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Analytical Methods

Changes produced in oils during vacuum and traditional frying of potato chips

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ABSTRACT

In this study the effect of vacuum frying (VF) and traditional frying (TF) on oil degradation, fatty acid composition and alpha-tocopherol content was investigated. Two different refined sunflower oils were used: sunflower oil with high oleic acid content (HOSO) and sunflower oil with synthetic antioxidant (tertiary-butylhydroquinone) (TBHQ-SO). Oil degradation was monitored by measuring the free acidity (FFA), peroxide (PV), p-anisidine (p-AV),) total polar compounds (TPC) and oxidative stability (OE). Oils samples were taken every 4 h of frying during 10 consecutive days. Values of FFA, p-AV, TPC using TBHQ-SO with traditional frying were (0.201, 207.0, 25.0) significantly higher than the obtained values with vacuum frying (0.073, 25.8, 11.2). The same parameters by using HOSO were (0.327, 82.0, 21.9) with traditional frying and (0.099, 33.3, 6.4) with vacuum frying. The EO was 2.44 and 7.95 with TBHQ-SO traditional and vacuum frying respectively, and with for HOSO 0.65 and 2.67, respectively. The polyunsaturated fatty acids percentage decreased in all treatments except in TBHQ-SOv. The alpha-tocopherol content decreased in all treatments at different rates. At the end of the frying processes the percentages of alpha-tocopherol reduction were TBHQ-SOv (4.90%), TBHQ-SOt (53.62%), HOSOv (96.87%), HOSOt (99.76%).

1. Introduction

The market trend for the consumption of healthier foods has forced the snacks industry to develop alternative technologies to traditional frying, maintaining their characteristic flavour and texture. The vacuum frying (VF) stands out among the studied processes to achieve quality improvement. In this operation, the food is immersed in oil at 40 mmHg in a closed system. The reduced pressure decreases the boiling temperature of water contained in the food, without affecting the characteristic texture of the fried food. The benefits of this technology are associated with frying at lower oil temperatures and reduced exposure to oxygen.

During the last 10 years the nutritional benefits of the vacuum frying have been studied. Dueik, Robert and Bouchon (2009) studied the preservation of colour and flavours in vacuum fried foods. They concluded that the vacuum-fried snacks retain more of their natural colour and flavour due to less oxidation and lower frying temperature. The carrots preserved around 90% of trans -carotene and 86% of trans -carotene. Granada, Moreira and Tichy (2004) showed that the process of vacuum frying produced potato chips with 97% less acrylamide, a potential carcinogen found in chips produced by the traditional process (atmospheric frying). Garayo and Moreira (2002) showed that vacuum frying of potato achieved chips with 30% less oil and the same texture and colour characteristics of the traditional frying. Fan, Zhan, Xiao, Sun and Tao (2005), Shyu, Hau and Hwang (1998) studied dehydrated foods produced by vacuum frying and concluded that crispy texture, good colour and flavour were maintained with good retention of nutrients. The vacuum frying technology is being industrially developed. So it is necessary to continue studying, how this new technology affects time of oil usage.

Different types of oils may be used for frying of foods. Their physical and chemical properties influence the degree of oxidation and hydrolysis reactions which occur during frying. Their stability depends on the composition of fatty acids and natural antioxidants as well as frying temperature.

Addition of synthetic antioxidants is one of the major treatments used to maintain the quality of fats and oils during frying. The effectiveness of natural (tocopherols and other phenolic compounds) and synthetic (tertiary butyl hydroquinone (TBHQ), butylated hydroxyanisol (BHA) and butylated hydroxyltoluene (BHT)) antioxidants during the traditional frying process was studied by Marmesat, Morales, Velasco, and Dobarganes (2010). TBHQ is reported as more effective than BHA and BHT, in controlling the oxidation reactions during frying. Similar conclutions were reported

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by other authors (Farhoosh and Tavassoli-Kafrani (2010), Allam and Mohamed (2002)). Regarding natural antioxidant, they concluded as other authors (Fujitani and Ando (1977); Verleyen et al. (2001); Verleyen, Verhe, Huyghebaert; Dewettinck, and de Greyt (2001), Pongracz (1988)), low volatility and rapid degradation of the tocopherols in oil at temperatures between 180 °C and 220 °C.

The high oleic acid sunflower oil is reported as a better oil compared to regular sunflower, soybean, corn and peanuts oils due to its good thermal and oxidative stability during traditional frying (Roman, Heyd, Broyart, Castillo, and Maillard (2013); Smith, King, and Min (2007); Abdulkarim, Long, Lai, Muhammad, and Ghazali (2007); Marmesat, Morales, Velasco, and Dobarganes (2012)).

There are extensive reports on health benefits due to the consumption of high oleic acid oil because it may decrease the risk of coronary heart disease. Until now it has not been reported how the vacuum frying process influence on oil degradation, fatty acid profile and tocopherols content.

The objective of this study was to evaluate the influence of vacuum frying on oil degradation, fatty acid composition and alpha-tocopherol content using to different oils: sunflower oil with high oleic acid content and sunflower oil with 200 ppm synthetic antioxidant TBHQ.

2. Materials and methods

The studied treatments were: (1) TBHQ-SO*v*: vacuum frying – sunflower oil with TBHQ; (2) TBHQ-SO*t*: traditional frying – sunflower oil with TBHQ; (3) HOSO*v*: vacuum frying – high oleic acid content oil; (4) HOSO*t*: traditional frying – high oleic acid content oil. These treatments correspond to a factorial experiment with two factors: type of frying (vacuum and traditional) and type of oil (sunflower with TBHQ and high oleic acid oil). For each treatment 8 frying cycles of 30 min each, during 10 days were performed. Oils samples were taken every day and evaluated for free acidity (FFA), peroxide (PV), p-anisidine (p-AV), oxidative stability (OE), and total polar compounds (TPC), fatty acid composition. Alpha-tocopherol was evaluated every two days.

2.1. Materials

The oils used were produced by COUSA (Uruguayan Company). The chemical characteristics of the oils are shown in Table 1.

Table 1
Composition of fresh sunflower oil.

		TBHQ-SO	HOSO
Fatty acid composition (relative%)	C14:0	0.02	0.04
	C16:0	5.64	4.16
	C16:1	0.02	0.10
	C18:0	2.82	3.26
	C18:1	35.97	84.61
	C18:2c	55.04	6.04
	C18:2t	0.17	0.04
	C18:3	0.07	0.05
	C20:0	0.09	0.26
	C20:1	0.04	0.23
	C22:0	0.17	0.86
	SFA	8.31	8.58
	MUFA	35.86	84.94
	PUFA	55.85	6.13
	PUFA/MUFA	1.55	0.07
Peroxide value, PV (mol LOOH/L oil)		2.7	6.9
Polar compounds (%)		9.5	3.3
Acidity (%)		0.06	0.03
αTocopherols (mg/100 gr)		60.0	59.5
Oxidative stability		15.0	17.4

TBHQ-SO: sunflower oil with 200 ppm TBHQ, HOSO: sunflower oil with high oleic content.

2.2. Experimental determinations

2.2.1. Total polar compounds

Total polar compounds (TPC) estimation was based on dielectric constant changes directly measured on hot oil with Deep Frying Oil Tester testoT270. The Deep Frying Oil Tester operation was verified with the AOCS Official Method Cd 20-91.

2.2.2. Free fatty acids

Free fatty acids (FFA), expressed as free oleic acid percentage, was determined using AOCS Method Ca 5a-40.

2.2.3. Peroxide value

Peroxide value (PV), expressed in milliequivalents of active oxygen per kilogram (mEq O_2/kg), was determined by AOCS Method Cd 8b-90 (93).

2.2.4. Anisidine value

Anisidine value estimates was determined by AOCS Method Cd 18-90.

2.2.5. Oxidative stability (Rancimat)

Oxidative stability was estimated by measuring the oxidation induction time, on a Rancimat apparatus (Metrohm 873 Biodiesel Rancimat). Air (10 L/h) was bubbled through the oil (5 g) heated at 110.0 ± 0.5 °C, with the volatile compounds being collected in water, and the increasing water conductivity continually measured. The time taken to reach the conductivity inflection was recorded.

2.2.6. Fatty acids composition

The fatty acid profile analysis was performed by converting glyceride fatty acid to their corresponding methyl esters prior to the analysis by GC–MS (According to AOCS Ce 2-66). The samples were methylated with 14% BF3 in methanolic NaOH. The methylated fatty acids were injected in a GC–MS-EI, with split injection system and a HP 88 Agilent column 100 m length, 0.25 um film thickness and 0.25 mm internal diameter. The initial oven temperature was 120 °C and the temperature was increased to 225 °C (rate of 1 °C/min), after this the column temperature was kept constant for 40 min. The injector temperature was 250 °C, and the source temperature of mass spectrometer was 200 °C. Helium was used as the carrier gas. The fatty acid methyl esters were identified by comparing their retention times and mass spectrum with a mixture standard FAME (37 compounds).

2.2.7. Alpha-tocopherol content

Alpha-tocopherol analysis was based on ISO 9936:2006 "Animal and vegetable fats and oils. Determination of tocopherol and tocotrienol contents-Method using HPLC". Briefly, 2.5 g of oil was dissolved in 25 ml hexane and after filtration the solution was analysed by normal phase HPLC on a Phenomenex Luna Silica column 250 mm × 4.6 mm × 5 μ. The mobile phase was a mixture of 99.5% hexane and 0.5% isopropanol (v/v). The eluent flow rate was adjusted to 2 ml/min. A fluorescent detector with excitation wavelength set at 290 nm and emission wavelength set at 330 was used. The concentrations were expressed in mg/100 g of oil.

2.2.8. Traditional frying conditions

Ten litres of oil was placed in the fryer at atmospheric pressure. On each day of frying 8 batches of 125 grams of 1.5 mm thick sliced potatoes were processed. The sliced potatoes were deep fried during 2 min at 180 °C. At the beginning of each day 160 ml of frying oil sample was taken for analysis and replaced with fresh oil to complete the initial volume.