ELSEVIER

Food Chemistry 85 (2004) 215–220

Food Chemistry

www.elsevier.com/locate/foodchem

Utilization of potato peels extract as a natural antioxidant in soy bean oil

Zia-ur-Rehman*, Farzana Habib, W.H. Shah

Biotechnology & Food Research Centre, PCSIR Laboratories Complex, Ferozepur Road, Lahore, Pakistan

Received 25 April 2003; accepted 6 June 2003

Abstract

Potato peel extract, as natural antioxidant was evaluated during 60 days storage of refined soy bean oil at 25 and 45 °C. Free fatty acids (FFA), peroxide values (POV) and iodine values (IV) were used as a criteria to assess the antioxidant activity of potato peel extract. Different organic solvents, including ethanol, methanol, acetone, hexane, petroleum ether and diethyl ether, were used to prepare extracts of potato peels. Maximum amount of extract (21%) was obtained with petroleum ether, followed by diethyl ether (15.25%) and methanol (14.75%). After 60 days' storage at 45 °C, soy bean oil, containing 1600 and 2400 ppm of petroleum ether extract of potato peels, showed lower values of FFA (0.120, 0.109%) and POVs (10.0, 9.0 meq/kg) than the control samples (FFA 0.320%, POV 59 meq/kg). Soy bean oil containing 200 ppm of BHA and BHT showed FFA values of 0.102 and 0.078%, whereas POVs were 8.0 and 6.0 meq/kg, respectively, after 60 days, storage at 45 °C. Similarly, after 60 days, storage at 45 °C, iodine values of soy bean oil containing 1600 and 2400 ppm of potato peel extract were 71 and 77, respectively, which were higher than the control samples of oil (58). However, iodine values for soy bean oil treated with 200 ppm of BHA and BHT were 80 and 84, respectively, after 60 days' storage at 45 °C. These results illustrate that potato peel extract, at various concentrations exhibited very strong antioxidant activity which was almost equal to synthetic antioxidants (BHA & BHT). Therefore, potato peel extract in oils, fats and other food products can safely be used as natural antioxidant to suppress lipid oxidation.

Keywords: Potato peels extract; Soy bean oil; Antioxidant

1. Introduction

Fats and oils undergo pronounced oxidative changes at elevated temperature during storage. The oxidative changes decrease the nutritional quality of fats and oils. However, addition of some suitable antioxidant in fats and oils retard the oxidation process. Synthetic antioxidants, especially butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are commonly used to prevent the oxidation process (Sobedio, Kaitaramita, Grandgiral, & Malkki, 1991). These synthetic antioxidants are known to have toxic and carcinogenic effects on humans (Ito et al., 1986). Synthetic antioxidants may cause liver swelling and influence liver enzyme activities (Martin & Gilbert, 1968). There is a strong need for effective antioxidants, from natural sources, as alternatives, to prevent deterioration of foods. The literature is replete with reports of extracts from natural sources that have demonstrated strong antioxidant activity (Alexander et al., 1998). Extracts from spices, herbs and hulls are known to have varying degrees of antioxidant activities (Nakatani, Inatani, Ohta, & Nishioka, 1986; Kohchi, 1995). These extracts have been reported to be more effective than some major synthetic antioxidants (Kikuzaki & Nakatani, 1993; Marinova & Yanishlieve, 1997). Recently, petroleum ether extract of potato peels showed strong antioxidant activity due to the presence of chlorogenic, gallic, cinnamic and ferulic acids as the major antioxidant compounds in the extract (Onyenecho & Hettiarachchy, 1993). However, effects of temperature and time period of storage on the antioxidant activity of potato peel extract have not yet been reported. Therefore, the present work was undertaken to investigate the

* Corresponding author. Tel.: +92-42-5877429; fax: +92-42-5877433.

E-mail address: pcsir@brain.net.pk (Zia-ur-Rehman).

0308-8146/$ - see front matter
doi:10.1016/j.foodchem.2003.06.015

effects of storage temperature and time period on antioxidant activity of potato peel extract in soy bean oil. Attempts were also made to extract natural antioxidant from potato peels using different organic solvents.

2. Materials and methods

2.1. Raw materials

Refined, bleached and deodorized soy bean oil was obtained from a local refinery, whereas the potato chip manufacturing industry supplied potato peels to carry out this study. Synthetic antioxidants, namely butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) were purchased from Sigma Chemical Co., USA.

2.2. Potato peel extract preparation (natural antioxidant)

The potato peels were washed and then dried in a hot air oven (Horizontal Forced Air Drier, Proctor and Schwartz Inc., Philadelphia, PA) at 55 °C. The dried peels were ground into a fine powder in a mill (Tecator-Cemotec 1090 samples mill, Hogans, Sweden). The material that passed through an 80 mesh sieve was retained for use. Ten grammes of ground peels were extracted with 100 ml of organic solvents (ethanol, methanol, acetone, hexane, petroleum ether or diethyl ether) overnight in a shaker at room temperature. The extract was filtered through cheese cloth and the residue was re-extracted under the same conditions. The combined filtrate was evaporated in a rotary evaporator (EVF-530-010K-GallenKamp) below 40 °C. The extract obtained after evaporation of organic solvent was used as natural antioxidant.

2.3. Application of potato peels extract to soy bean oil

Refined soy bean oil, free of additives, was used as the substrate for oxidation studies. Soy bean oil samples containing 800, 1600 and 2400 ppm potato peel extract (petroleum ether) were separately prepared. Each 100 ml prepared oil sample was placed in 250 ml brown airtight glass bottle. Synthetic antioxidants (BHA and BHT) were mixed in oil for a comparative study at their legal limit of 200 ppm (Duh & Yen, 1997). Control samples of soy bean oil without antioxidant were also placed under identical conditions. All oil samples of each treatment were prepared in triplicate which were left at 25 and 45 °C for 60 days. The oil samples of each treatment were withdrawn periodically after 15-day intervals to assess the antioxidant activity of potato peel extract.

2.4. Antioxidant activity testing

Potato peel extract, as antioxidant, was tested by the determination of free fatty acids (FFA), peroxide value (POV) and iodine value (IV) during storage of soy bean oil at 25 and 45 °C. Free fatty acids, as oleic acid percentage in oil samples, were determined using an alkali titration method whereas peroxide value (meq/kg of oil) was measured by titration with 0.1 N sodium thiosulphate, using starch as indicator (AOAC, 1990). However, iodine value in oil samples was determined by Wij's method, as described in AOAC (1990). All determinations were carried out in triplicate and mean values were calculated. Significant differences ($P<0.05$) were calculated using Duncan's multiple range test, as described by Steel and Torrie (1980).

3. Results and discussion

3.1. Extraction

Table 1 shows the percentage yield of potato peel extract obtained after refluxing ground potato peels with different organic solvents, i.e. ethanol, methanol, acetone, hexane, diethylether and petroleum ether. About 5.88–21.00% potato peel extract was obtained with these six different organic solvents. However, the maximum amount of potato peels extract (21.00%) was obtained with petroleum ether. followed by diethyl ether (15.25%) and methanol (14.75%). About 12 different phenolic antioxidant compounds have been reported in the non-volatile fraction of petroleum ether extract of potato peels by Onyenecho and Hettiarrachchy (1993). Therefore, antioxidant activity of the extract of highest yield (petroleum ether) was tested in refined soy bean oil at 25 and 45 °C during 60 days, storage.

3.2. Development of rancidity during storage of soy bean oil

Table 2 summarizes the effect of storage conditions on free fatty acids (FFA), peroxide value (POV) and iodine

Table 1
Percent yield of potato peels extract obtained with different organic solvents

Organic solvent	Potatoe peels extract yield (%)[a]
Ethanol	10.20±0.99[b]
Methanol	14.75±1.20
Acetone	5.88±1.49
Hexane	13.00±1.38
Petroleum ether	21.00±1.40
Diethyl ether	15.25±1.22

[a] g oil/100 g dried potato peels.
[b] Mean value±S.D. triplicate determination.

Table 2
Effect of storage conditions on peroxide value (POV), free fatty acids (FFA) and iodine value (IV) of soy bean oil without antioxidant (control)

Storage time (days)	25 °C			45 °C		
	POV (meq/kg)	FFA (% oleic acid)	IV	POV (meq/kg)	FFA (% oleic acid)	IV
0	0.32±0.07a	0.028±0.02a	109±1.21a	0.32±0.07a	0.028±0.02a	109±1.21a
15	4.00±0.06b	0.052±0.01a	103±1.18a	6.30±0.09b	0.079±0.13a	100±1.05a
30	21.50±0.09c	0.090±0.03b	94±1.130b	28.00±0.09c	0.121±0.14b	87±1.13b
45	41.00±0.12d	0.133±0.09c	80±1.20b	58.00±0.17d	0.155±0.17b	75±1.05c
60	56.00±0.17d	0.154±0.09c	69±1.12c	79.00±0.21d	0.320±0.15c	55±1.11d

Mean values±S.D. triplicate determinations. Mean values within a column with different letters are significantly different at $P<0.05$.

value (IV) of refined soy bean oil. Gradual increases in FFA and POVs were observed on storing the soy bean oil at 25 and 45 °C for 60 days. However, decrease in iodine value was noted during storage of soy bean oil. These changes were more pronounced at 45 than 25 °C. Initially, FFA, POV and IV of soy bean oil without antioxidant (control) were 0.028%, 0.32 meq/kg and 109, respectively. After 60 days' storage, FFA values at 25 and 45 °C were 0.164 and 0.32%, respectively, whereas POVs of soy bean oil were found to be 56.0 meq/kg at 25 °C and 79.0 meq/kg at 45 °C.

On the other hand, IVs of untreated soy bean oil (control) became 109–69 at 25 °C and 55 at 45 °C after storage for 60 days. The decrease in iodine value could be attributed to breaking of double bonds of unsaturated fatty acids of lipid during storage of soy bean oil at elevated temperature, as reported by earlier workers (Noor & Augustin, 1984). Generally, the principal route of the deterioration of fat is through oxidative rancidity, which takes place at the double bond in the triglyceride molecule (Akhtar, Asghar, & Sheikh, 1985). In fat deterioration, the first initiating step is the formation of free fatty acids which are susceptible to oxygen attack in the presence of light, resulting in the formation of many organic compounds and free fatty acids which are responsible for development of rancidity and off flavours in fatty food materials (Sattar & Demen, 1973). Production of free fatty acids and increases of peroxide values are the best predictors of fat deterioration, which could be used to monitor the extent of oil spoilage. It is well known that decrease in iodine value is another factor by which deterioration of fat can also be examined.

3.3. Free fatty acids and peroxide values after addition of synthetic antioxidants

The changes in FFA and POVs during storage of soy bean oil at 25 and 45 °C after addition of synthetic antioxidants, are given in Table 3. It is apparent from these results that addition of BHA and BHT retarded the development of rancidity in soy bean oil but BHT resulted in better protection than BHA. The FFA values were reduced from 0.320% (control) to 0.102% and 0.078% by the addition of BHA and BHT, POVs decreased from 79 meq/kg (control) to 8.0 and 6.0 meq/kg, respectively, after 60 days' storage at 45 °C. At 25 °C, the addition of BHA and BHT caused reduction in FFA values from 0.164 (control) to 0.095 and 0.080%, respectively, during storage for 60 days. Similarly, POVs were also reduced from 56.0 meq/kg (control) to 7.0 and 5.80 meq/kg by the addition of BHA and BHT, respectively, during 60 days, storage at 25 °C. These results are consistent with findings of Kiyomi and Yasuko (1995) and Yanping, Mourning, Yuhang, and Zhiying (1999) who reported that lipid peroxides were significantly reduced by the addition of antioxidants in processed foods and oils. Kathy, Randel, Peter, and George (1994) suggested that addition of BHA, along

Table 3
Effects of synthetic antioxidants and storage conditions on free fatty acids (FFA) and peroxide value (POV) of soy bean oil

Storage time (days)	BHA (200 ppm)				BHT (200 ppm)			
	25 °C		45 °C		25 °C		45 °C	
	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)
0	0.32±0.07a	0.028±0.027a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a
15	1.25±0.17b	0.035±0.03a	1.30±0.21a	0.040±0.01a	1.20±0.16a	0.030±0.01a	1.27±0.95a	0.033±0.01a
30	3.00±0.20b	0.061±0.04a	3.50±0.27a	0.067±0.03a	2.73±0.15a	0.055±0.02a	2.95±0.11a	0.065±0.03a
45	4.80±0.22c	0.080±0.04b	5.30±0.22b	0.085±0.04b	4.00±0.21b	0.068±0.02b	4.80±0.12b	0.074±0.03b
60	7.00±0.29c	0.095±0.05b	8.00±0.24c	0.102±0.04c	5.80±0.23c	0.080 ±0.03b	6.00±0.13b	0.078±0.02b

Mean values±S.D. triplicate determinations. Mean values within a column with different letters are significantly different at $P<0.05$.

with other antioxidants, inhibited food deterioration during storage at both high and ambient temperature. It has already been reported by earlier workers that addition of BHA and BHT retarded the development of rancidity in fried banana chips during storage (Noor & Augustin, 1984). Statistical analysis of the data revealed that FFA and POV of soy bean oil were significantly ($P < 0.05$) reduced by the addition of BHA and BHT.

3.4. *Free fatty acids and peroxide values after the addition of potato peels extract*

Addition of potato peel extract caused significant reduction in FFA and POVs of soy bean oil during 60 days' storage at 25 and 45 °C. It is evident from these results that, as the concentration of potato peel extract increased, inhibitory effects on FFA and POVs also increased considerably (Table 4). After 60 days' storage at 45 °C, FFA values of soy bean oil treated with 800, 1600 and 2400 ppm of potato peel extract were 0.176, 0.120 and 0.109%, whereas POVs were 40.0, 10.0 and 9.0 meq/kg, respectively (Table 4). Significant differences ($P < 0.05$) in free fatty acid and peroxide values were observed between the control and the soy bean oil treated with petroleum ether extract of potato peels. However, there was no distinct difference between synthetic antioxidants (200 ppm) and potato peel extract (1600 ppm) in inhibition of soy bean oil peroxidation. Similarly, there was no distinct difference in free fatty acid and peroxide values when the amount of potato peel extract in soy bean oil was increased from 1600 ppm to 2400 ppm. These results confirm the findings of Onyencho and Hittiarchchy (1993) who found 12 different phenolic antioxidant compounds, especially chlorogenic, protocatechuic, ferulic, cinnamic and caffeic acids in the non-volatile fraction of petroleum ether extract of potato peels. No changes in colour, taste and flavour of oil were observed by the addition of potato peel extract during storage. In this study, potato peels extract used was 8–12 times more than that of the synthetic antioxidants to control the development of rancidity of soy bean oil. These findings are consistent with the results of Farag, Basel, and El Baraty (1989) who found that extracts of thyme and clove at 1200 and 2400 ppm, respectively, produced an antioxidant power similar to that produced by BHT at 200 ppm.

3.5. *Effect of synthetic antioxidants and potato peels extract on iodine value of soy bean oil during storage*

Besides increase in free fatty acids and peroxide values, a marked decrease in iodine value was observed during storage of soy bean oil at 25 and 45 °C (Table 5). In fact, a decreasing trend in iodine values indicate the development of rancidity due to formation of secondary oxidation products in fat and oils during storage.

Table 4
Effect of potato peels extract (petroleum ether) and storage conditions on free fatty acids (FFA) and peroxide value (POV) of soy bean oil

Storage time (days)	800 ppm				1600 ppm				2400 ppm			
	25 °C		45 °C		25 °C		45 °C		25 °C		45 °C	
	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)	POV (meq/kg)	FFA (% oleic acid)
0	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a	0.32±0.07a	0.028±0.02a
15	1.90±0.09b	0.040±0.01a	2.10±0.11b	0.060±0.02a	1.40±0.10b	0.045±0.01a	1.65±0.12b	0.055±0.01a	1.35±0.13b	0.040±0.01a	1.59±0.14b	0.050±0.02a
30	7.00±0.11c	0.082±0.02b	10.50±0.17c	0.104±0.07b	3.60±0.12b	0.065±0.01b	4.50±0.12c	0.080±0.03b	3.00±0.12b	0.060±0.01b	4.00±0.13c	0.075±0.02b
45	14.00±0.11d	0.130±0.04c	23.00±0.17d	0.145±0.07c	5.50±0.13c	0.095±0.07b	7.00±0.13c	0.102±0.04c	5.00±0.12c	0.080±0.03b	6.70±0.12c	0.098±0.03c
60	21.0±0.30d	0142 ±0.04d	40.0±0.15d	0.176±0.11d	8.80±0.18d	0.114±0.07c	10.0±0.16d	0.120±0.04d	7.70±0.14d	0.108±0.04c	9.00±0.15d	0.109±0.03c

Mean values±S.D. triplicate determinations. Mean values within a column with different letters are significantly different at $P < 0.05$.

Table 5
Effect of synthetic antioxidants and potato peels extract on iodine value of soy bean oil during 60 days storage

Antioxidant	Storage time (days)									
	0		15		30		45		60	
	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C
Control	109a±1.16	109a±1.16	104a±1.11	99b±1.06	92b±1.17	88b±1.06	81c±1.21	76c±1.11	62d±1.17	58d±1.20
BHA-200ppm	109a±1.16	109a±1.16	106a±1.22	102a±1.31	96b±1.19	94b±1.11	90b±1.05	88c±1.00	82c±1.01	80c±1.11
BHT-200ppm	109a±1.16	109a±1.16	106a±1.20	104a±1.32	98b±1.12	96b±1.32	91b±1.12	90b±1.37	86c±1.16	84c±1.20
PPE-800ppm	109a±1.16	109a±1.16	89b±1.35	85b±1.29	94b±1.22	79c±1.21	80c±1.19	72d±1.11	71d±1.19	69d±1.11
PPE-1600ppm	109a±1.16	109a±1.16	92b±1.08	88b±1.10	87b±1.13	83c±1.00	85c±1.22	78d±1.10	76d±1.14	71d±1.29
PPE-2400ppm	109a±1.16	109a±1.16	94b±1.05	90b±1.24	91b±1.11	87b±1.00	88b±1.20	82c±1.22	80c±1.15	77d±1.17

BHA = butylated hydroxyanisole; BHT = butylated hydroxytoluene; PPE = potato peels extract. Mean values ± S.D. triplicate determination. Mean values within a row with different letters are significantly different at $P < 0.05$.

Results in Table 5 show that addition of synthetic antioxidants (BHA and BHT) and potato peel extract retarded the decreasing trend of iodine value in soy bean oil during storage. Addition of BHA and BHT in soy bean oil showed iodine values of 80 and 84, respectively, after 60 days' storage at 45 °C. Similarly, iodine value of soy bean oil treated with 800, 1600 and 2400 ppm of potato peel extract were 69, 71 and 77, respectively, after 60 days' storage at 45 °C (Table 5). On the other hand, the iodine value of untreated soy bean oil, stored for 60 days at 45 °C, was 55 while 109 was the iodine value of fresh and untreated soy bean oil. Therefore, iodine values of stored soy bean oil treated with synthetic antioxidants and potato peel extract were distinctly higher than control samples of soy bean oil. Similarly, an increase in iodine value was also observed at 25 °C during storage of treated soy bean oil for 60 days. These results clearly illustrate that auto-oxidation of soy bean oil was greatly reduced in the presence of BHA, BHT and potato peel extract. It is also obvious from these results that iodine values of soy bean oil treated with potato peel extract (2400 ppm) and 200 ppm of synthetic antioxidants (BHA, BHT) were almost equal after 60 days' storage at 25 and 45 °C. Changes in iodine values confirm the deterioration of oil as had already been observed by the increase in free fatty acids and peroxide values occurring during storage of soy bean oil. This study revealed that the level of potato peel extract needed was 8–12 times more than that of the synthetic antioxidants to control the development of rancidity in soy bean oil. However, natural antioxidant extract of potato peel extract would be preferred over synthetic antioxidants to minimize the adverse effects on health.

4. Conclusion

It is apparent from the study that potato peel extract (with petroleum ether), exhibited strong antioxidant activity in soy bean oil during storage which was almost equal to the antioxidant activity of synthetic antioxidants (BHA and BHT). However, the level of potato peel extract needed was 8–12 times higher than that of the synthetic antioxidants to control the development of rancidity during storage of cooking oils at elevated temperature. Therefore, it is suggested that natural antioxidant extract from potato peels can safely be used instead of synthetic antioxidant to prolong the shelf life of fats and oils.

References

AOAC. (1990). *Official methods of analysis* (15th ed). Washington DC: Association of Official Analytical Chemists.

Akhtar, P., Asghar, A., & Sheikh, A. S. (1985). Effect of peroxy radical scavengers on flourescent light induced oxidation in some edible oils. *Journal of Pure Applied Science*, *4*, 1–7.

Alexander, P., Ritsuko, M., Miechal, S., Bat-Sheva, C., Fostik-Magyar, C., & Dubinsley, Z. (1998). Natural antioxidant activity in some microalgal species. *Journal of Plant Science*, *46*, 169–176.

Duh, P. D., & Yen, G. C. (1997). Antioxidant efficacy of methanolic extracts of peanut hulls in soybean and Peanut Oils. *Journal of American Oil Chemical Society*, *74*, 745–748.

Farag, R. S., Badel, A. Z. M. A., & El Baraty, G. S. A. (1989). Influence of thyme and clove essential oils on cotton seed oil oxidation. *Journal of American Oil Chemical Society*, *66*, 800–804.

Ito, N., Hiroze, M., Fukushima, G., Tauda, H., Shira, T., & Tatematsu, M. (1986). Studies on antioxidant; their carcinogenic and modifying effects on chemical carcinogensis. *Food Chemistry Toxicology*, *24*, 1071–1081.

Kathy, G., Randel, B., Peter, T., & George, C. F. (1994). Effect of three different preservative systems on the stability of extended dog food subjected to ambient and high temperature storage. *Journal of Nutrition*, *124*, 26385–26425.

Kikuzaki, H., & Nakatani, N. (1993). Antioxidant effects of some ginger constituents. *Journal of Food Science*, *58*, 1407–1410.

Kiyomi, K., & Yasuko, S. (1995). Formation of lipid peroxides in processed foods in storage and the inhibitory effects of vitamin A and vitamin E in lipid peroxidation. *Kassigeku Kenkyu*, *41*, 91–96.

Kohchi, Y. (1995). Antioxidative activity of spices and herbs. *Food Ingredients Journal of Japan*, *163*, 44–55.

Marinova, E. M., & Yanishlieve, N. N. (1997). Antioxidant activity of extracts from selected species of the family lamiaccae in sunflower oil. *Food Chemistry*, *58*, 245–248.

Martin, A. D., & Gilbert, D. (1968). Enzyme changes accompanying liver enlargement in rats treated with 3-tert.butyl-4-hydroxyanisole. *Biochemical Journal*, *106*, 22–27.

Nakatani, N., Inatani, R., Ohta, H., & Nishioka, A. (1986). Chemical constituents of pepper and application of food preservation. naturally occurring antioxidative compounds. *Environmental Health Perspectives*, *67*, 135–141.

Noor, N., & Augustin, M. A. (1984). Effectiveness of antioxidant on the stability of banana chips. *Journal of Science Food & Agriculture*, *35*, 805–812.

Onyencho, S. N., & Hettiarachchy, N. S. (1993). Antioxidant activity; fatty acids and phenolic acids composition of potato peels. *Journal of Science Food & Agriculture*, *62*, 345–350.

Sattar, A., & Demen, J. M. (1973). Effect of packing material on light induced quality deterioration of milk. *Journal of Canada Science Technology Aliment*, *6*, 170–174.

Sobedio, J. L., Kaitaramita, J., Grandgiral, A., & Malkkl, Y. (1991). Quality assessment of industrial pre-fried French fries. *Journal of American Oil Chemical Society*, *68*, 299–302.

Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics*. London: McGraw Hill.

Yanping, W., Mourning, Z., Yuhang, Z., & Zhying, P. (1999). Study on effect of different antioxidants on antioxidant properties of oils. *Zhongguo Youzhi*, *24*, 37–39.