Recycling of sumac waste as a source of polyphenols using the novel processing technology of instant controlled pressure drop (DIC)

I.M Kamal and K. Allaf

University of La Rochelle
Laboratory For Transfer Phenomena and Instantaneity in Agro-Industry and Building (LEPTIAB)
La Rochelle / France

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The talk content

Introduction

- Polyphenols and sumac
- Sumac waste pre-treatment
- DIC Process: fundamentals and applications.

Experimental design

- The protocol of polyphenol extraction from sumac waste.
- Experimental design with DIC operating parameters as independent variables for the extraction of polyphenols from sumac waste.
- Assessment parameters as dependent variables.

Results and discussion

- Kinetic model and parameters,
- Energy consumption and environment content
- Economic and industrial impacts

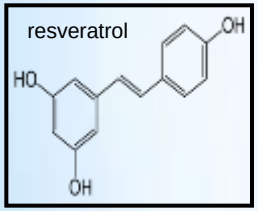
Conclusions

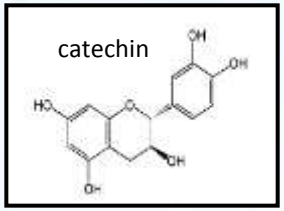
Sumac And Polyphonols

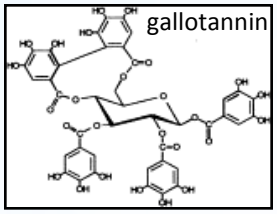
Plant polyphenols

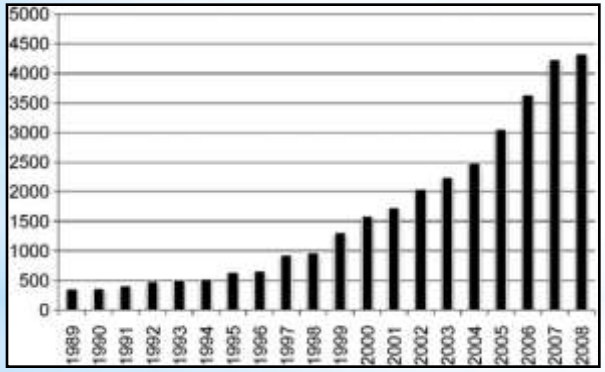
are a structural class of natural organic compounds characterized by the presence of large multiples of phenol substructures. Polyphenols present in fruits, seeds, vegetables and derived foodstuffs

- flavonoids
- tannins
- lignins







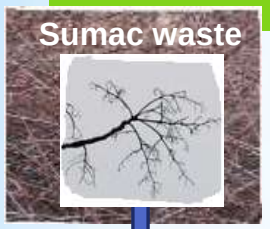


Evolution of the number of publications related to “polyphenols” from 1989 to 2008. (SciFinder Scholar).

Polyphenols benefits:
Their regular consumption has been claimed to be beneficial to human health owing to their ability to scavenge oxidatively generated free radicals, reducing their risk of certaine age-related degenerations and diseases.

Principal sumac uses:
The berries are used as a spice, drinks (wine and pink lemonade) , antiseptic mouthwash, a gargle for sore throats and in wound healing.
The leaves and berries as a substitute for tobacco, and in leather tanning.
The branches were used to make teas for treating tuberculosis.

Sumac Waste Pre-treatment And Polyphenols Recovery



Cleaning and cutting

Thermo-mechanical treatment by DIC

Air drying

waste

Treatment

Physical

Chemical

Thermal

Biological

Changing the characteristics of the waste

Reduce its quantity

Reduce its hazardous nature

Facilitate its handling

Enhence its recovery

Solvent Extraction

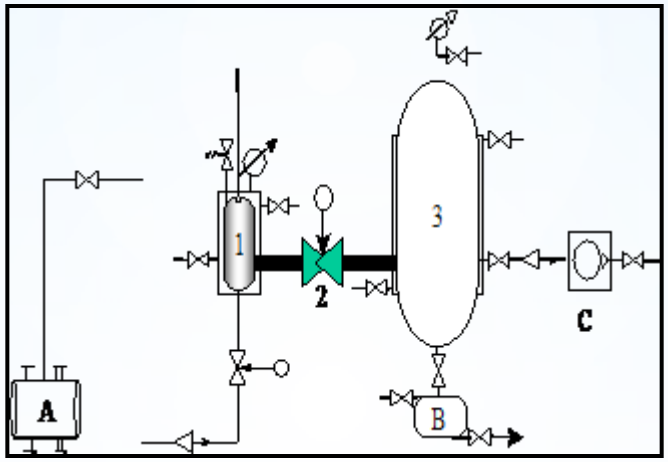
Methanol: Water (70:30 v/v), solvent/sample ratio (20:1) (v/wt)

Polyphenols

Quantification and evaluation

The DIC Process : The Instant Control Pressure Drop (Détente Instantanée Controlée)

The controlled short time-high temperature process

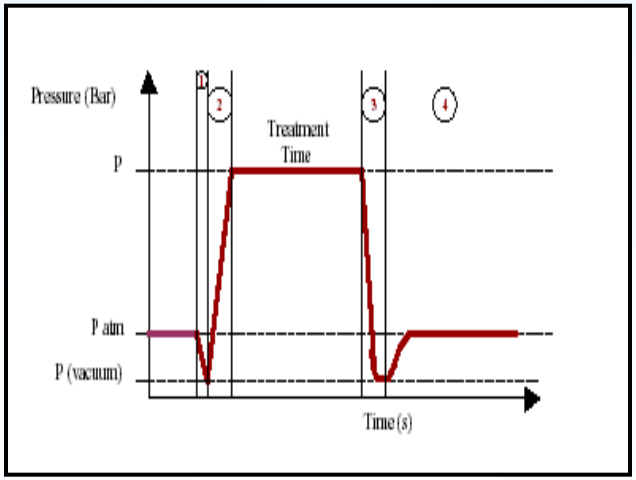


Schematic diagram of the DIC unit

(1): Reaction chamber. (2): Pressure-Drop valve.
(3): Vacuum tank; (A): Steam generator. (B): condenser.
(C): : Vacuum pump

How does DIC operate?

The DIC Process : The Instant Control Pressure Drop (Détente Instantanée Controlée)



DIC Pressure-Temperature-Time profile

The impacts of DIC process

1. Deep modification in texture and structure of the complex material. **2**. Decrease the degree of polymerization.
3. Weakining of the molecular bonds between the constituents. **4.** Increasing superficial area of the particulates.
5. Enhence waste hydrolysis. **6.** Improving the extraction kinetics. **7.** Effective decontamination.

Process and product optimization using designed experiments (RSM)

Independent variables

Dependent variables (responses)

DIC operating parameters

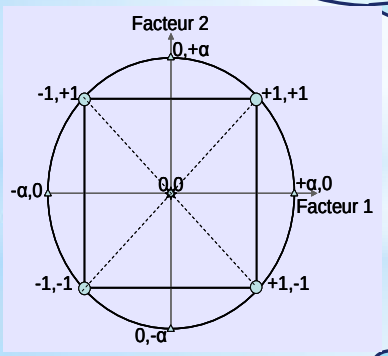
Substrate (RM) characteristics

Product characteristics:
Physical and chemical properties of the product, production rate and yield, etc.

P, t, cycles no.

% water content, particle size, etc.

Evaluation



$$\alpha = \sqrt[4]{2^k} = 2^{0,25*k}$$

Experimental Design

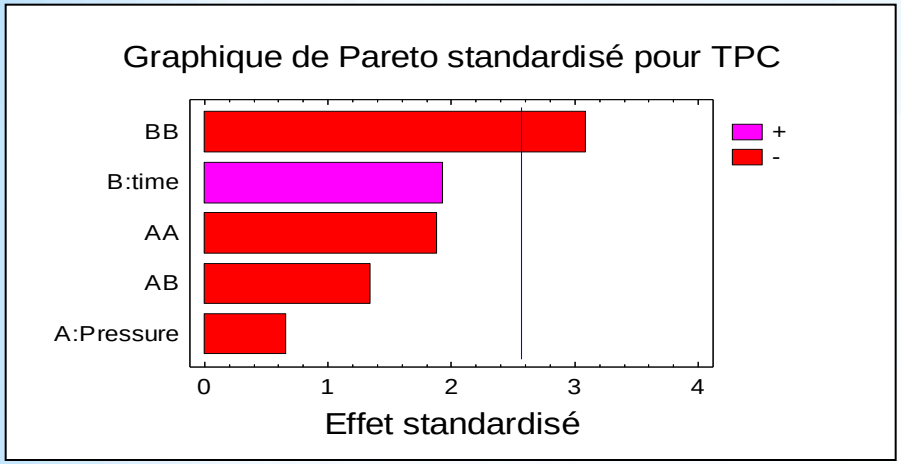
Data analysis

Data

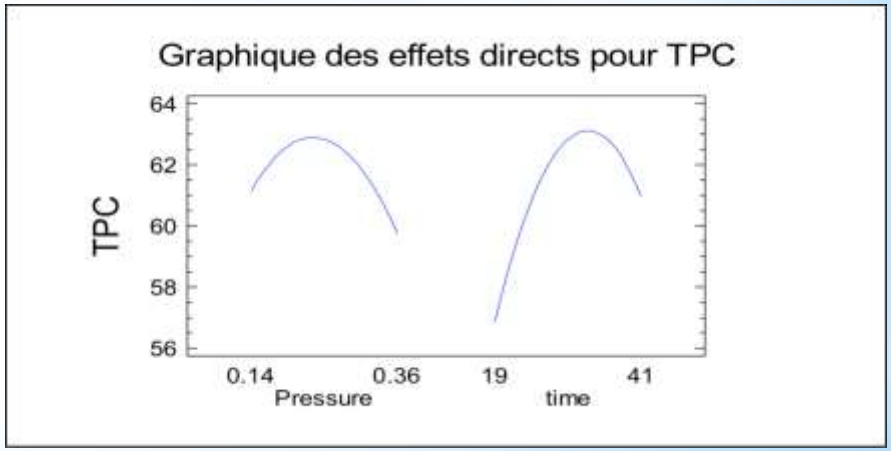
Carrying out no. of experiments

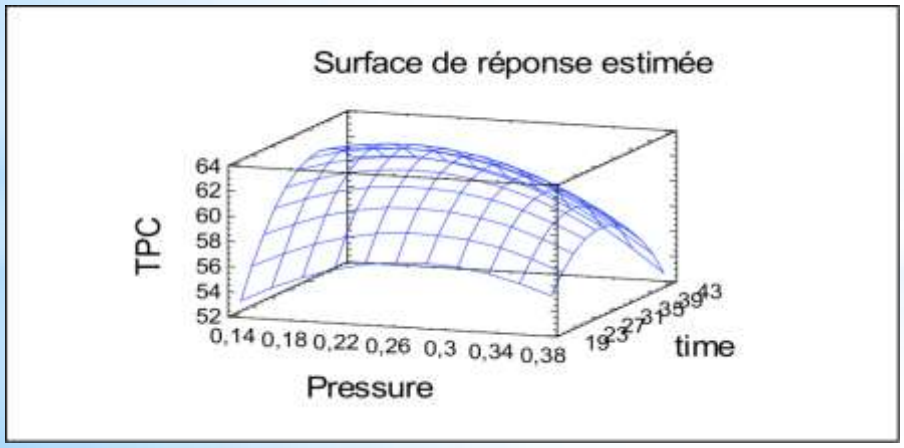
exp. No.	Pressure MPa	Total time s
1	0.4	30
2	0.3	45
3	0.3	30
4	0.4	41
5	0.4	19
6	0.3	30
7	0.1	19
8	0.1	41
9	0.1	30
10	0.3	15
11	0.3	30

Response surface analysis of TPC for sumac waste



RM TPC (1 h extraction):
50mg GA/g dry basis

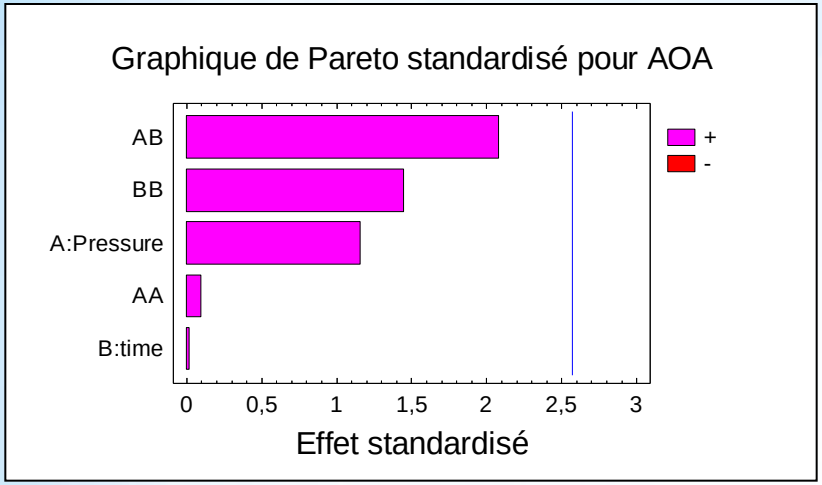


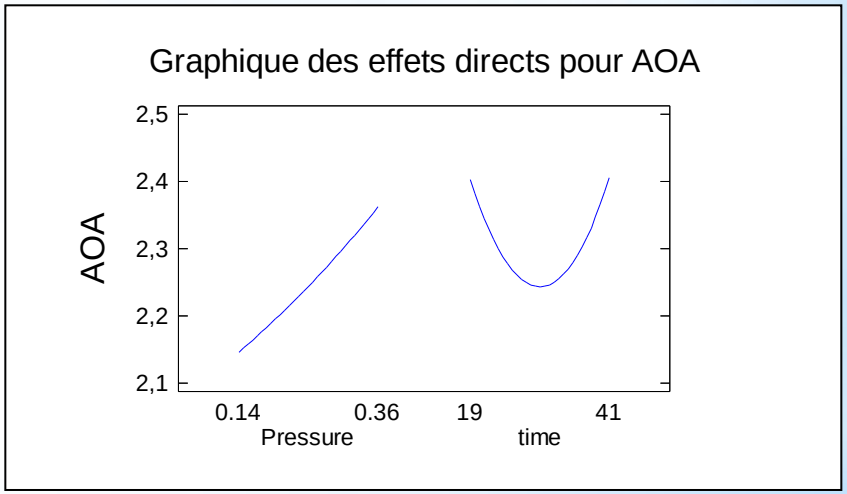


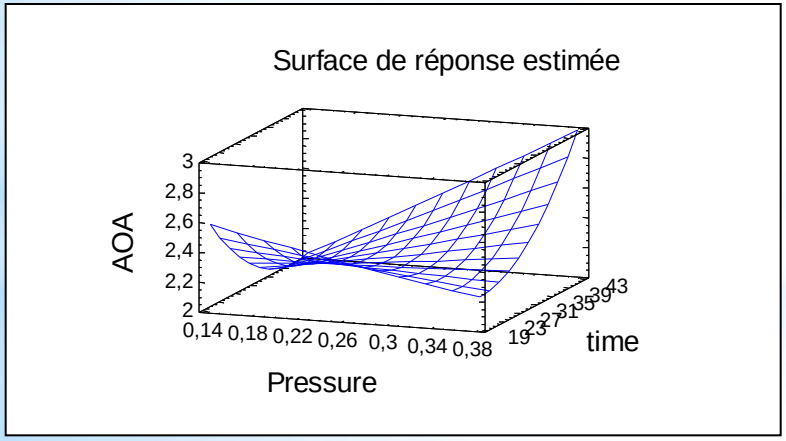
Optimum Pressure	0.22
Optimum time	33.72

$$TPC = 4.69 + 142.69\ P + 2.55\ t - 197.52\ P^2 - 1.68\ Pt - 0.0324\ t^2$$

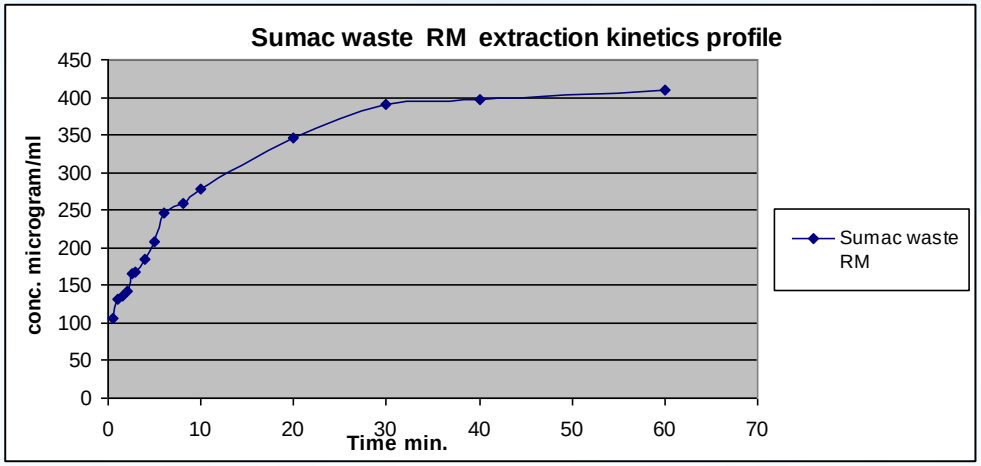
Response surface analysis of AOA for sumac waste

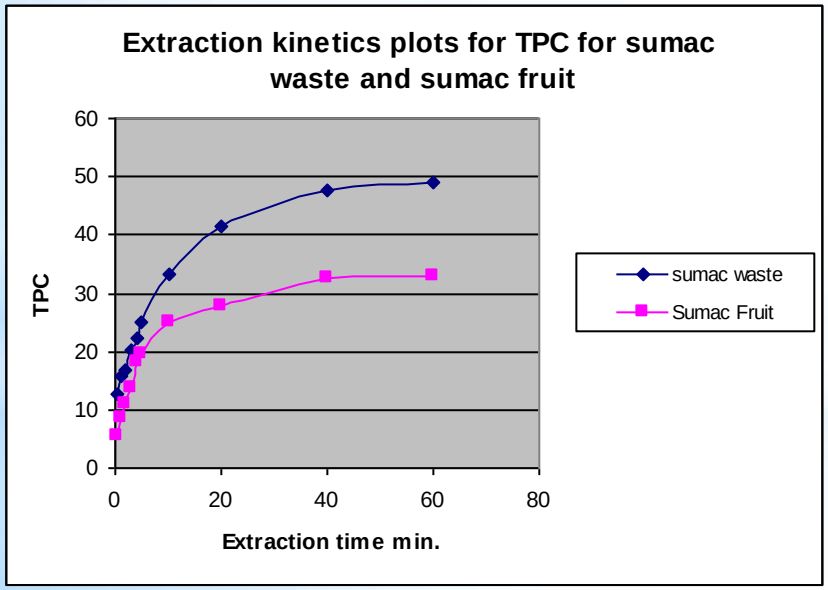


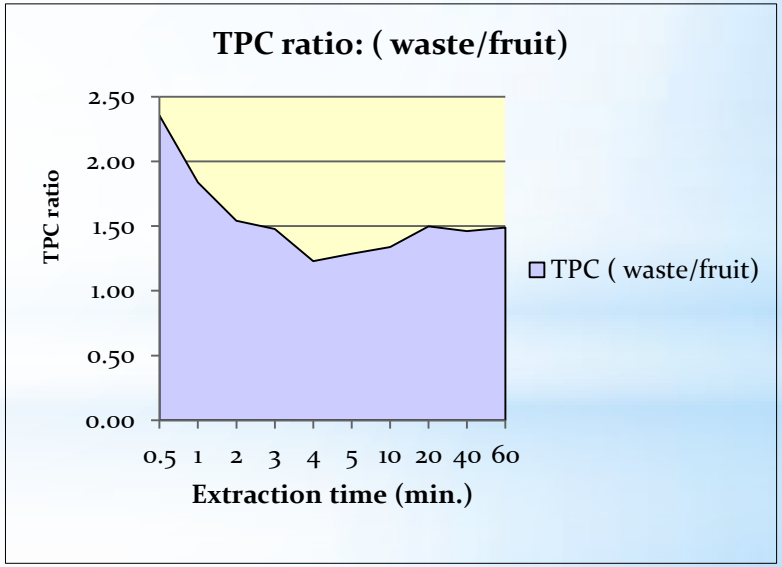


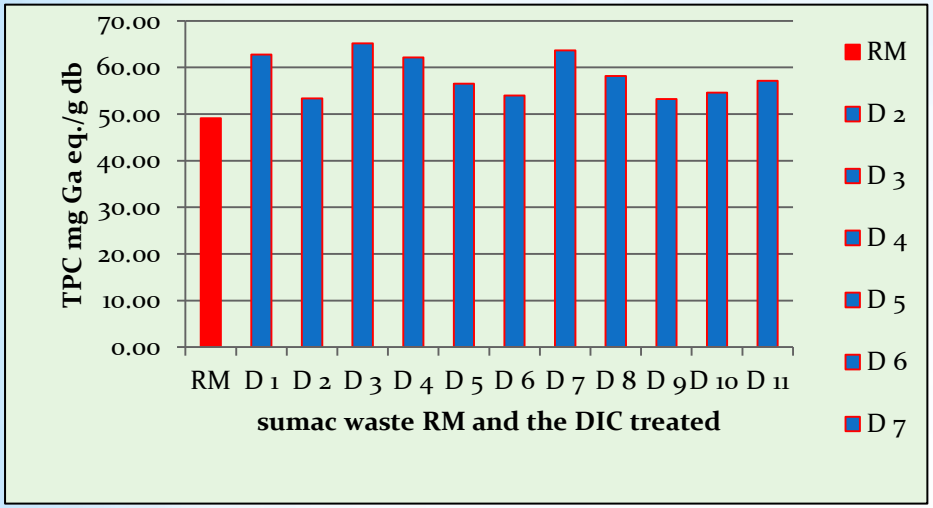


RM AOA : 2.1 µg/ml

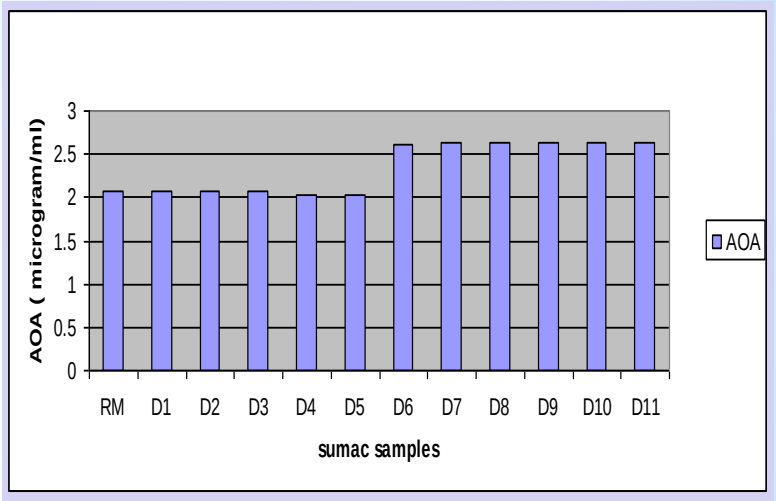

Sumac waste RM extraction kinetics profile
conc. microgram/ml
Time min.
Sumac waste RM


Extraction kinetics plots for TPC for sumac waste and sumac fruit
TPC
Extraction time min.
sumac waste
Sumac Fruit


TPC ratio: (waste/fruit)
TPC ratio
Extraction time (min.)
TPC (waste/fruit)

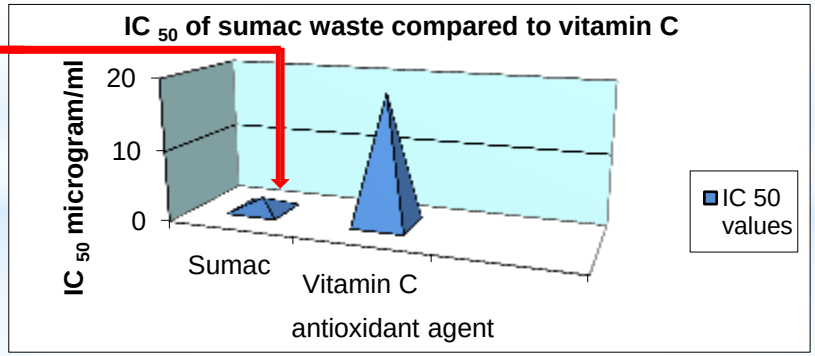


TPC for sumac waste RM and the DIC treated



AOA from DPPH assay for sumac waste RM and the DIC treated

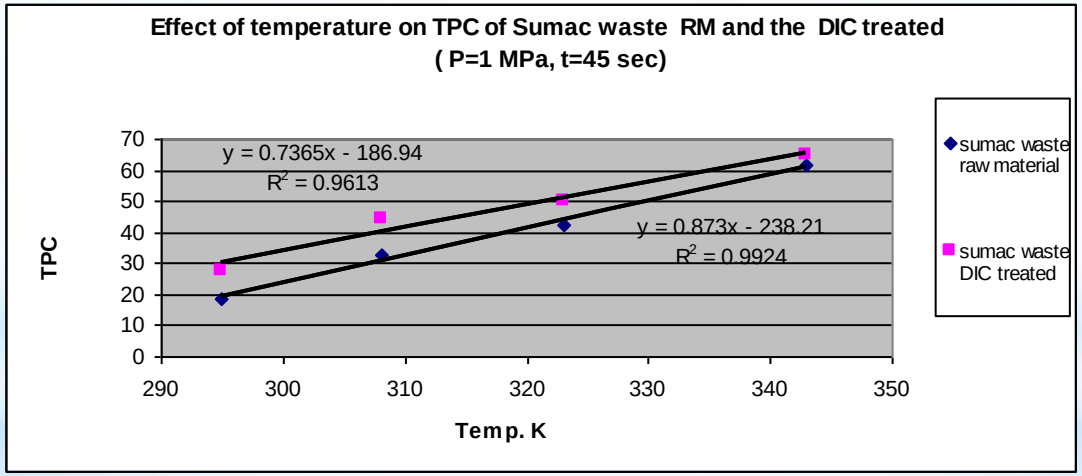
The lower IC $_{50}$ the higher AOA



IC$_{50}$: (The conc. Of antioxidant necessary to decrease the initial DPPH concentration by 50%) for sumac waste and vitamin C.

The effect of temperature on the TPC extracted from sumac waste raw material and sumac waste treated by DIC (P= 1 MPas, time= 45 sec)

TPC (RM)	TPC (waste)	Extraction temp. (K)
18,35	27,61	295
32,80	44,27	308
42,36	49,89	323
61,46	65,14	343



The activation energy estimated were:

17.74 kJ/mole for sumac waste raw material

11.48 kJ/mole for the DIC treated waste sample

Conclusions

1. Sumac waste could be considered as a **natural antioxidant source**.

2. **Higher antioxidant yield** with **sumac waste** than sumac fruits.

3. DIC as a pre-treatment step prior to extraction leads to remarkable **improvement** in the **extraction kinetics** of polyphenols.

4. The extraction temperature up to 70 ^{o}C has a positive effect on the yield of total phenols.

5. The **activation energy** for total phenol extraction estimated at a temperature range from 22 to 70 ^{o}C is **lower** for the DIC treated sumac waste samples compared to the untreated sumac waste raw material.

THANK YOU FOR YOUR ATTENTION

Дякую вам за увагу