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Antioxidant efficacy of rosemary ethanol extract in palm oil during frying and accelerated storage

Qing Guo[a], Shan Gao[a], Yanwei Sun[a], Yunfeng Gao[a], Xiaoran Wang[a], Zesheng Zhang[a,b,*]

[a] Key Laboratory of Food Nutrition and Safety, Ministry of Education of China, Tianjin University of Science and Technology, 300457, Tianjin, China
[b] Tianjin Food Safety & Low Carbon Manufacturing Collaborative Innovation Center, 300457, Tianjin, China

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ABSTRACT

The rosemary extract is a new natural antioxidant. In this study, the stability of palm oil with rosemary extract during frying and accelerated storage was studied. The antioxidant of palm oil with different concentrations of rosemary ethanol extract were evaluated at 180 °C and 65 °C. The effect of rosemary ethanol extract was also compared with the one of synthetic antioxidants. Results showed that the optimum addition of rosemary ethanol extract in palm oil during frying and accelerated storage were 0.12 g/kg and 0.7 g/kg. Under such conditions, a significant antioxidant effect was observed. Rosemary ethanol extract can effectively reduce the peroxide value, P-anisidine value, free fatty acid value and absorbances at 232 and 268 nm, especially in the long-time frying process. It can also reduce the production of saturated fatty acids after 25 h of frying and 24 d of accelerated storage. Under frying condition, the oil with rosemary ethanol extract showed an enhanced stability compared to the oil with synthetic antioxidants. Under accelerated storage condition, rosemary ethanol extract could prevent the palm oil from oxidation the same as the synthetic antioxidants, but it is safer than synthetic antioxidants.

1. Introduction

Lipid oxidation is one of the major problems during the process of frying and storage, resulting in the generation of free radicals as well as degradation of food quality and possibly leading to diseases ultimately (Aladedunye and Matthaus, 2014). In order to retard, reduce or prevent oxidative deterioration, antioxidants are added to oil, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) and tertiarybutyl hydroxyquinone (TBHQ) (Casarotti and Jorge, 2014).

Synthetic antioxidants are effective at low temperatures (Nenadis et al., 2003). However, during frying, the oil temperature is around 180 °C, the heat of which can quickly destroy antioxidants, for they are erratic and can easily evaporate at high temperatures, which may be related to their structures (Chang et al., 1977). Therefore, they can not provide the oil with enough protection against oxidative deterioration. In addition, it is showed in some studies that synthetic antioxidants might have potential toxicity (Hou, 2003). To overcome these shortcomings, more researches are focused on natural antioxidants.

Natural antioxidants mostly come from spices and herbs, which are known to contain many phytochemicals that can slow down lipid oxidation. Among the plant extracts that have been studied, rosemary extract shows a remarkable antioxidant effect and it is likely to be used industrially (Chammem et al., 2015). The antioxidant properties of rosemary extract have mainly contributed by the presence of phenolic diterpene compounds, such as carnosic acid, carnosol and rosmanol (Alizadeh et al., 2016). During the extraction, carnosic acid can be converted to other diterpenes which are more lipophilic, and their antioxidant activity is also important when the temperature is over 100 °C (Nogala-Kalucka et al., 2005).

Palm oil is widely used in cooking and food industry (Pillai et al., 2016). In comparison, the content of saturated fatty acids in palm oil is relatively higher (Lida et al., 2002), which makes the palm oil more stable at high temperatures. Besides, the content of unsaturated fatty acids is richer in palm oil, which makes palm oil more easily absorbed and reduces the incidence of various diseases that are induced by oxidative stress.

Although the components and the antioxidant activity of rosemary extract in oil have been widely reported, most studies are mainly about the antioxidant effect, and there are few researches were related to the suitable concentration of rosemary extract

* Corresponding author at: Key Laboratory of Food Nutrition and Safety, Ministry of Education of China, Tianjin University of Science and Technology, 300457, Tianjin, China.

E-mail addresses: gq12191219@sohu.com (Q. Guo), gaoshanmyday@163.com (S. Gao), 15661642243@126.com (Y. Sun), gaoyunfeng@mail.tust.cn (Y. Gao), wangxiaoran0219@sina.com (X. Wang), zhangzesheng@tust.edu.cn (Z. Zhang).

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Table 1
Addition amount of antioxidants to palm olein.

Antioxidant	Addition amount (antioxidant g/palm olein kg)					
	0	1	2	3	4	5
Rosemary extract	0	0.04	0.08	0.12	0.16	0.20
TP	0	0.04	0.08	0.12	0.16	0.20
TBHQ	0	0.04	0.08	0.12	0.16	0.20
BHA	0	0.04	0.08	0.12	0.16	0.20

added into palm oil at frying temperature and accelerated storage temperature. The purpose of this study was to select the most suitable concentration of rosemary ethanol extract added into palm oil, in order to improve the stability of palm oil not only at accelerated storage temperature but also at frying temperature. The antioxidant effect of which rosemary ethanol extract was also compared with the one of synthetic antioxidants. To provide support for the replacement of synthetic antioxidants with rosemary extract, a comprehensive evaluation on the antioxidant effect of rosemary ethanol extract was conducted in palm oil.

2. Materials and methods

2.1. Sample materials and chemicals

Refined, bleached, deodorized palm oil without additives and antioxidants was purchased from Longwit Oils and Grains Co. Ltd. (TianJin,China). The dry rosemary leaves (Rosemarinus Officinalis L.) used in this study were purchased from Sheng Hao Chinese Herbal Medicine Co.,Ltd. (Anhui,China). Butylated hydroxyanisole (BHA), Tertiarybutyl hydroxyquinone (TBHQ) and Tea Polyphenols (TP) were purchased from Sigma-Aldrich (St. Louis. Mo. USA). The frozen potato chips were purchased from Wei Ke Mei Food Co. Ltd. (GuangZhou,China). All other chemicals used in this study were of analytical grade.

2.2. Preparation of rosemary ethanol extract

The volatile oil in dried rosemary leaves was extracted though steam distillation method with a slight modification (Chen et al., 2016). Dried rosemary leaves (100 g) were put into a round-bottomed flask which contained 1L of deionized water, and heated them up to boiling. Then it was steam distilled for 4 h in a Clevenger-type apparatus for essential oil isolation, and the residue was dried at 65 °C and pulverized with a blender. The powder (10 g) were extracted with 100 mL of 80% ethanol solution by ultrasonic extraction (SB25-12DTDN, NingBo Scientz Biotechnology Co.,Ltd.,China) at 50 °C for 40 min. After filtration, a second extraction with ethanol was done under the same conditions, and the combined filtrate was evaporated in a rotary evaporator. It was determined by the HPLC that the extract contained 8% carnosic acid and 10% carnosol, and it was kept at −20 °C for further analysis.

2.3. Mixture preparation

Rosemary ethanol extract, TP and synthetic antioxidants (BHA, TBHQ) were added directly to palm oil. Each antioxidant was added at different concentrations according to the legal limit of China. A control sample was prepared with the same oil without any antioxidant. All the samples were kept at 4 °C.

2.4. Frying test

2.4.1. Determination of concentration for frying

In the present work, the addition amount was studied according to the conditions shown in Table 1. To evaluate their optimal concentrations during the frying, the formulated oils were subjected to frying at 180 °C for 5 h. At the end of essay, samples were taken for peroxide value, p-anisidine value, iodine value and free fatty acids value.

Table 2
Concentration of antioxidants in palm olein.

Antioxidant	Concentration of antioxidant in oil (antioxidant g/palm olein kg)					
	0	1	2	3	4	5
Rosemary extract	0	0.14	0.28	0.42	0.56	0.70
TP	0	0.08	0.16	0.24	0.32	0.40
TBHQ	0	0.04	0.08	0.12	0.16	0.20
BHA	0	0.04	0.08	0.12	0.16	0.20

2.4.2. Frying process

According to the previous result, rosemary ethanol extract, TP, BHA and TBHQ were added to palm oil at concentrations of 0.12 g/kg, 0.2 g/kg, 0.12 g/kg and 0.12 g/kg, respectively. Frying procedures were carried out according to the method of Che Man (Yaakob and Che Man, 2000) with some modifications. The samples were heated to 180 ± 5 °C within 15 min. Potatoes were used for frying with 1 g per 10 g of oils. The first frying process was conducted after the oil temperature reached 180 °C. A batch of potatoes were fried for 5 min, afterwards, the oil temperature was risen up to 180 °C again in 15 min, and the frying process was repeated. There were 15 frying batches of potatoes fried as above in one day. After the work, 35 g of oil was collected and stored at 4 °C. The frying procedures were carried out in the same way for 5 consecutive days. This was equivalent to a total frying time of 25 h. Frying oil was weighted at the beginning of each day, according to the oil weight the dosage of potatoes was determined.

2.5. Schaal oven test

2.5.1. Optimization of addition level of antioxidants for accelerated storage

Each antioxidant has a maximum added amount according to standards for use of food additives in China. In order to obtain the optimal concentration for Schaal oven test, rosemary ethanol extract, TP, BHA, TBHQ were added to palm oil as shown in Table 2. All samples were stored in an oven at 65 °C for 6 days and characterized by peroxide value, p-anisidine value, iodine value and free fatty acids value.

2.5.2. Schaal oven test

The inhibitive ability of antioxidants to oxidative deterioration of oil is measured by Schaal oven test. As a result of previous experiments, rosemary ethanol extract, TP, BHA and TBHQ were added into the palm oil at concentrations of 0.7, 0.4, 0.2, 0.16 g/kg, and then the oil were filled into bottles without headspace and stored in an oven at 65 °C for 24 days, during which time samples were analyzed every 6 days. Samples stored under such storage condition for one day is equivalent to one month of the storage at ambient temperature (Chong et al., 2015).

2.6. Analysis of oil

2.6.1. Determination of peroxide value (PV), free fatty acids (FFA), P-anisidine value (p-AnV) and iodine value (IV)

The determination of peroxide value (GB/T 5009.37-2003), free fatty acids (GB/T 5530-2005), p-anisidine value (GB/T 24304-2009) and iodine value (GB/T 5532-2008) were carried out according to the National Standard of the People's Republic of China.