EFFECT OF HEAT TREATMENT ON SMOOTHIE QUALITY BY RESPONSE SURFACE METHODOLOGY

The 1st International Electronic Conference on Food Science and Functional Foods

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Introduction

Smoothies are a popular and convenient way of fruit and vegetables consuming and are defined as semi-processed, not refined, obtained by mechanical treatment (or, less often, by thermal treatment) of fruit followed by their preservation [1]. Products colour, texture and flavour are the key factors influencing the consumer acceptability. Enzyme polyphenoloxidase (PPO, EC 1.14.18.1) activity leading to degradation of polyphenols content and could decrease the nutritional status of product as a significant portion of anti-inflammatory and health promoting properties attributes related to polyphenolic compounds [2,3]. Preservation technologies are necessary to minimize quality changes and extend the shelf-life of foods. The conventional treatment usually applied is heat treatment, which promotes the enzymatic and microbial inactivation resulting in to organoleptic and nutritional quality losses of product.

MAIN GOAL: To evaluate the impact of **heat treatment (HT)** on **smoothie** constituted by "Fuji "apple (41%), pineapple (31%), cabbage (8%), pumpkin (10%) and banana (10%), based on response surface methodology (RSM), using the **temperature (70° – 100 °C)** and **treatment time (0.5 – 10.5 min)**, as dependent variables.

Material and methods

SMOOTHIE PREPARATION

41% 31% 8% 10% 10%

1. Decontamination treatment — Chlorinated water (HIPO, 150 ppm, 2 min at 5 °C)
2. Washing — Tap water
3. Water excess elimination — Absorbent paper
4. Peeling and slicing
5. Pre-heat treatment — (100 °C/5 min) (90 °C/6 min)
6. Cooling — (water/ice bath during 5 min)
7. Homogeneization
8. Packaging — (Laminated polyamide polyethylene)
9. Heat treatment — (see Table 1)
10. Cooling

Figure 1 – Diagram flow of processing operation for smoothie preparation.

OPTIMIZATION OF HEAT TREATMENT CONDITIONS

EXPERIMENTAL DESIGN

Evaluation of main interaction and quadratic effects of heat treatment conditions (temperature and time) on smoothie quality by central composite rotatable design (CCDR).

Table 1 – Coded and decoded matrix of independent variables.

Coded independent variables		Decoded independent variables	
X1	X2	Temperature (ºC)	Time (min)
-1	-1	75	2
-1	1	75	9
1	-1	95	2
1	1	95	9
-1.41421	0	70	5.5
1.41421	0	100	5.5
0	-1.41421	85	0.5
0	1.41421	85	10.5
0	0	85	5.5
0	0	85	5.5
0	0	85	5.5
0	0	85	5.5
0	0	85	5.5
0	0	85	5.5

INDEPENDENT VARIABLE

Temperature (70 – 100 ºC) and time (0.5-10.5 min)

DEPENDENT VARIABLE

Colour and PPO enzymatic activity

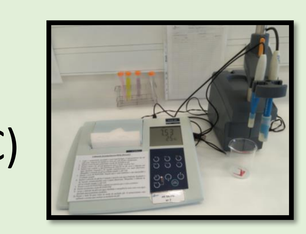
EVALUATION OF OPTIMIZED HEAT TREATMENT

Impact of optimized heat treatment (85 ºC during 7 min) on smoothie quality: A REDUCTION OF PPO ENZYMATIC ACTIVITY WITH MINIMAL EFFECT ON GREEN COLOUR WAS ATTAINED?

METHODOLOGY

COLOUR[4]

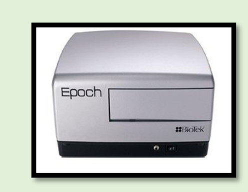
pH and SOLID SOLUBLE CONTENT (SSC)



POLYPHENOLOXIDASE ENZYMATIC ACTIVITY (PPO)[5]

ANTIOXIDANT CAPACITY (DPPH[6], FRAP[7], ABTS[8])

TOTAL PHENOLIC CONTENT[9] (TPC)



STATISTICAL ANALYSIS

ANOVA, Tukey test $P < 0.05$, significant differences

Results

OPTIMIZATION OF HEAT TREATMENT CONDITIONS

The mathematical models for all attributes studied have been developed by response surface methodology (RSM) and its adequacy was tested by analysis of variance technique (ANOVA). The models equations (Eq. 1–4) resulted from RSM and the corresponding correlation coefficient (R^2 and R^2_{adj}) are summarized at Table 2. Both values of R^2 and R^2_{adj} indicated the variation in colour changes and inactivation of PPO activity explained by the models. The obtained results showed that the second-order polynomial model adequately represented the experimental data .

Table 2 - Model equations of L*, a* and hue colour parameter and PPO enzymatic activity with respective regression coefficient.

Eq.	Parameter	Model equations	R^2	R^2_{adj}
(1)	PPO	$PPO=414.70-8.42*T+0.05*T^2-1.22*t+0.55*t^2-0.09*T*t$	0.97	0.96
(2)	L*	$L^*=-12.52+1.57*T-0.010*T^2-2.58*t+0.029*T*t$	0.84	0,77
(3)	a*	$a^*=-28.56+0.18*T+1.89*t-0.021*t^2-0.013*T*t$	0.86	0.79
(4)	hue	$^oh=166.43-0.99*T+0.004*T^2-2.71*t+0.091*t^2+0.01*T*t$	0.92	0.87

Figure 1 shows the effects of temperature (T) and time (t) of heat treatment on colour (L* and a* colour value) and PPO enzymatic activity (C) of smoothie, respectively. Visual assessment of heat-treated smoothies confirm the darkness as consequence of heat treatment intensity.

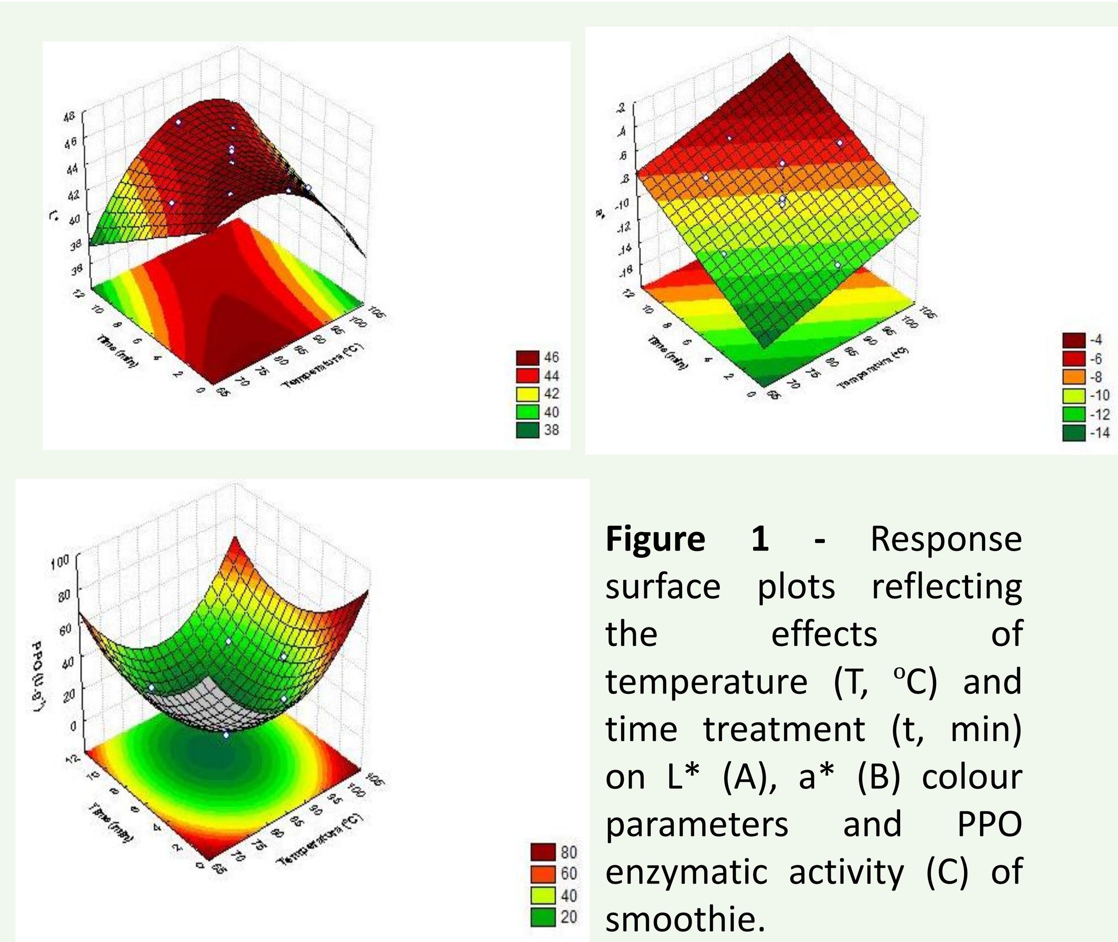


Figure 1 - Response surface plots reflecting the effects of temperature (T, ºC) and time treatment (t, min) on L* (A), a* (B) colour parameters and PPO enzymatic activity (C) of smoothie.

The highest values of luminosity were obtained after treatments at temperature range of 75° – 85 °C during period less than 6 min. The temperature and the time between 75 ° - 90 °C and 5 - 10 min led to the reduction of PPO enzymatic activity, an important enzyme that contributes to the enzymatic browning by oxidation of phenolic compounds.

EVALUATION OF OPTIMIZED HEAT TREATMENT

Regarding the Table 3, the heat-treated smoothie denoted a reduction of PPO enzymatic activity (90%), an important achievement since this enzyme is responsible for browning product.

Table 3 - Physical-chemical characterization of untreated and heat-treated smoothie

Quality parameter	Untreated	Heat-treated
CIE Lab		
L*	42.14 ± 0.35 ᵃ	43.94 ± 0.60 ᵇ
a*	-16.14 ± 0.49 ᵃ	-7.73 ± 0.42 ᵇ
b*	29.95 ± 1.14 ᵃ	29.51 ± 0.59 ᵃ
ºh	118.33 ± 0.30 ᵃ	104.67 ± 0.60 ᵇ
Antioxidant capacity (µmol Trolox.100g^{-1})		
FRAP	5230.49 ± 177.10 ᵃ	5911.44 ± 216.81 ᵇ
DPPH	6321.29 ± 441.15 ᵃ	7443.79 ± 448.85 ᵇ
ABTS	1564.32 ± 183.00 ᵃ	2350.56 ± 82.07 ᵇ
Total phenolic content (mg GAE.100g^{-1})	77.68 ± 2.05 ᵃ	85.34 ± 4.51 ᵇ
PPO activity (U.g^{-1})	28.12 ± 2.66 ᵃ	2.46 ± 0.96 ᵇ
pH	3.57 ± 0.01 ᵃ	3.57 ± 0.01 ᵃ
Solids soluble content (ºBrix)	10.51 ± 0.06 ᵃ	10.61 ± 0.06 ᵇ

Average ± standard deviation, different letters between columns indicate significant difference (P <0.05)

Conclusions

The impact of **heat treatment at 85 °C during 7 min**, condition optimized by response surface methodology, was validated to guarantee the **reduction of PPO enzymatic activity (90%), minimal colour alteration and augmented of antioxidant capacity of green smoothie**. The study contributed to elevate the **potential of fruits and vegetables consumption by food development** with remarkable bioactive compounds, which can be positive for maintenance of smoothie quality during refrigerated storage.

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