ANTIOXIDANTS APPLICATION FOR PREVENTION OF RANCIDITY DEVELOPMENT IN CHICKEN REFRIGERATED BREAST MEAT USING RESPONSE SURFACE METHODOLOGY

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BACKGROUND

Pre-cooked, refrigerated ready-to eat meat based foods are increasingly in demand by consumers. The quality of this type of food is limited by warmed-over flavor, which is rancid or stale flavors that develops in cooked meat, even at short time in refrigeration. The term warmed-over flavor (WOF) was first introduced by Tims e Watts (1958) to describe the rapid development of oxidized flavor in cold cooked meat upon subsequent heating. The oxidized flavor becomes readily apparent within first 48 h of refrigeration at 4°C in contrast to the more slowly developing rancidity that becomes evident only after freezing storage for several days.

Response Surface Methodology (RSM) is a statistical technique for empirical model building. By careful design and analysis of experiments, RSM can relate a response or variable output with the levels of a number of predictors or input variables (Box & Draper, 1987). Subsequently, a three dimensional plot provides modes for checking operating conditions to achieve the desired specifications, and search for optimum conditions (Pearson *et al.*, 1962, Barretto, *et al.*, 1996).

OBJECTIVES

The objective of this work was to investigate the best conditions of exogenous addition of phytic acid and vitamin E on lipid oxidation and WOF development in chicken breast meat, *Pectoralis major m.*, using response surface methodology.

METHODS

Phytic acid (phytic acid dodecassodium salt, Sigma) (0-4mM) and vitamin E (α-tocopheryl acetate, Roche) (0-0.40g/kg of samples) were added in fresh breast meat samples at three-levels and 2-factors with three replicates at the center point according to Table 1. For WOF determination, samples were vacuum packed and cooked in a water bath up to an internal temperature value of 75°C. Subsequently, samples were stored at 6°C for 48 h under fluorescent light. Then, samples were re-heated in a microwave for 4 minutes, cooled and for development of WOF. The response functions were lipid oxidation and WOF development, both measured by TBARS according to Tarladgis et al. (1964) expressed in log of μg of TBARS/kg of samples.

RESULTS AND DISCUSSIONS

The analysis of variance for both lipid oxidation and WOF development is shown in Tables 2 and 3, respectively. It is shown that the model for lipid oxidation presented $R^2 = 0.852$, coefficient of variation of 4.60% and no significant lack of fit ($P = 0.2655$). This model is given below:

$$Y = 2.064 - 0.128x_1 - 0.1302x_2 + 0.059x_1^2 + 0.093x_2^2 - 0.099x_1x_2$$

Analysis of variance for WOF development showed that the model presented satisfactory $R^2 = 0.977$, coefficient of variation of 2.50%, indicating low variability of results and regression highly significant ($P = 0.0004$). But the lack of fit was significant ($P = 0.0277$), however Box and Draper (1987) postulated that lack of fit test would not be considered when sum of square of error is very low (Table 3). Then, the model was considered to be adequate for the present investigation:

$$Y = 3.485 - 0.505x_1 - 0.034x_2 + 0.232\,x_1^2 - 0.012x_2^2 + 0.012x_1x_2$$

The relationship between factors and both response; lipid oxidation and WOF development, can be better understood by examining the response surface plots in Figures 1 and 2, respectively. Phytic acid and vitamin E inhibited the lipid oxidation, the minimum region occurred at concentrations of 4mM of phytic acid and 0.40g of vitamin E/kg of samples. However, for WOF development only the presence of phytic acid showed to be significantly relevant. The exogenous addition of vitamin E up to 0.40g/kg of sample was the minimum concentration to influence lipid oxidation and this amount did not affect WOF formation. This is not the case when vitamin E is given in the dietary supplementation for the birds which efficiently inhibited WOF development as demonstrated recently (Shimokomaki, *et al.*, 1999).

CONCLUSIONS

Response surface methodology indicates that phytic acid significantly contributes to inhibit both lipid oxidation and WOF development and the most effective concentration was 4mM. The exogenous vitamin E was not efficient antioxidant for prevention neither lipid oxidation nor WOF formation.

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Table 1 – Variables, levels and experimental design

Assays n°*	Coded variables		Uncoded variables	
	x_1	x_2	X_1	X_2
1	-1	-1	0	0
2	0	-1	2	0
3	+1	-1	4	0
4	-1	0	0	0.20
5	0	0	2	0.20
6	0	0	2	0.20
7	0	0	2	0.20
8	+1	0	4	0.20
9	-1	+1	0	0.40
10	0	+1	2	0.40
11	+1	+1	4	0.40

X_1= phytic acid (mM) and X_2= vitamin E (g of tocopheryl acetate / kg of samples)
* Assays were run in a random order

Table 2 – Analysis of variance for lipid oxidation

Source	df	Sum of square	Prob > F
Model	5	0.2799	0.0168
Linear	2	0.1999	0.2153
Quadratic	2	0.0411	0.1016
Cross product	1	0.0389	0.0385
Lack of fit	3	0.0395	0.2655
Pure error	2	0.0090	
Total error	5	0.0485	

$R^2 = 0.852$; cv = 4.60%

Table 3 – Analysis of variance for WOF development

Source	df	Sum of square	Prob > F
Model	5	1.6825	0.0004
Linear	2	1.5391	0.0001
Quadratic	2	0.1428	0.0229
Cross product	1	0.0006	0.8020
Lack of fit	3	0.0397	0.0277
Pure error	2	0.0008	
Total error	5	0.0405	

$R^2 = 0.977$; cv = 2.50%

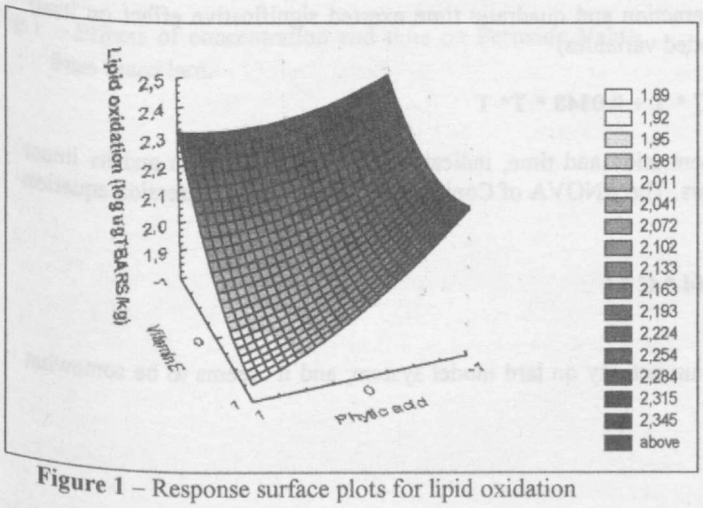

Figure 1 – Response surface plots for lipid oxidation

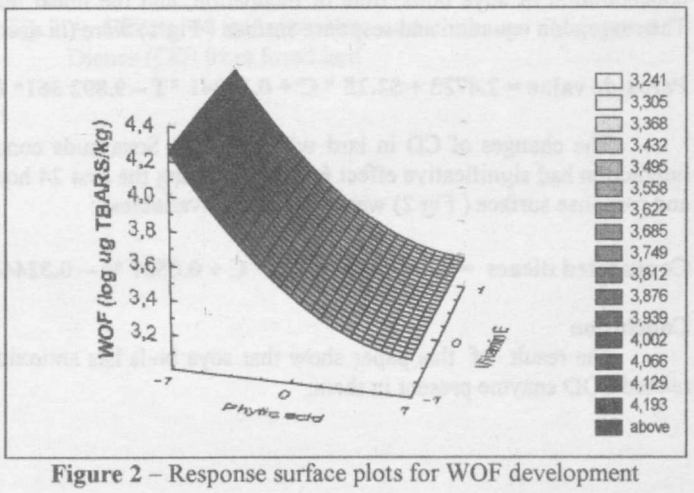

Figure 2 – Response surface plots for WOF development