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Effects of the addition of microencapsulated omega-3 and rosemary extract on the technological and sensory quality of white pan bread

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ABSTRACT

Omega-3 enriched foods are considered functional foods, however they may present undesirable sensory characteristics due to oxidation. The objective of this study was to evaluate the influence of the addition of 0.00–5.00 g/100 g microencapsulated omega-3 fatty acids (MO) and of 0.000–0.100 g/100 g rosemary extract (RE) on the technological and sensory quality of white pan bread, following a 2^2 central composite rotational design (CCRD). The responses evaluated were the specific volume, texture, moisture and color, and the scores obtained in the sensory acceptance test for appearance, aroma, flavor, texture and overall acceptance, and purchase intention. Increasing MO concentration reduced specific volume and lightness and increased firmness and color saturation. Increasing RE concentration presented only a small effect on the reduction of lightness. In the sensory acceptance test, all samples presented acceptable scores (>5).

1. Introduction

Currently, consumers and food companies have become increasingly concerned about healthy diets. The reasons that have motivated production, consumption and research of functional foods include increasing strength to face the stress of modern life, eliminating bad diet habits, weight control (about 50% of the population in industrialized countries is obese), preventing degenerative diseases (heart disease, cancer and diabetes, which account for almost two thirds of deaths in the world), compensating the effects of lack of exercises and slowing the aging process (Kahlon & Keagy, 2003).

Foods enriched with omega-3 polyunsaturated fatty acids of marine origin, EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), may be classified as functional foods, by acting on human health. The omega-3 fatty acids constitute the tissues that compose the central nervous system, act in the proper functioning of sight, as well as in the prevention of cardiovascular diseases, cancer and autoimmune and inflammatory diseases (Simopoulos, 1991; Thautwein, 2001).

Whelan and Rust (2006) list the recommendations for the daily intake of omega-3 made by various authors and entities. In 1999, the *British Nutrition Foundation* (U.K.) recommended the consumption of 1.25 g/day total omega-3 fatty acids; in 2000, Simopoulos, Leaf and Salem, 650 mg/day EPA + DHA; in 2002, the *Scientific Advisory Committee on Nutrition*, also from the U.K., >0.2 g/day omega-3 fatty acids; in 2003, the World Health Organization (WHO), 1–2 calories/100 calories from omega-3 fatty acids; in 2004, the *International Society for the Study of Fatty Acids and Lipids*, ≥500 mg/day EPA + DHA. In 2004, the *Food and Drug Administration* (FDA) of the United States of America allowed the claim of functional foods enriched with omega-3 belonging to the functional foods group, but also suggested that EPA + DHA consumption does not exceed 3 g/day because of possible adverse effects on glycemic control, increased bleeding time and elevation in LDL cholesterol. In Brazil, the National Health Surveillance Agency (ANVISA) requires that products enriched with omega-3 fatty acids should provide at least 0.1 g EPA and/or DHA per serving or 100 g or 100 mL to allow the claim of functional property (ANVISA, 2009).

The greatest difficulty for the fortification of food with fish oil containing EPA and DHA is because they are polyunsaturated fatty acids, highly unstable and susceptible to oxidation in the presence of light and oxygen, losing their functional and sensory qualities (Ackman, 2006).

In order to be incorporated into food formulations, a maximum limit should be observed to avoid affecting sensory acceptance. Depending on the food type, the added concentration ranges from

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1.0 to 60.0 g/kg food, and the product cannot be strongly heated, stored in packages exposed to light and oxygen and for long periods of time (Kolanowski & Laufenberg, 2006).

Microencapsulation is one of the strategies used by industry to protect the polyunsaturated fatty acids of external factors which initiate the oxidation process that can produce off-flavors, both during processing and storage; also to mask any unwanted odor and flavor in the final product and to facilitate handling (Kolanowski & Laufenberg, 2006).

Natural antioxidants have been widely used by manufacturers of food products, and have the advantage of being well accepted by consumers because they are considered healthy or “non-chemical”. In the Brazilian legislation they are classified as spices (Nassu, Gonçalves, Silva, & Beserra, 2003).

Rosemary extract (*Rosmarinus officinalis*) has antioxidant properties and is widely used in the food industry. The antioxidant activity of rosemary extract is associated with the presence of phenolic compounds, such as carnosic acid, rosmarinic acid, carnosol, rosmanol, rosmariquinone and rosmaridiphenol, which react with free radicals formed in the oxidation process (Aruoma, Halliwell, Aeschbach, & Löligers, 1992; Basaga, Tekkaya, & Acitel, 1997).

The purpose of this study was to evaluate the influence of the addition of microencapsulated omega-3 (MO) and rosemary extract (RE) on the technological and the sensory quality of white pan bread, following a Central Composite Rotational Design (CCRD) and analyzing the results by the Response Surface Methodology (RSM).

2. Materials and methods

2.1. Raw materials

The wheat flour used for the production of the bread was kindly donated by *Bunge Alimentos S/A* (Tatuí, SP, Brazil), containing 13.28 ± 0.06 g/100 g moisture, 10.49 ± 0.09 g/100 g proteins, 1.22 ± 0.07 g/100 g lipids, 0.46 ± 0.10 g/100 g ash, 74.55 g/100 g carbohydrates, *Falling Number* of 353 s ± 13.5, stability of 6.17 min and water absorption of 63.2 g/100 g.

The microencapsulated omega-3, BA35 Plus, containing 12.9 g EPA + DHA/100 g (supplier’s specifications), was provided by *Funcional Mikron* Company (Valinhos, SP, Brazil). The rosemary extract (*R. officinalis*) powder, GUARDIAN Rosemary Extract 10, containing 96 g/100 g salt (NaCl) and natural rosemary extract and 4 g phenolic diterpenes/100 g (supplier’s specifications), was provided by *Danisco Brasil Ltda*. (Cotia, SP, Brazil). The other ingredients were supplied by the bakery of the Faculty of Food Engineering, UNICAMP.

2.2. Bread preparation

The formulation used for the preparation of white pan bread was composed of flour (100 g), water (67 g/100 g), salt (2 g/100 g), sugar (4 g/100 g), instant yeast (2 g/100 g), bread improver Diacetyl tartaric acid ester of mono- and diglycerides (DATEM) from Danisco (Cotia SP) (1 g/100 g), fat (3 g/100 g), calcium propionate (0.3 g/100 g). The percentages of rosemary extract and microencapsulated omega-3 were calculated by total dough weight multiplied by the concentration determined by the experimental design. The production of bread was carried out at the bakery of the Faculty of Food Engineering, UNICAMP, using: an automatic spiral dough mixer, model HAE10; a bread-molding machine, model HM2; a Hypo mini-oven, model HF4B, from *Indústria de Máquinas Hyppolito Ltda.* (Ferraz de Vasconcelos, SP). The ingredients were homogenized in the dough mixer, for 4 min on first speed. They were mixed on second speed until the complete development of the gluten network (dough temperature of 28 °C ± 2 °C). Portions of 200 g of dough were left to rest, covered with plastic, for 5 min, and were then put through the molding machine. The molded doughs were placed in open pans and allowed to ferment for 35 min. The baking was conducted at 160 °C for 20 (±2) minutes with steam.

2.3. Experimental design

The loaves of bread were produced with varying concentrations of microencapsulated omega-3 (MO) and rosemary extract (RE), according to the levels presented in Table 1. The 2^2 central composite rotational design (CCRD) described in Table 1 was followed, with 4 factorial points, 4 axial points and 3 central points, totalizing 11 trials. A control formulation was also prepared (without the addition of the compounds under study) for comparison purposes.

Table 1
Effect of concentration of rosemary extract and microencapsulated omega-3 on the technological characteristics (moisture, specific volume, firmness and color parameters) of white pan bread.

Samples	Coded variables[a]		Real variables[b]		Moisture (g/100 g)[c]	Specific Volume (cm³/g)[c]	Firmness (*N*)[c]	L^*[c]	C^*[c]	h°[c]
	x_1	x_2	RE (g/100 g)	MO (g/100 g)						
1	−1	−1	0.015	0.73	$38.31^{CD} \pm 0.46$	$3.56^{BC} \pm 0.13$	$6.02^{EF} \pm 0.21$	$80.57^{A} \pm 0.43$	$16.30^{A} \pm 0.14$	$90.28^{B} \pm 0.16$
2	+1	−1	0.085	0.73	$40.43^{ABC} \pm 0.79$	$3.49^{CD} \pm 0.27$	$6.07^{EF} \pm 1.35$	$80.51^{A} \pm 0.73$	$15.98^{A} \pm 0.21$	$91.25^{A} \pm 0.24$
3	−1	+1	0.015	4.27	$40.06^{ABC} \pm 0.58$	$2.57^{F} \pm 0.22$	$13.81^{A} \pm 1.05$	$78.75^{B} \pm 0.21$	$23.27^{E} \pm 0.07$	$88.38^{D} \pm 0.39$
4	+1	+1	0.085	4.27	$40.76^{AB} \pm 1.30$	$2.66^{F} \pm 0.06$	$11.88^{ABC} \pm 0.73$	$77.23^{C} \pm 0.36$	$22.35^{D} \pm 0.13$	$89.27^{C} \pm 0.23$
5	$-\alpha$	0	0.000	2.50	$41.86^{A} \pm 0.09$	$3.25^{CDE} \pm 0.11$	$9.14^{CD} \pm 0.62$	$79.11^{B} \pm 0.26$	$20.30^{C} \pm 0.26$	$89.12^{CD} \pm 0.18$
6	$+\alpha$	0	0.100	2.50	$36.94^{D} \pm 0.20$	$2.98^{EF} \pm 0.15$	$8.70^{DE} \pm 1.85$	$78.16^{BC} \pm 0.20$	$19.45^{B} \pm 0.26$	$88.63^{D} \pm 0.23$
7	0	$-\alpha$	0.050	0.00	$36.77^{D} \pm 0.88$	$4.05^{A} \pm 0.19$	$4.56^{F} \pm 1.34$	$80.50^{A} \pm 0.35$	$16.02^{A} \pm 0.47$	$90.40^{B} \pm 0.22$
8	0	$+\alpha$	0.050	5.00	$41.28^{A} \pm 1.58$	$2.59^{F} \pm 0.10$	$12.32^{AB} \pm 2.70$	$77.90^{B} \pm 0.30$	$23.33^{E} \pm 0.17$	$89.20^{C} \pm 0.10$
9	0	0	0.050	2.50	$38.92^{BCD} \pm 0.57$	$2.92^{EF} \pm 0.12$	$7.75^{DEF} \pm 0.30$	$78.73^{B} \pm 0.74$	$19.81^{BC} \pm 0.31$	$89.13^{C} \pm 0.22$
10	0	0	0.050	2.50	$40.29^{ABC} \pm 0.87$	$2.92^{EF} \pm 0.12$	$9.63^{BCD} \pm 1.92$	$78.19^{BC} \pm 0.49$	$20.39^{C} \pm 0.35$	$88.42^{D} \pm 0.23$
11	0	0	0.050	2.50	$40.52^{ABC} \pm 0.05$	$3.00^{DEF} \pm 0.26$	$7.83^{DEF} \pm 1.15$	$78.11^{BC} \pm 0.53$	$19.80^{BC} \pm 0.39$	$89.41^{C} \pm 0.19$
Control	–	–	–	–	$38.23^{CD} \pm 0.24$	$4.01^{AB} \pm 0.13$	$5.50^{F} \pm 1.26$	$80.84^{A} \pm 0.70$	$16.21^{A} \pm 0.24$	$90.31^{B} \pm 0.26$

[a] $\alpha = (2^n)^{1/4}$, where n = number of independent variables, in this case $\alpha = 1.41$; x_1 = Rosemary extract, x_2 = Microencapsulated omega-3.
[b] Rosemary extract (RE); Microencapsulated omega-3 (MO).
[c] The results represent the averages of determinations ± standard deviation. Samples followed by same letters do not differ ($p \le 0.05$) by the Tukey test.