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Response surface methodology for predicting quality characteristics of beef patties added with flaxseed and tomato paste

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ABSTRACT

Response surface methodology was used to study the effect of flaxseed flour (FS) and tomato paste (TP) addition, from 0 to 10% and 0 to 20% respectively, on beef patty quality characteristics. The assessed quality characteristics were color (L^*, a^*, and b^*), pH and texture profile analysis (TPA). Also, sensory analysis was performed for the assessment of color, juiciness, firmness, and general acceptance. FS addition reduced L^* and a^* values and decreased weight loss of cooked products ($P < 0.05$). An opposite effect was observed when TP was added ($P < 0.05$). All TPA parameters decreased when percentages of FS and TP were increased in the formulation of beef patties. Furthermore, FS and TP addition adversely affected the sensory characteristics of the cooked product ($P < 0.05$); nevertheless, all sensory characteristics evaluated had an acceptable score (>5.6). Thus FS and TP are ingredients that can be used in beef patty preparation.

1. Introduction

Meat is an important source of protein and essential nutrients including iron, zinc, vitamin B12 and folic acid (Schönfeldt & Gibson, 2008; Scollan et al., 2006). Some studies have shown the benefits of meat consumption (Biesalski, 2005; Givens, Kliem, & Gibbs, 2006; McAfee et al., 2010; Valsta, Tapanainen, & Männistö, 2005). However, a sector of the population perceives meat as a food that is detrimental to their health (Oliveira et al., 2011) because some epidemiological studies have associated meat consumption with cardiovascular diseases (CVD) and colon cancer (Chan & Giovannucci, 2010; Goldhaber, 2010; Paik, Wendel, & Freeman, 2005). For these reasons, these meat consumers look for healthier food alternatives as a means to maintain good health. This new tendency represents a good opportunity for the meat industry to develop new products such as functional meat ones (Arihara & Ohata, 2010; Bhat & Bhat, 2011; Jiménez-Colmenero, Carballo, & Cofrades, 2001).

Natural foods may be used as nontraditional ingredients to develop new meat products to reach health-oriented consumers with the objective of increasing antioxidant activity (Yıldız-Turp & Serdaroglu, 2010), improving the fatty acid profile (Rodríguez-Carpena, Morcuende, & Estévez, 2012; Yılmaz, Şimşek, & Işıklı, 2002), fiber addition (Fernández-Ginés, Fernández-López, Sayas-Barberá, Sendra, & Pérez-Alvarez, 2003), or incorporate other bioactive compounds (Bhat & Bhat, 2011).

Flaxseed has high contents of protein, dietary fiber, lignans and α-linolenic acid (Bloedon & Szapary, 2004), while tomato is an excellent source of phytochemicals, including carotenoids and polyphenols (Navarro-González, García-Valverde, García-Alonso, & Periago, 2011). These food components have been associated with reduced risks of certain types of cancer and CVD (Canene-Adams, Campbell, Zaripheh, Jeffery, & Erdman, 2005; Dodin et al., 2008). Incorporating flaxseed and tomato in a new meat product formulation not only would incorporate these components in the product but would decrease saturated fats, and replace simple carbohydrates whose consumption has been linked to health problems.

However incorporation of nontraditional ingredients in the formulation could affect the final quality properties. Response surface methodology (RSM) helps explore variations in meat product quality when ingredient levels are changed in the formulation (Sarıçoban, Yılmaz, & Karakaya, 2009; Velioğlu, Velioğlu, Boyacı, Yılmaz, & Kurultay, 2010). This technique is a mathematical and statistical tool used to simultaneously evaluate several factors and estimate their linear, quadratic and interaction effects (Gan, Alkarkhi, & Easa, 2009; Gan & Latiff, 2011). RSM has been used to optimize different quality parameters during meat product development (Sarıçoban et al., 2009; Velioğlu et al., 2010).

Therefore, the objective of this work was to evaluate the effect of flaxseed and tomato paste addition on the quality of beef patties using RSM.

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2. Materials and methods

2.1. Experimental design

The effect of adding flaxseed and tomato paste on the quality (pH, color, antioxidant capacity, texture profile analysis and sensory analysis) of beef patties was studied. The characteristics of quality were evaluated using a response surface model with a central composite design (CCD) with two factors (flaxseed and tomato paste). Experimental and coded levels for both factors are presented in Table 1. Thirteen experimental runs in random order, with five replications on the central point and simple runs for the rest of the treatments of the CCD were performed. All determinations of the response variables were carried out in triplicate. The experimental design is presented in Table 2.

2.2. Ingredient acquisition and meat preparation

Lean beef, inside round (*Semimembranosus*), flaxseed flour (FS) (*Linum usitatissimum L*) and tomato paste (PT) (*Lycopersicum esculentum*) were obtained from the local market (Natural Health, Canadian flaxseed, Guanajuato, Mexico; S&W® Premium, Tomato Paste, S&W Fine Foods Inc., San Francisco, USA). Inside round cuts were obtained from animals within 5 days of slaughter. Meat, used on the same day of purchase, was cut into pieces no larger than 5 cm^3 and ground using a Hobart grinder (model 4152, Troy, Ohio, USA) through a 4.7 mm plate. Ground meat was stored at 2 °C until further use.

One kilogram batches per treatment were used for beef patty preparation. Meat (73% moisture, 6% fat), FS (19% protein, 7% moisture), TP (80% moisture) and spices were mixed according to percentages specified in the experimental runs in Table 2. Ingredients in each batch were manually homogenized for 10 min. Beef patties were manually formed into 9 cm × 1 cm thick samples to obtain approximately 70 g per unit. An electric skillet (Cook Master Oster, Model 3222-3, Mississauga, Ontario, Canada) was used for cooking the patties, 1 min each side and then 15 s per side until reaching 72 °C, measured in the geometrical center with a thermocouple.

2.3. Product quality determinations

Quality parameters assessed for fresh products were: proximate analysis (moisture, fat, protein and ash), objective color (L*, a*, and b*), pH and sensory color; and for cooked products were: texture profile analysis (hardness, elasticity, cohesiveness and chewiness) and sensory analysis (juiciness, taste, firmness and overall acceptability). All determinations were carried out within 24 h of preparation of the beef patties, except proximate analysis. Samples for this determination were stored at −18 °C until analyzed.

2.3.1. Proximate composition

Moisture, ash, protein and fat content were determined according to AOAC methods (AOAC, 2011). Moisture (g water/100 g sample) was determined by drying a 5 g sample at 100 °C to constant weight. Ashing was performed at 550 °C for 4 h (g ash/100 g sample). Protein (g protein/100 g sample) was analyzed according to the Kjeldahl method. Factor 6.25 was used for conversion of nitrogen to crude protein. Fat (g fat/100 g sample) was calculated by weight loss after an extraction with petroleum ether in a goldfish apparatus.

Table 1
Experimental levels of two independent variables in terms of actual values.

Variables	Symbols	Coded variable levels				
		−α (−1.414)	−1	0	1	α (1.414)
FS (%)	X_1	0	1.5	5	8.5	10
TP (%)	X_2	0	3	10	17	20

Flaxseed flour (FS), tomato paste (TP).

Table 2
Coded and experimental values of response variables for central composite design.

Run	Coded level		Experimental value	
	X_1	X_2	FS (%)	TP (%)
1	−	−	1.5	3
2	−	+	1.5	17
3	+	−	8.5	3
4	+	+	8.5	17
5	−1.414	0	0	10
6	1.414	0	10	10
7	0	−1.414	5	0
8	0	1.414	5	20
9	0	0	5	10
10	0	0	5	10
11	0	0	5	10
12	0	0	5	10
13	0	0	5	10

Flaxseed flour (FS), Tomato paste (TP)

2.3.2. Physicochemical evaluation

Surface color was measured with a Minolta colorimeter using the D65 illuminant and 10° standard observer (Chroma meter CR-400, Konica Minolta Sensing, Inc. Japan) recording L*, a* and b* values. L* indicates lightness; a* redness; and b* yellowness. For pH measurement, 5 g of ground patty sample was weighed into 100 mL beakers and 45 mL of distilled water was added and the mixture homogenized. A portable pH meter (Hanna, Model HI 98140, Woonsocket, RI, USA) equipped with a puncture type combination pH electrode was used, and the reading was taken once stabilized.

2.3.3. Texture profile analysis (TPA)

A Texture Analyzer TA-XT2 (Stable Micro Systems, Surrey, UK) was used for the raw beef patties. Cubic samples (1 × 1 × 1 cm) were cut from burgers and subjected to a two-cycle compression test. Samples were compressed to 50% of their original height with a 7.5 cm diameter cylindrical probe attached to a 50 kg compression cell with a cross-head speed of 1 mm/s. Texture profile parameters were determined according to Bourne (1978) and interpreted as follows: Hardness (kg) is the maximum force required to compress the sample; cohesiveness is the extent to which sample could be deformed prior to rupture (A2/A1), A1 being the total energy required for the first compression and A2 the total energy required for the second compression; springiness (cm) is the ability of the sample to recover its original shape after the deforming force is removed, and chewiness (kg × cm) is the work needed to masticate the sample for swallowing (hardness × cohesiveness × springiness).

2.3.4. Sensory analysis

Sensory evaluations were conducted by a trained 8 member panel (ISO-8586-1, 1993) in an environmentally controlled (21 ± 1 °C, 55 ± 5% relative humidity) room partitioned into booths. Three patties from each formulation were cooked as previously described, and maintained warm in an oven until testing, within 4–7 min. Square pieces approximately 1.5 × 1.5 cm, cut from the center of patties, were served at room temperature. Each sample was coded with randomly selected 3-digit numbers. Panelists were instructed to clean their palates between samples using water. Color, flavor, firmness and juiciness of beef patties were scored using a 9 point Hedonic scale, where 1 represented dislike extremely and 9 represented like extremely. Each attribute was discussed and tests were initiated after the panelists were familiarized with the scales. At the end of the test, panelists were asked to give a score for product overall acceptability from 0 to 9.