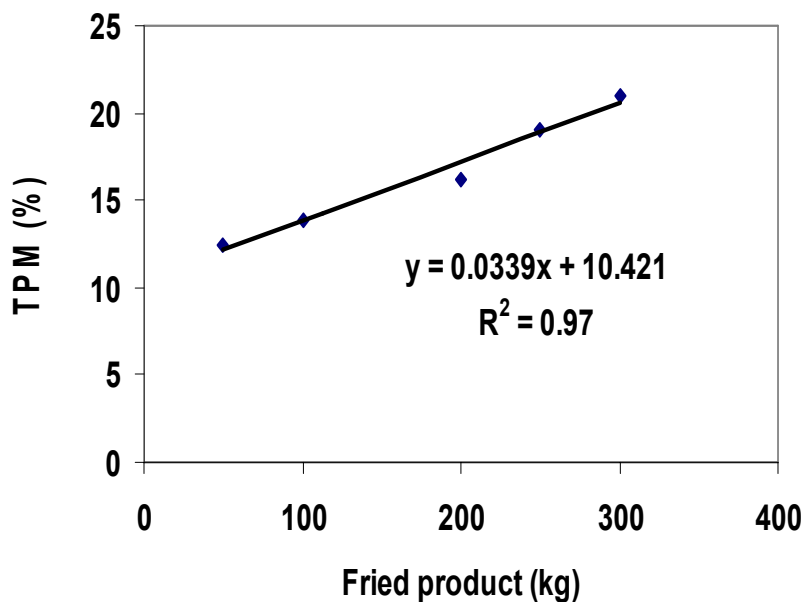
FATTY ACID COMPOSITION OF THE FRYING OILS

Fatty acids (% of identified fatty acids)	Palm oil	Frying oil A	Frying oil B	Frying oil C
Lauric acid (C12:0)	0.23 ± 0.01	-	0.31 ± 0.02	0.35 ± 0.02
Myristic acid (C14:0)	1.34 ± 0.05	-	0.63 ± 0.01	0.70 ± 0.03
Palmitic acid (C16:0)	48.68 ± 0.21	4.20 ± 0.03	18.28 ± 0.25	21.16 ± 0.35
Palmitoleic acid(C16:1)	0.17 ± 0.00	0.12 ± 0.01	0.19 ± 0.01	0.19 ± 0.01
Stearic acid(C18:0)	4.03 ± 0.02	2.65 ± 0.02	2.68 ± 0.03	2.91 ± 0.06
Oleic acid (C18:1n-9)	35.67 ± 0.18	75.72 ± 0.90	60.04 ± 0.39	59.06 ± 0.47
Linoleic acid (C18:2n-6)	9.28 ± 0.09	13.68 ± 0.06	15.38 ± 0.09	13.00 ± 0.08
Linolenic acid (C18:3n-3)	0.19 ± 0.00	1.77 ± 0.01	1.87 ± 0.02	1.51 ± 0.03
Arachidic acid (C20:0)	0.31 ± 0.00	0.34 ± 0.00	0.34 ± 0.04	0.31 ± 0.02
Eicosenoic acid (C20:1)	0.11 ± 0.02	0.49 ± 0.01	0.45 ± 0.01	0.39 ± 0.01
Behenic acid (C22:0)	-	0.75 ± 0.00	-	-
Σ SFA	54.59	7.94	23.24	25.43
Σ MUFA	35.95	76.33	61.04	59.92
Σ PUFA	9.47	15.45	15.25	14.51

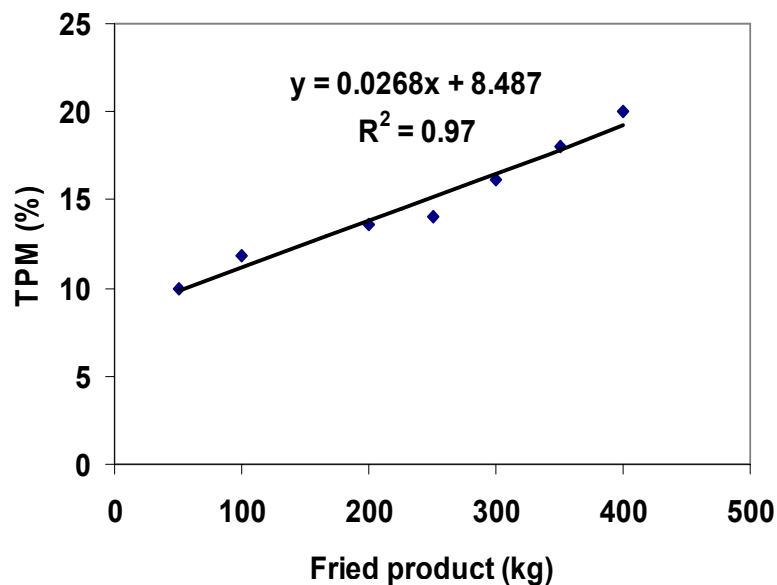
FREE FATTY ACIDS OF THE DIFFERENT FRYING OILS

French fries (kg)	Palm oil	Frying oil A	Frying oil B	Frying oil C
0	0.03 ± 0.00	0.02 ± 00	0.05 ± 0.01	0.05 ± 0.01
50	0.20 ± 0.00	0.11 ± 0.01	0.16 ± 0.01	0.20 ± 0.00
100	0.30 ± 0.01	0.20 ± 0.00	0.23 ± 0.02	0.30 ± 0.00
150	0.40 ± 0.01	0.30 ± 0.01	0.35 ± 0.01	0.38 ± 0.01
200	0.53 ± 0.02	0.38 ± 0.00	0.48 ± 0.01	0.48 ± 0.01
250	0.62 ± 0.02	0.49 ± 0.02	0.55 ± 0.00	0.60 ± 0.01
300	0.67 ± 0.01	0.55 ± 0.02	0.68 ± 0.01	0.68 ± 0.01
350	---	0.68 ± 0.00	0.72 ± 0.01	0.75 ± 0.00
400		0.76 ± 0.03	0.75 ± 0.01	---
450		0.88 ± 0.01	0.86 ± 0.01	
500		0.90 ± 0.02	---	
550		0.98 ± 0.01		

CORRELATION BETWEEN TPM AND AMOUNT OF FRIED PRODUCTS



Palm oil



Frying oil A

THE CHOICE...

...OF THE FRYING OIL “A”



✓ Physicochemical properties

Oil

Peroxide value

FFA content

Total Polar Materials

Fatty acid composition

Products

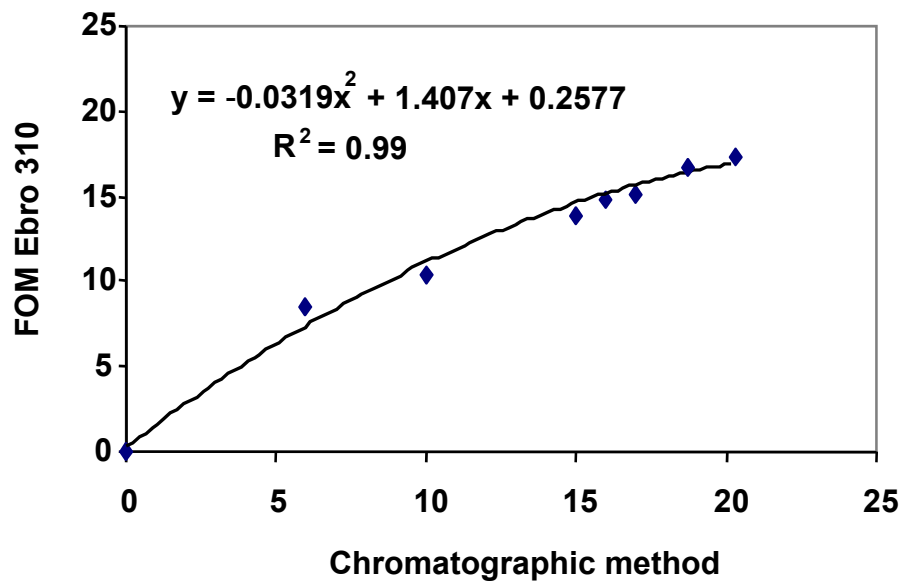
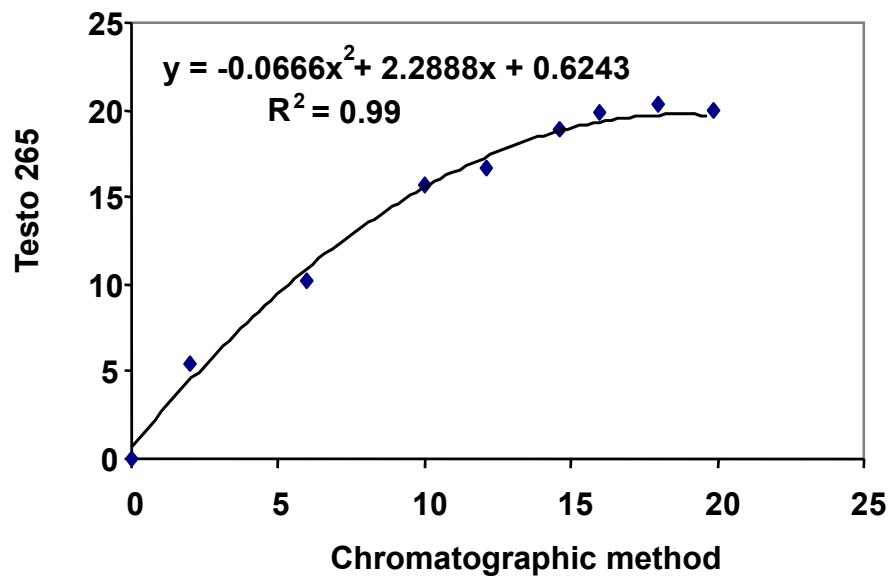
Fatty acid composition

Absorption of oil

Colour

✓ Rheological and sensorial tests

CORRELATION BETWEEN INSTRUMENTAL AND OFFICIAL METHODS



Polar degradation compounds measured via the migration of a coloured spot on a silica strip (3M™ PCT 120 test)

[illegible]

**Obergrenze blaue
Linie ablesen!**
Osservare attentamente
la parte superiore del
punto blu!



Esempio: il grasso è in ordine.
Nell'esempio riportato l'olio può essere utilizzato.

Ref: FY1301600938

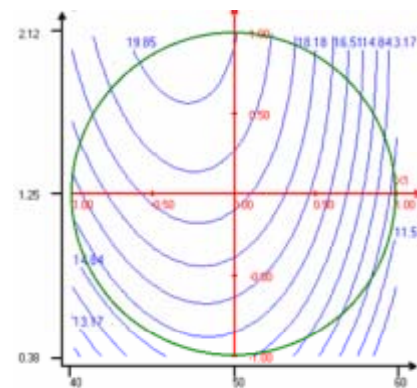
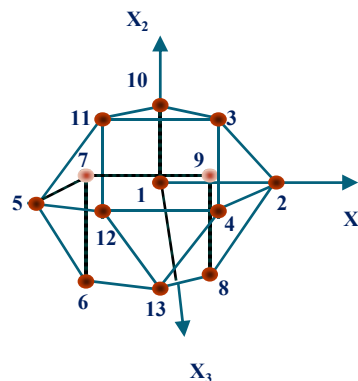
OPTIMIZATION OF THE FRYING PARAMETERS

✓ Pilot trials were carried out on an industrial deep fryer (batches of 50 kg). Assays were performed at LIBio.

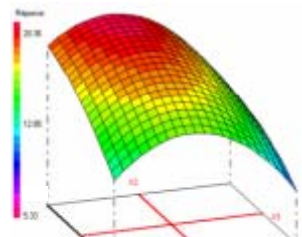
✓ Optimization by Response Surface Methodology

✓ Doehlert matrix

- amount of fried product
- frying temperature
- duration



$$Y = \beta_0 + \sum_{i=1}^3 \beta_i X_i + \sum_{i=1}^3 \beta_{ii} X_i^2 + \sum_{i=1}^2 \sum_{j=i+1}^3 \beta_{ij} X_i X_j$$



Exp	Temperature (°C)	Time (sec)	Amount (kg)
Level	5	7	3
1	175.0	170	1.25
2	165.0	170	1.25
3	172.5	190	1.25
4	167.5	150	1.25
5	172.5	150	1.25
6	167.5	190	1.25
7	172.5	177	1.50
8	167.5	163	1.00
9	172.5	163	1.00
10	170.0	183	1.00
11	167.5	177	1.50
12	170.0	157	1.50
13	170.0	170	1.25
14	170.0	170	1.25
15	170.0	170	1.25

Frying oil

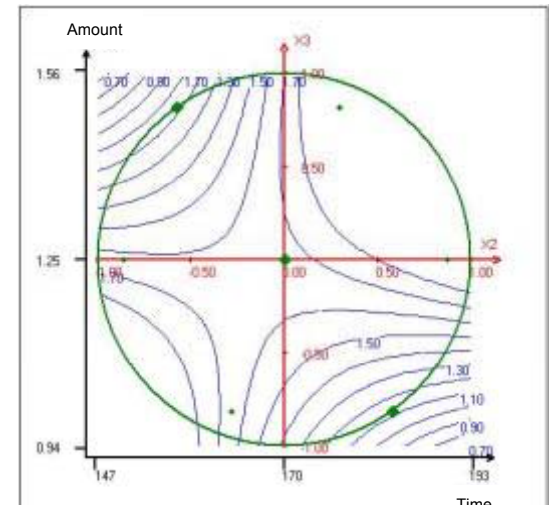
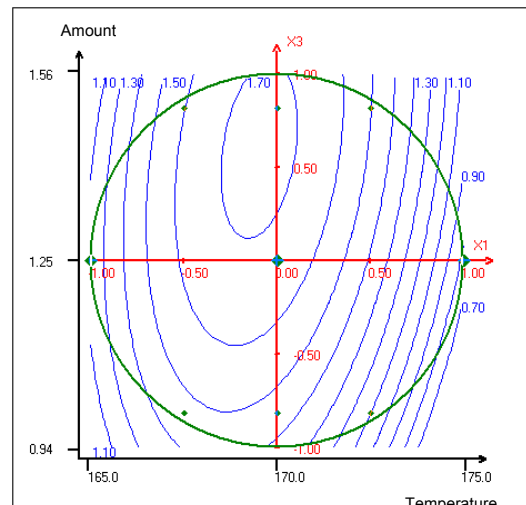
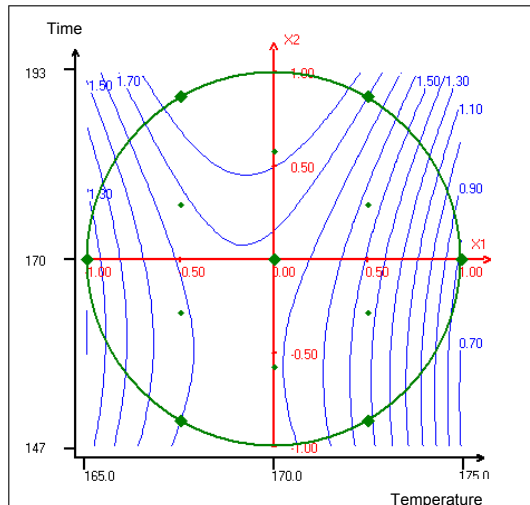
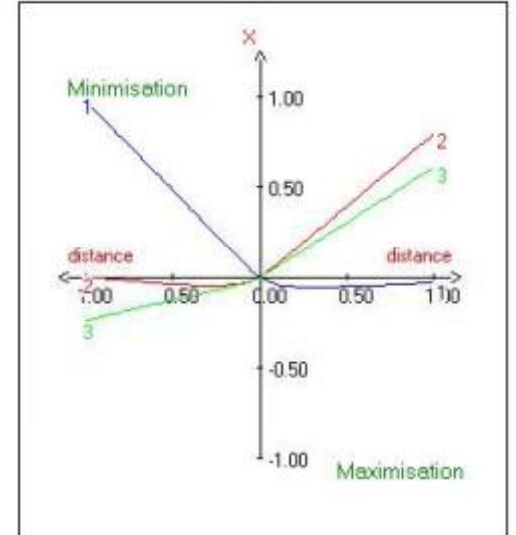
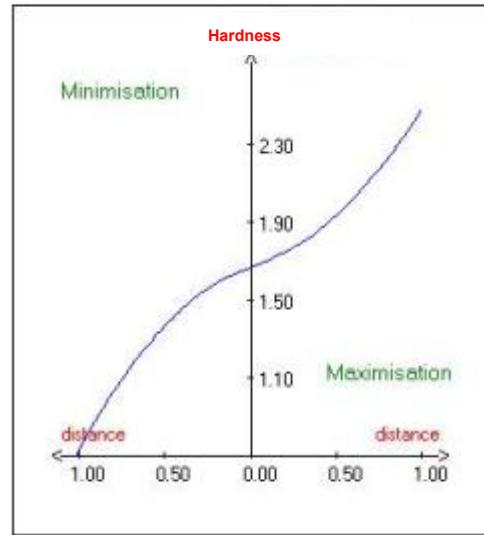
- Acidity (% oleic acid)
- Total polar materials (TPM)
- Recorded instrumental measurements with different devices (Testo , Ebro, PCT 120)

Fried products

- Oil content of fried product
- Fatty acid composition
- Crispness
- Hardness and rigidity

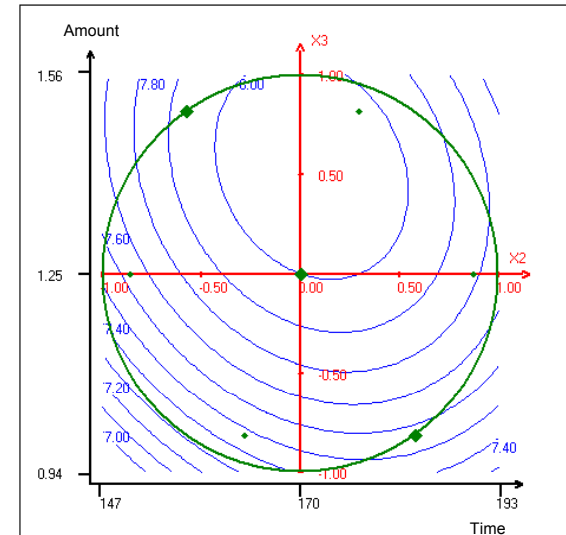
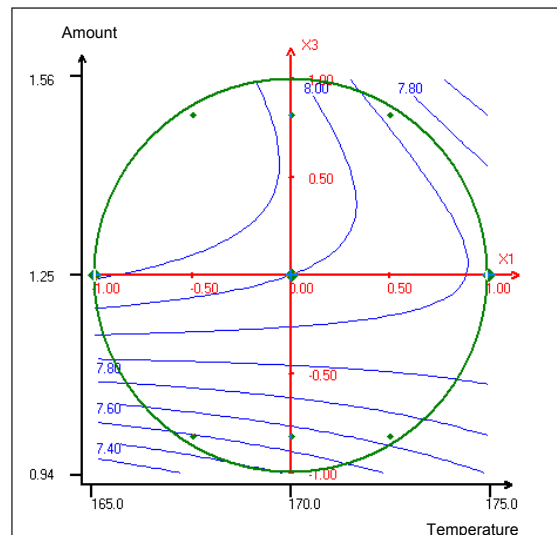
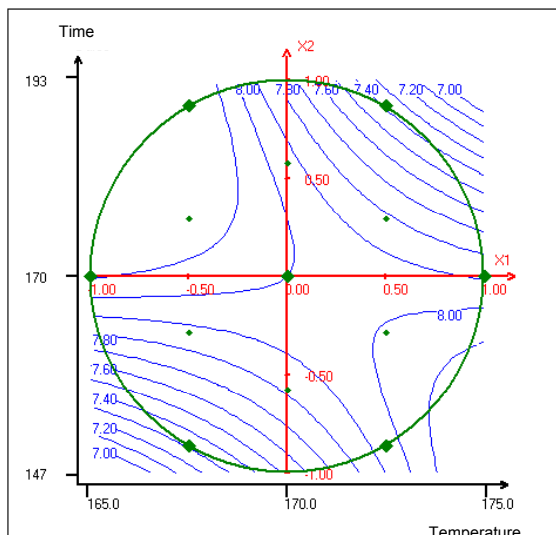
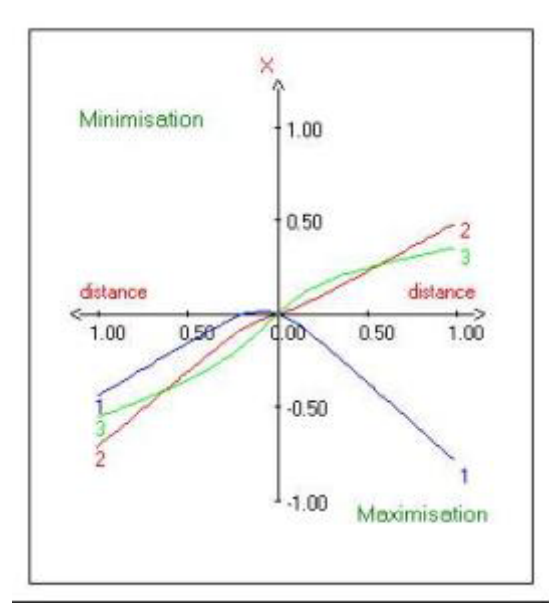
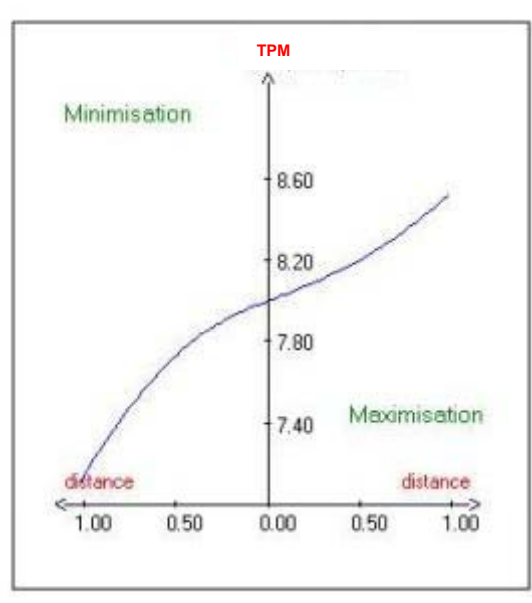
Hardness and rigidity obtained by puncturing French fries

Nom	Coefficient
b0	1.667***
Temperature b1	-0.225**
Time b2	0.188*
Amount b3	0.163*
b11	-0.667
b22	0.167
b33	-0.125
b12	0.058
b13	0.163
b23	1.037**



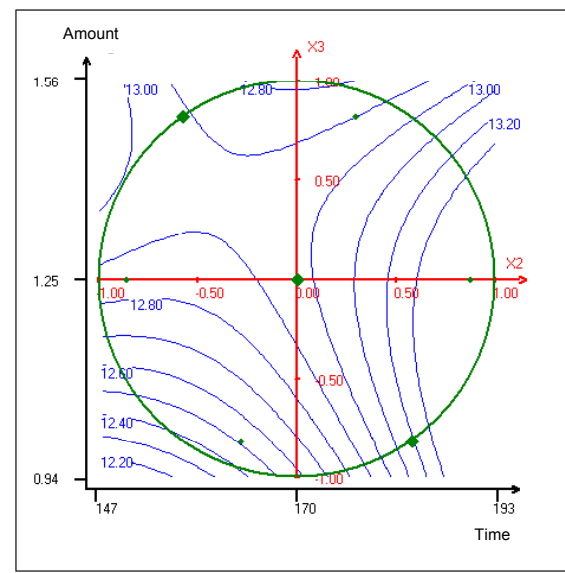
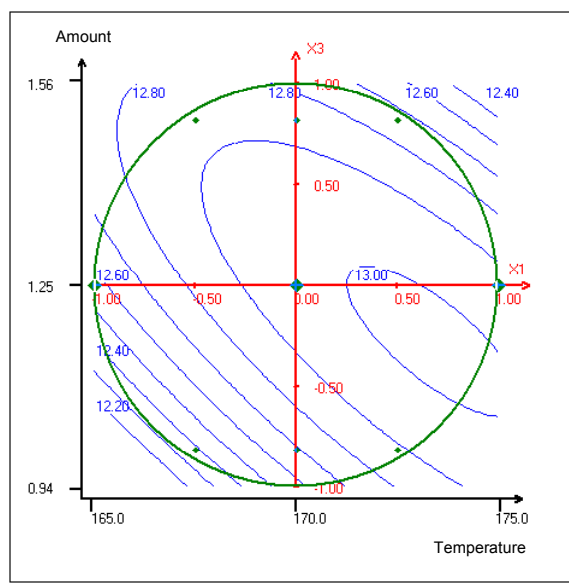
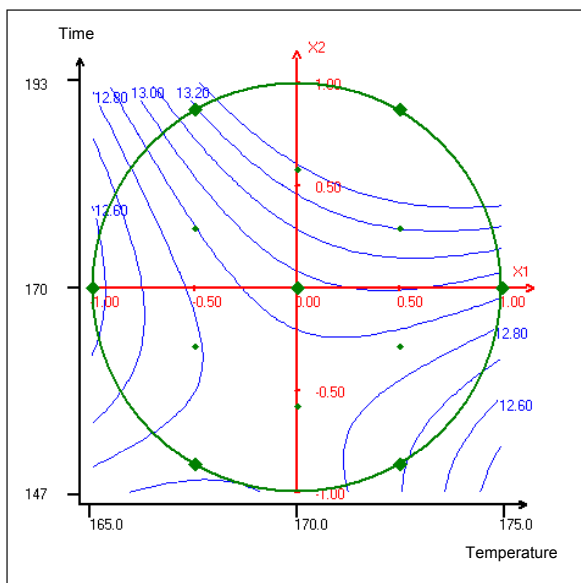
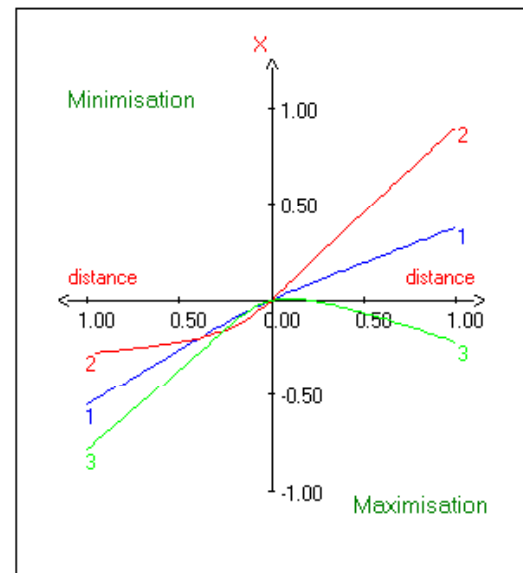
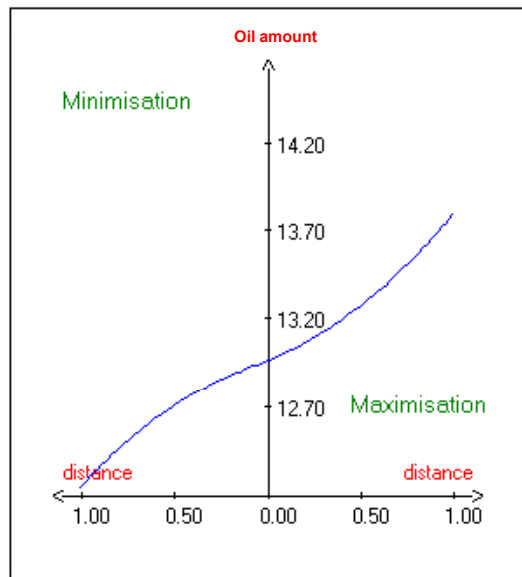
Total polar materials (TPM)

	Coefficient
b0	8.000***
Temperature b1	-0.112**
Time b2	0.108*
Amount b3	0.306*
b11	0.000
b22	-0.367
b33	-0.283
b12	-0.866*
b13	-0.306**
b23	-0.130



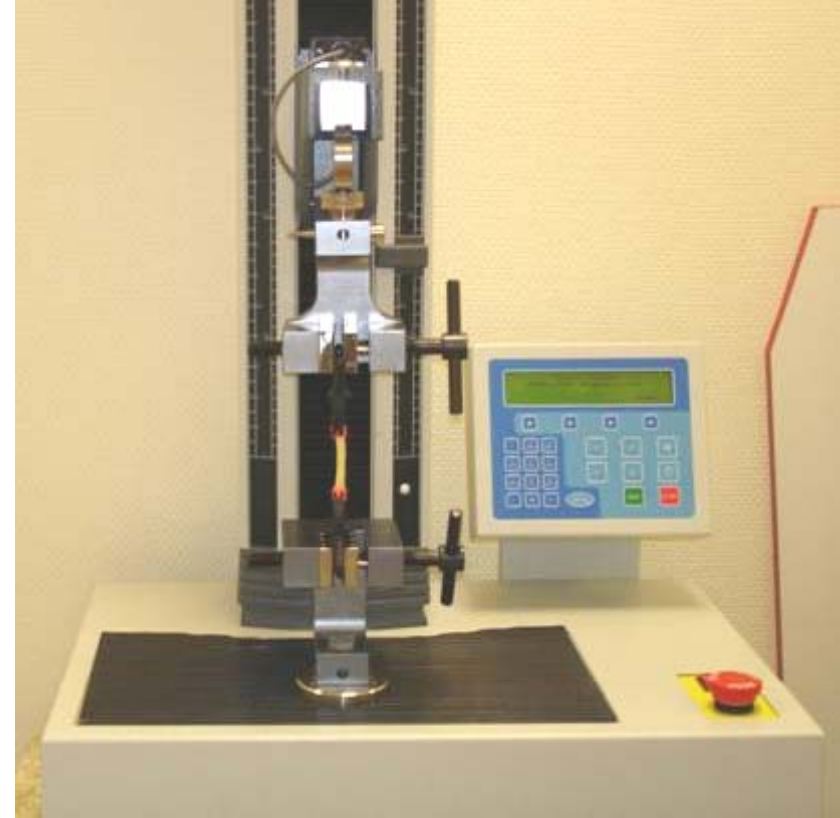
	Coefficient
b0	12.967***
Temperature b1	0.188 *
Time b2	0.382 ***
Amount b3	0.102 *
b11	-0.217
b22	0.283
b33	-0.292
b12	0.404
b13	-0.388
b23	-0.389

OIL AMOUNT IN FRIED PRODUCT



Texture of French fries is recognized as one of the most important quality aspects

Different mechanical properties of French fries have been measured using a LLOYD apparatus connected to a computer

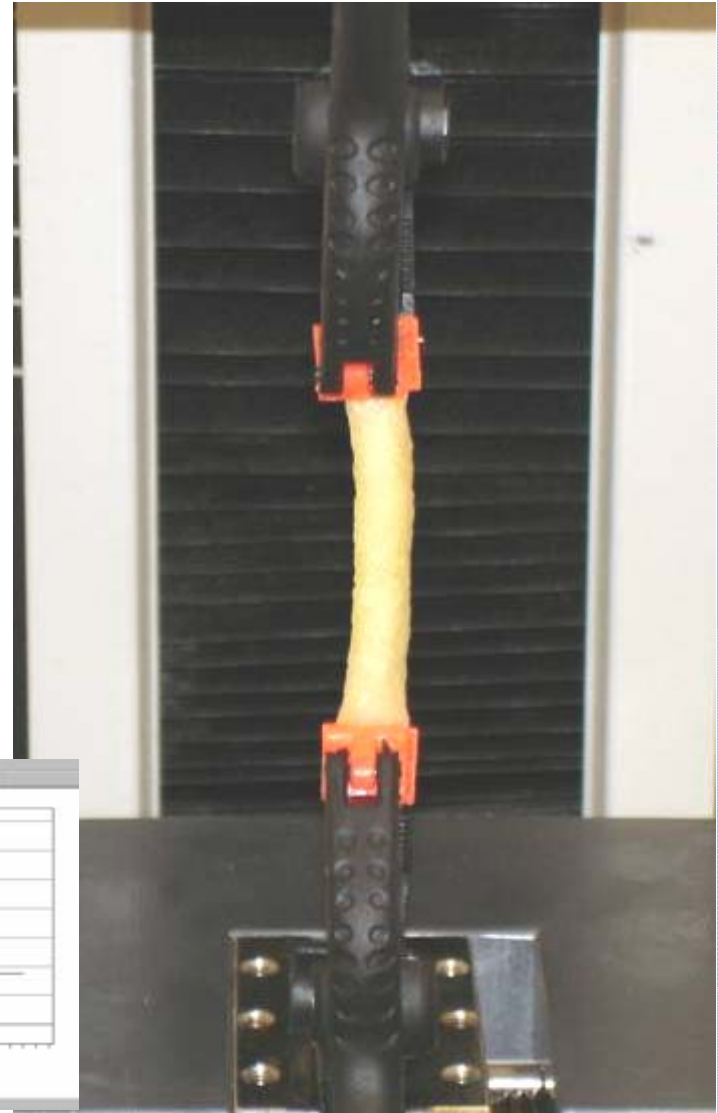
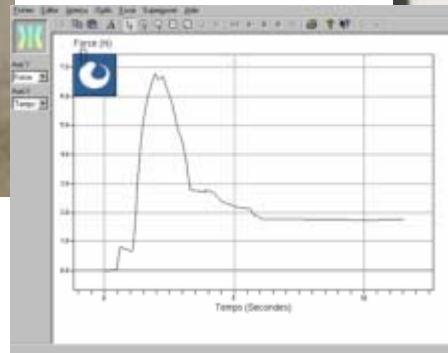
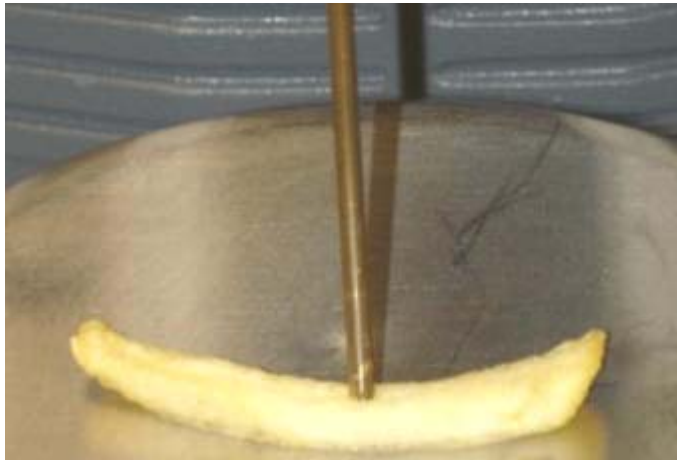


Timing for the texture measurements was strictly determined and exactly the same with each sample.

Different parameters characterizing the force displacement curve (hardness and rigidity) obtained by puncturing 10 French fries were performed

Stretching French fries 5 min after frying

Puncturing of French fries 5 min after frying



FATTY ACID COMPOSITION OF FRENCH FRIES

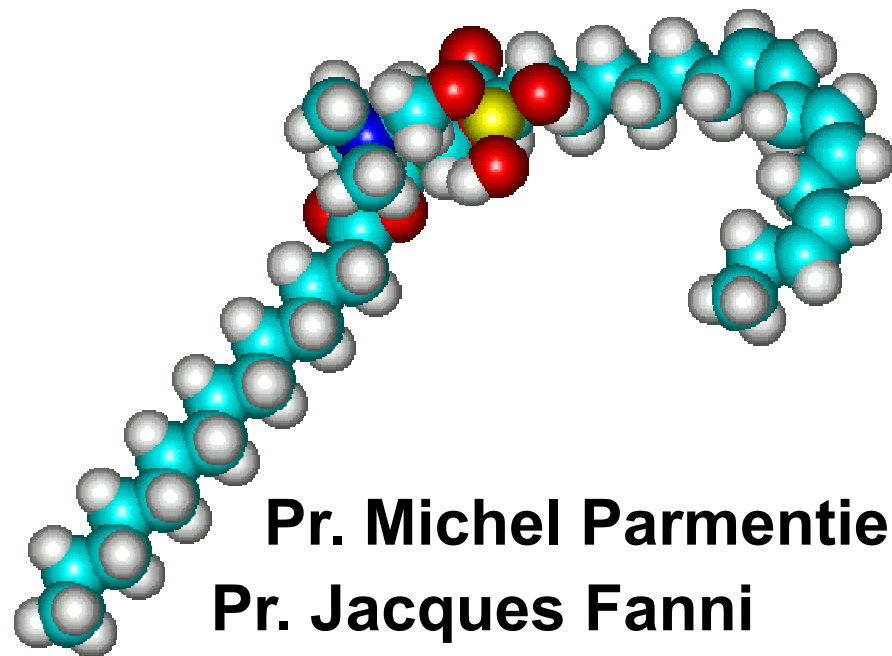
Palm oil (identified fatty acid %)	Oil from French fries
Lauric acid (C12:0)	0.22 ± 0.01
Myristic acid (C14:0)	1.34 ± 0.04
Palmitic acid (C16:0)	49.03 ± 0.20
Palmitoleic (C16:1)	0.21 ± 0.01
Stearic acid (C18:0)	4.22 ± 0.03
Oleic acid (C18:1n-9)	35.97 ± 0.20
Linoleic acid (C18:2n-6)	8.25 ± 0.13
α-linolenic acid (C18:3n-3)	0.11± 0.02
Arachidic acid (C20:0)	0.42 ± 0.01
Eicosenoic acid (C20:1)	0.19 ± 0.02
Behenic acid (C22:0)	-
ΣSFA	55.01
ΣMUFA	36.37
ΣPUFA	8.36
n-6	8.25
n-3	0.11

Frying oil (identified fatty acid %)	Oil from French fries
Lauric acid (C12:0)	-
Myristic acid (C14:0)	0.43± 0.01
Palmitic acid (C16:0)	18.46 ± 0.04
Palmitoleic (C16:1)	0.13 ± 0.01
Stearic acid (C18:0)	3.22 ± 0.01
Oleic acid (C18:1n-9)	61.72 ± 0.19
Linoleic acid (C18:2n-6)	13.38 ± 0.12
α-linolenic acid (C18:3n-3)	1.25 ± 0.01
Arachidic acid (C20:0)	0.40 ± 0.01
Eicosenoic acid (C20:1)	0.42 ± 0.01
Behenic acid (C22:0)	0.44 ± 0.01
ΣSFA	22.95
ΣMUFA	62.27
ΣPUFA	14.63
n-6	13.38
n-3	1.25

NEW CHARACTERISTICS... OF THE FRYING OIL

- ✓ A lower frying temperature
- ✓ Very low index of acidity
- ✓ The total amount of oil in French fries remained unchanged
- ✓ Improvement of the fatty acid profile according to the French National Nutrition Project for Health “PNNS 2”
- ✓ Preservation of the crispness





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