EVALUATION OF EFFECTS OF ADDING TEXTURED SOY PROTEIN, OKARA AND FAT ON TECHNOLOGICAL CHARACTERISTICS OF HAMBURGERS

Fábio A. G. Coró[1*], Neusa F. Seibel[1], Heloisa G. Falcão[1], Jéssica C. Devidé[2], Sarah N. Ribeiro[2], Margarida M. Yamaguchi[1]

[1]Professional Master Program, Federal Technological University - Paraná - Campus Londrina, Estrada dos Pioneiros, 3131, CEP 86036-370, Londrina. Paraná. Brazil.
[2]Graduate Student in Food Technology, Federal Technological University – Paraná – Campus Londrina. Paraná. Brazil.

Abstract – Brazil has one of the largest productions of soybeans in the world, with 75 million tons in 2011 and considering an increase in its industrialization a large amount of by-products will be produced. The aim of this study was to use okara, a low-cost residue obtained from the processing of soybeans in developing beef hamburgers. The effect of okara in burgers was evaluated by examining the amount of swelling volume, water absorption index and rate of oil absorption index. A Simplex-Centroid experiment was used to evaluate the effect of addition of textured soy protein (TSP), the okara and fat in concentrations ranging from 0 to 8% applied at seven different assays. The models obtained from the statistical analysis proved to be significant, up to 95%. Tests with addition of okara produced better results in swelling volume, for water absorption index when used textured soy protein, and for the oil absorption index, when used fat. The results show that all ingredients improved characteristics of hamburgers evaluated in this study in the range studied.

Key Words – Beef hamburgers, Simplex centroid experimental design, Soy residue, Okara.

I. INTRODUCTION

Soy is considered the main culture of the Brazilian agricultural sector [1] and in crop year 2010/2011, Brazil was the second largest global producer of soybeans, producing 75 million tons of grain, representing about 28% of the world crop is estimated at 263.7 million tonnes [2]. The aqueous extract of soybean is the main form of consumption among its derivatives [3] however, its processing produces a byproduct called by the Orientals as "okara". this in turn has high nutritional quality [4] and protein amount, but little use in the food industry. Response surface methodology, a powerful mathematical and statistical technique for testing, multiple process variables and their interactive and quadratic effects, is useful in solving multivariable equations obtained from experiments simultaneously. This method has been used for the simultaneous analysis of the effects of process parameters in fresh meat processing and also in meat products. The aim of this study was to determine the combined effect of fat, okara and texturized soy protein (TSP) on volume swelling, water absorption index, oil absorption index of hamburger.

II. MATERIALS AND METHODS

The effect of okara on technological properties (functional) of beef hamburgers was evaluated through analysis of volume swelling, water absorption index, oil absorption index [5]. A simplex-centroid experimental design was applied to evaluate the effect of the addition of texturized soy protein (TSP) (x1), okara (x2) and fat (x3), in concentrations ranging from 0 to 8%, applied in seven treatments. The analysis was carried out in five samples of each test. Statistical analysis was performed using the Statistica software for Windows 11.0. for experiments.

The okara used in this work was produced from soybean cultivar BRS232, obtained from adjusted methodology described by Mandarino *et al*. [6] and flour was obtained according Grizotto *et al*. [7]. The formulations are shown in Table 1. Technological properties analysis (or functional properties) were carried out for raw samples.

Table 1 Formulations (%) and their ingredients.

	F1	F2	F3	F4	F5	F6	F7
Oregano	0,02	0,02	0,02	0,02	0,02	0,02	0,02
Garlic powder	0,1	0,1	0,1	0,1	0,1	0,1	0,1
CF**	2,67	2,67	2,67	2,67	2,67	2,67	2,67
MSG***	1	1	1	1	1	1	1
Water	5	5	5	5	5	5	5
Beef	76,21	76,21	76,21	76,21	76,21	76,21	76,21
Bacon	7	7	15	7	11	11	9,67
TSP****	8	0	0	4	4	0	2,66
Okara	0	8	0	4	0	4	2,66
Total	100	100	100	100	100	100	100

*Fomulation in percent
**Condiment for hamburguers
***MSG – Glutamate monossodium
****TSP – Textured soy protein

III. RESULTS AND DISCUSSION

The simplex-centroid design for mixtures of three components was applied to investigate the effects of the independent variables textured soy protein (x1), okara (x2) and fat (x3) on the functional properties of hamburgers, besides establishing statistically valid models to describe the relationship between the ingredients and the analysis results (Table 2).

Table 2 Experimental designs of mixtures of type simplex-centroide to study the properties of TSP*, okara and fat in seven tests.

Treatment	TSP	Okara	Fat
1	1	0	0
2	0	1	0
3	0	0	1
4	1/2	1/2	0
5	1/2	0	1/2
6	0	1/2	1/2
7	1/3	1/3	1/3

*TSP – Textured Soy Protein

Results for analysis of volume swelling, water absorption index, oil absorption index for raw sample are shown in Table 3.

Table 3 Results for analysis of volume swelling, water absorption index , oil absorption index for raw samples.

Treatment	Volume Swelling*	Water Absorption Index**	Oil Absorption Index***
1	4,26±0,06	1,61±0,06	1,62±0,11
2	5,94±0,27	1,61±0,14	1,36±0,05
3	5,06±0,28	1,44±0,17	1,32±0,06
4	5,79±0,59	1,80±0,05	1,46±0,17
5	5,49±1,05	1,41±0,12	1,31±0,05
6	5,56±0,05	1,32±0,07	2,12±0,31
7	6,08±0,78	1,37±0,04	2,09±0,09

* mL water/ g sample
** g water absorbed/ g sample
*** g oil absorbed/ g sample

No problems were found to fit the model equation (quadratic model) for all parameters studied ($p>0,05$). Thus, the model equation and the experimental results are in conformity with insignificant lack of fit. The R^2 values were 0,98, 0,94, and 0,87 respectively, and it indicated that the model had good prediction capability. The predicted equations models are given bellow with the significant terms for volume swelling (a), water absorption index (b), and fat absorption index (c):

$$y = 4,24*x1 + 5,92*x2 + 5,04*x3 + 3,16x1x2 + 3,72x1x3 + 0,64x2x3 \quad (a)$$

$$y = 1,62*x1 + 1,62*x2 + 1,45*x3 + 0,59x1x2 - 0,63x1x3 - 0,99x2x3 \quad (b)$$

$$y = 1,59x1 + 1,33x2 + 1,29x3 + 0,42x1x2 – 0,10x1x3 + 3,66x2x3 \quad (c)$$

In relation to the swelling property the equation demonstrated that there was a higher significant contribution at x2 and positive variable (okara). This result shows that higher concentrations of okara improve succulence volume of the hamburger. The amount of swelling depends on the density porosity, and solubility of the material under consideration [8]. A response surface analysis (Figure 1), it is also possible to verify that the biggest influence suffered with the increase of the amount of component x2 (okara).

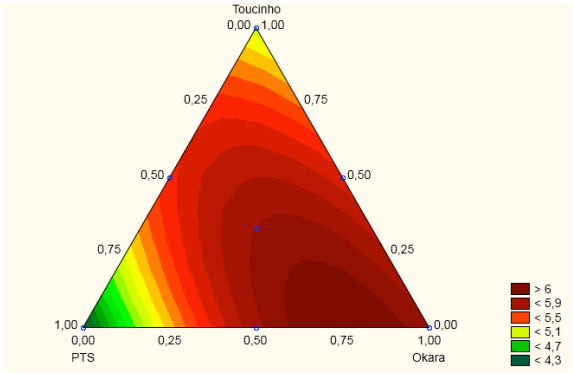

Figure 1. Effect of TSP, okara and fat on the volume swelling.

For water absorption index was observed in equation b, the variables x1 (PTS) and x2 (okara) exerted an influence on raw hamburgers, with positive and significant contribution and both the samples with added okara or PTS will have the same behavior before this functional property. There was no change in the physical structure of components of hamburgers, since the rate of water uptake depends on the particle size, numbers of binding sites of the molecules and applied centrifugal force [8]. Analyzing the response surface (Figure 2), there was a tendency of improvement of this property with increasing components x1 and x2.

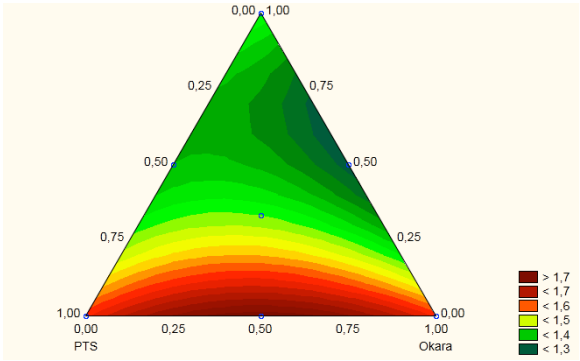

Figure 2. Effect of TSP, okara and fat on the water absorption index.

For Index oil absorption, the binary mixture x2 (okara) and x3 (fat) had a greater influence on the sample still raw (Equation c). Observing the response surface (Figure 3), this behavior can be verified. This increased oil absorption is related to the hydrophobicity of the protein and promotes a sub utilization of food protein in the formulation of meat products [9]. Already the binary mixture x1 and x3 had negative effect, which contributes to lower oil absorption in the raw hamburgers.

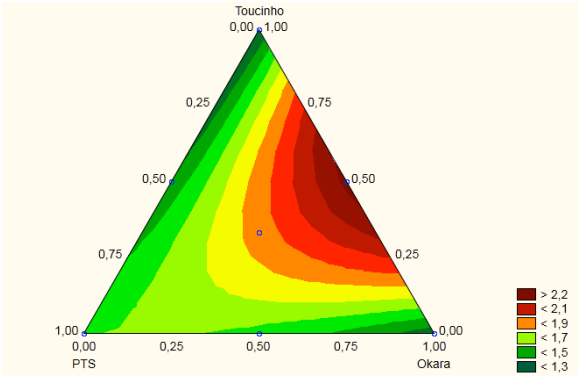

Figure 3. Effect of TSP, okara and fat on the oil absorption index.

IV. CONCLUSION

In relation to the use of okara in the formulations, the variable that was most influenced was the swelling. Analyzing the results for rate of water absorption, the best result was obtained by combining the binary mixture of okara and PTS. Regarding the analysis of oil absorption best result was found to binary combination of fat and okara.

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REFERENCES

1. Telles, T. S., Guimarães, M. F. & Roessing, A. C. (2009). A infra-estrutura de transporte frente à expansão da cultura da soja no Brasil. Semina: Ciências Agrárias 30: 1109-1122.
2. EMBRAPA. Soja em números. 2011a. Avaiable:

<http://www.cnpso.embrapa.br/index.php?op_page=294&cod_pai=16>.

3. Larosa, G., Rossi, E. A., Barbosa, J. C. & Carvalho, M. R. B. (2006). Aspectos sensoriais, nutricionais e tecnológicos de biscoito doce contendo farinha de 'okara'. Alimentos e Nutrição. 17: 151-157.
4. Lescano, C. A. A. & Tobinaga, S. (2004). Modelo codificado e real para a difusividade efetiva da secagem do resíduo do extrato hidrossolúvel de soja. Revista Brasileira de produtos Agroindustriais 6: 17-25.
5. Seibel, N. F. (2006). Caracterização, fracionamento e hidrólise enzimática dos componentes do resíduo do processamento da soja [*Glycine Max (L.)* Merrill], fibras dos cotilédones. 101f. Tese (Doutotado em Ciência de Alimentos).
6. Mandarino, J. M. G., Benassi, V. T. & Carrão-Panizzi, M. C. (2003). Manual de receitas com soja.
7. Grizotto, R. K., Andrade, J. C., Miyagusku, L.& Yamada, E. A. (2012). Physical, chemical, technological and sensory characteristics of Frankfurter type sausage containing okara flour. Ciência e Tecnologia de Alimentos 32: 538-546.
8. Seibel, N. F. & Beléia, A. (2008). Obtenção de novos ingredientes alimentares por hidrólise enzimática de fibra de cotilédones de soja (*Glycine Max* (L.) Merril). Ci. Exatas Terra, Ci Agr. Eng. 14:171-175.
9. Cavalcanti, M. T., Bora, P. S. & Carvajal, J. C. L. (2009). Propriedades funcionais das proteínas de amêndoas da faveleira (Cnidosculus phyllachantus (Mart.) Pax. et K. Hoffm.) com e sem espinhos. Ciência Tecnol. Aliment. v.29, n.3, p. 597-602, jul.-set. 2009.