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PRODUCTION AND STABILIZATION OF PEANUT OIL

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Summary

The colour of peanut oil is pale-yellow, it has a neutral scent and it is rich in oleic and linoleic acid. The aim of this study was to investigate the effect of peanut kernel conditioning (25 °C, 35 °C, 45 °C, 55 °C), the addition of sunflower shells (3%, 6%, 9%), and the usage of oil during pressing. Peanut pressing is performed with a continuous press. Following the pressing process, a decision is made on the volume and the temperature of crude oil, as well as on pressing time. The additional steps include the natural precipitation of crude oil and the vacuum filtration of crude oil to obtain cold pressed oil. Some of the basic parameters for oil quality that are determined using standard methods are: peroxide number, free fatty acids, the proportion of insoluble impurities, and moisture content. Additionally, the results of the addition of natural and synthetic antioxidants on the oxidation stability of cold pressed peanut oil were examined. Finally, the results of the research show that conditioning and the addition of sunflower shells affect oil recovery during the pressing process. Conditioning peanuts at higher temperatures and the addition of a larger proportion of sunflower hulls resulted in greater amounts of produced oil. The natural antioxidant rosemary extract and synthetic propyl gallate achieve greater protection from oxidative degradation for the oil.

Keywords: peanut oil, cold pressing, oxidative stability, antioxidants

Introduction

Peanut is an important oilseed crop in Taiwan and one third of these seeds is processed for edible oil (Chu and Hsu, 1999). Peanut oil is the main natural edible oil consumed without additives in the middle Mediterranean region south of Turkey. Peanut oil is one of the most stable vegetable oils in relation to oxidation. The oxidative stability of oils may be influenced by many factors, such as light, metal ions, oxygen, temperature, and enzymes (Nawar, 1985). The effect of fatty acid composition on the oxidative stability of oil for vegetable oils has been studied by a number of investigators (OKeefe et al., 1993; Liu and White, 1992). Peanut oil is composed of ≈80% of unsaturated fatty acids, with oleic acid (18:1, ω-9) comprising an average of ≈50% and linoleic acid (18:2, ω-6) 30% of the total fatty acid composition (Mercer et al., 1990). Because of the polyunsaturated fatty acids, peanuts are susceptible to lipid oxidation (Braddock et al., 1995). The production of edible cold-pressed oil is done with a continuous screw press without the use of organic solvents. The processing of oil yielding plants through the cold pressing procedure ensures the maximum retention of active compounds in oil, like essential fatty acids, phenolic and flavonoid compounds, tocopherols, tocotrienols, phytosterols, and others (Teh and Birch, 2013), as well as the preservation of characteristic sensory properties of oil. This pressing procedure results in crude oil, which must undergo the procedure of removing insoluble solid particles (through sedimentation, filtration, centrifuge) in order to obtain cold pressed oil. One of the by-products in the process of pressing oil yielding plants is cake, which retains a certain amount of oil, significant proteins, minerals, fibre, and other ingredients (Zubr, 1997; Quezada and Cherian, 2012). Jokić et al. (2014) investigated the optimisation of the production of cold pressed walnut oil with a screw press and determined that the processing parameters of the pressing process have an effect on the utilisation of oil. Moslavac et al. (2014) indicated that the process parameters of cold pressing have an effect on the utilisation of camelina oil (*Camelina sativa* L.). Cold-pressed pumpkin seed oil is made through the process of mechanical pressing of an industrial variety of pumpkin (field pumpkin) using screw presses, and it is consumed as salad oil (Fruhwirth, 2008). Cold-pressed pumpkin seed oil belongs to the group of edible oils with high nutritional value, due to the favourable composition of fatty acids and other ingredients that yield a positive effect in the organism (Murković and Pfannhauser, 2000; Neđeral, 2006). Tocopherols and tocotrienols are non-glycerol ingredients in plant oils with antioxidant properties that protect the oil from oxidative degradation. Edible plant oils very quickly become sensitive to negative changes (chemical reactions, enzymatic and microbiological processes), which results in the spoiling of the oil. Auto-oxidation can occur faster or slower, depending on the production process, oil composition, storage conditions, the presence of compounds that accelerate

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(pro-oxidants) or decelerate (antioxidants) this oxidation reaction (Martin-Polvillo, 2004). Primary and secondary oxidation products are created in the process of oxidative degradation of oil (Gray, 1978; Rovellini, 1997). The small quantities of these products of oil degradation deteriorate the sensory properties of oil (Broadbent and Pike, 2003). It is important to know the sustainability or stability of plant oils, in order to be able to determine the time required to preserve the oil from the more significant effects of oxidation and to determine the time period in which the oil can be used. A significant amount of research into oxidative degradation of plant oils has shown that their sustainability depends on the type of oil or the composition of fatty acids and the type and share of the active compounds with antioxidative properties in oil. Frega et al. (1999) determined that free fatty acids in plant oil act as pro-oxidants, accelerate the oxidative degradation of oil, and in larger shares reduce the stability of oil. Matthaus (1996) indicated that specific ingredients affect the stability of sunflower oil, rapeseed oil, and walnut oil. Various methods based on the accelerated oxidation of oil are used today to determine the oxidative stability of plant oil: Oven test, AOM test, and the Rancimat test (Shahidi, 2005; Suja, 2004; Abramović, 2006; Farhoosh, 2008). The stability of plant oils can be improved with the addition of antioxidants, compounds that decelerate the auto-oxidation process. There are synthetic and natural antioxidants which are applied for the stabilisation of edible plant oils, i.e. increasing their resistance to oxidation (Yanishlieva and Marinova, 2001; Merrill, 2008). Recently, various plant materials, particularly herbs, are investigated due to their active compounds (phenolic compounds) which are showing significant antioxidative properties in plant oils (Berra, 2006; Bandoniene, 2000). The stabilisation of cold-pressed oils is focused toward the application of various plant extracts (rosemary, green tea, sage, oregano, and others) for the purpose of protection against oxidative degradation (Pan, 2007; Ahn, 2008). Erkan et al. (2008) investigated the antioxidant activity of rosemary extracts and other compounds for the purpose of oil stabilisation. Gramza et al. (2006) reported high antioxidant activity, measured as an induction period, in the ethanol extract of green tea, regarding the activity of BHT and the extract of black tea in sunflower oil. Hraš et al. (2000) tested and determined that rosemary extract and alpha tocopherol have antioxidant and synergetic effects for the stabilisation of sunflower oil.

The aim of this research was to investigate the effect of conditioning peanut kernels (25 °C, 35 °C, 45 °C, 55 °C), as well as the effect of adding sunflower hulls (3%, 6 %, 9%) on the utilisation of oil during pressing. The effect of adding natural and synthetic antioxidants to the produced cold-pressed peanut oil on the changes of the oxidative stability of the oil was tested.

Materials and methods

Materials

Peanut kernels purchased in the store were used in this research. The antioxidants used in the research are natural antioxidants: rosemary extract (type Oxy Less CS), sage extract, DOPE-dry olive pomace extract (type hpDOPE and ramDOPE) in the concentration of 0.2%, alpha tocopherol and mixtures of tocopherols in the concentration 0.05%, and synthetic antioxidants: propyl gallate and butylhydroxyanisole in the concentration of 0.01%. Rosemary extract (type Oxy Less CS) and sage extract were supplied from Naturex (France). Alpha tocopherol and the mixtures of tocopherols were supplied from DSM Nutritional Products Ltd. (Switzerland). Dry olive pomace extract type hpDOPE is extract prepared with hydroxypropyl-β-cyclodextrin and ramDOPE is extract prepared with randomly-methylated-β-cyclodextrin. Propyl gallate (PG) and butylhydroxyanisole (BHA) were purchased from the company Danisco (Denmark). All other chemicals and reagents were of analytical reagent grade. The peanut oil was obtained by pressing, using different process conditions. The peanut kernels were pressed in a screw expeller (firm Gorenje, power of the electric motor 650 W). The produced crude oil was collected in a graduated cylinder and the volume and temperature were measured. After the precipitation of crude oil, vacuum filtration was carried out to remove insoluble particles from the oil. Cold pressed oil was produced in this way. Part of the peanut kernel press samples were heated in an oven to a temperature 25 °C, 35 °C, 45 °C, 55 °C for 30 minutes and sunflower hulls were added to some samples (3%, 6%, 9%) to influence the change of oil consumption during pressing.

Determination of initial oil and water content

The initial oil content in peanut kernels was measured using the automatic extraction system Soxterm by Gerdhart with *n*-hexane (Aladić et al., 2014). The measurement was performed in duplicate. The average of the initial oil content for two replicates was 51.82 ± 0.12 %. Cake residual oil (CRO) was also determined by the automatic extraction system Soxterm. The moisture content of the peanut kernels (2.81 ± 0.09 %) was determined according to the AOAC Official Method 925.40. The determination of moisture in the defatted cake was done using the modified standard HRN ISO 6496:2001.

Oil quality parameters

The peroxide value (PV) of oil samples was determined according to ISO 3960. The PV was expressed as mmol O_2/kg of oil. Free fatty acids (FFA) in oil were determined using ISO 660. Insoluble impurities (II) and moisture and volatile matter content of oil were determined according to ISO 663 and ISO 662. All these determinations were carried out in duplicate.

Determination of oxidative stability

Oxidative stability was determined using the rapid oil oxidation test - sustainability test at 98 °C during 20 days. The influence of the addition of natural antioxidants, namely rosemary extract, sage extract, olive pomace extract in concentration of 0.2%, alpha tocopherol and mixtures of tocopherols (0.05%), and synthetic antioxidants propyl gallate and butylhydroxyanisole in the concentration of 0.01%, on the oxidative stability of cold pressed peanut oil were monitored. The result of the oil oxidation was expressed as peroxide value (PV) during the 20 days of the test. All determinations were carried out in duplicate.

Results and discussion

Table 1 shows the results of determining the basic quality parameters of peanut kernels for pressing. The resulting values for the oil content are 51.82% and for the moisture content 2.81%.

Table 1. Peanut composition

Parameters	Content
Oil (%)	51.82%
Moisture (%)	2.81%

The testing results regarding the influence of the conditioning temperature of peanut kernels (25 °C, 35 °C, 45 °C, 55 °C) on the efficiency of crude oil and cold pressed oil production are shown in Table 2. After pressing the peanuts (0.5 kg) at room temperature (25 °C), 78 mL of crude oil was obtained, with the temperature of 29 °C. After 7 days of sedimentation and vacuum filtration of the crude oil, 15 mL of cold pressed peanut oil was obtained. An analysis was conducted to determine the share of oil cake waste (pressing by-product) and it was 47.87%. When conditioning the peanut kernels at the temperature of 35 °C before pressing, 110 mL of crude oil was obtained, and 32 mL of cold pressed oil was obtained after sedimentation and filtration. The share of oil cake waste was 47.42%. By increasing the peanut conditioning temperature to 45 °C and pressing, a larger quantity of crude oil (144 mL) and cold pressed oil (71 mL) was obtained, with even less oil cake waste (42.71%). After increasing the peanut heating temperature even more, to 55 °C, even more crude oil (146 mL) and cold pressed oil (80 mL) was obtained. The analysis determined a lower share of oil cake waste (42.37%). The results achieved in this research have shown that the peanut kernel conditioning temperature affects the level of utilisation of oil in the pressing process.

Table 2. The influence of the conditioning of peanut kernels (0.5kg) on the efficiency of the production of crude oil and cold pressed oil

Conditioning temperature (ºC)	Crude oil (mL)	Temp. crude oil (ºC)	Cold pressed oil (mL)	Mass of cakes (g)	Oil in cakes (%)	Moisture in cakes (%)
25	78	29	15	404.22	47.87	2.54
35	110	29	32	393.15	47.42	2.44
45	144	34	71	386.09	42.71	2.62
55	146	39	80	379.99	42.37	2.59

The sedimentation and filtration of crude oil lasted for 7 days

Table 3 shows the results of the testing regarding the utilisation of oil after the addition of sunflower hulls (3%, 6%, 9%) to the peanut kernels. After the addition of sunflower hulls (3%) to the peanut kernels, a larger quantity of crude oil (111 mL) and cold pressed oil was obtained, when compared to the peanut oil obtained without adding the sunflower hulls (control sample). By increasing the share of sunflower hulls to 6% and pressing the peanuts, the quantity of the obtained crude oil (139 mL) and cold pressed oil (55 mL) increased. The share of oil cake waste was determined by analysis at 41.81%. By increasing the share of the added sunflower hulls even further, to 9%, the amount of the obtained crude oil (150 mL) and cold pressed peanut oil (61 mL) increased even more, after 7 days of sedimentation and filtration. This research indicates that sunflower hulls have a significant effect on the utilisation of peanut oil in the cold pressing process.

Table 3. Effects of the addition of sunflower hulls (3%, 6%, 9%) to peanuts (0.5 kg) on the production of cold pressed oil

Sunflower hulls (%)	Conditioning temperature (ºC)	Crude oil (mL)	Temp. crude oil (ºC)	Cold pressed oil (mL)	Mass of cakes (g)	Oil in cakes (%)	Moisture in cakes (%)
0	25	78	29	15	404.22	47.87	2.54
3	25	111	35	44	402.00	44.24	2.72
6	25	139	30	55	398.10	41.81	2.98
9	25	150	33	61	412.88	39.30	3.13

The basic quality parameters for the cold pressed peanut oil were determined according to the Regulation on Edible Oils and Fats (Official Gazette of the Republic of Croatia 11/2019), which is shown in Table 4. The obtained results show that the peroxide value (PV), free fatty acids (FFA), and the moisture value conform to the regulation values. The share of insoluble impurities in oil (0.2%) is somewhat higher than indicated in the Regulation (max. 0.05%) and the sedimentation time of the crude oil should be increased, in order to separate the solid particles from the oil.

Table 4. The basic quality parameters of the produced cold pressed peanut oil

Oil quality parameters	Content
Peroxide value (PV), mmol O_2/kg	0.70
Free fatty acids (FFA), %	0.73
Moisture, %	0.0082
Insoluble impurities, %	0.20

Table 5 shows the results of adding antioxidants (natural and synthetic) on the oxidation stability of cold pressed peanut oil. The oxidation stability test was conducted at the temperature of 98 °C in a thermostat, during a period of 20 hours. The obtained results show that the peroxide value (PV) of the oil gradually increases during the testing, due to increased oxidative degradation. According to research done by Chu and Hsu (1999) efficient peanut oil stabilization is achieved by adding catechins in combination with other antioxidants. The cold pressed peanut oil (control sample) had the PV of 3.57 mmol O_2/kg of oil after 20 hours of testing. With individual additions of natural antioxidants, the oil was stabilised, i.e. its resistance to oxidative degradation increased. Apart from the addition of α- tocopherol (0.05%), where a higher PV (4.08 mmol O_2/kg) was observed when compared to the control sample after 20 hours of testing. With the addition of rosemary extract (type OxyLess CS) to the oil in the share of 0.2%, the highest protection of the oil from oxidative degradation was achieved, after 20 hours of testing the PV was the lowest, at 1.75 mmol O_2/kg. Ozcan (2003) investigated the effect of antioxidants on the oxidative stability of peanut oil during storage and determined their positive effect on oil stabilization. A satisfactory protection of the oil from oxidative degradation was also achieved with the addition of dry olive pomace extract (type ramDOPE) in the share of 0.2%, where the PV was 2.02 mmol O_2/kg after 20 hours of testing. Sage extract (0.2%) and olive pomace extract (type hpDOPE) in the share of 0.2% showed equal antioxidation effects, where the PV remained approximately equal during 20 hours of testing. The use of a tocopherol mixture (0.05%) resulted in a very low level of oil protection against oxidative degradation. The PV was 3.40 mmol O_2/kg after 20 hours of testing, only slightly lower than the control sample (3.57 mmol O_2/kg). The use of synthetic antioxidants propyl gallate (PG) and *butylated hydroxyanisole* (BHA) in the share of 0.01% also achieved the protection of peanut oil from oxidative degradation. The application of PG resulted in a significantly higher level of oil protection from oxidation (PV was 1.58 mmol O_2/kg), when compared to BHA (3.40 mmol O_2/kg) after 20 hours of testing.

Table 5. The influence of the addition of antioxidants (natural and synthetic) on the oxidative stability of cold pressed peanut oil

Sample	Share of antioxidants (%)	PV (mmol O_2/ kg)								
		0 h	1 h	2 h	3 h	4 h	6 h	8 h	12 h	20 h
Oil without antioxidant addition	-	0.70	0.97	1.55	1.74	1.79	2.24	2.50	2.67	3.57
Rosemary extract (type Oxy' Less CS)	0.2	0.70	0.72	1.19	1.33	1.43	1.45	1.51	1.56	1.75
hpDOPE	0.2	0.70	1.15	1.43	1.28	1.48	1.58	1.73	2.03	2.53
ramDOPE	0.2	0.70	0.95	1.30	1.36	1.40	1.52	1.58	1.66	2.02
α- tocopherol	0.05	0.70	1.27	1.57	1.70	1.96	2.26	2.39	3.13	4.08
Tocopherol mixture	0.05	0.70	1.25	1.65	1.66	1.75	2.32	2.41	2.81	3.40
Sage extract	0.2	0.70	1.26	1.63	1.64	1.66	1.53	1.75	1.85	2.48
PG	0.01	0.70	0.87	1.02	1.36	1.35	1.36	1.46	1.51	1.58
BHA	0.01	0.70	1.54	1.79	1.69	1.80	1.84	2.13	2.89	3.40

DOPE-dry olive pomace extract; hpDOPE-extract prepared with hydroxypropyl-β-cyclodextrin; ramDOPE-extract prepared with randomly methylated-β-cyclodextrin; BHA-butylhydroxyanisol; PG-propyl-gallate

Conclusions

The peanut conditioning temperature before pressing affects the utilisation of oil. With the increase of the peanut conditioning temperature, the production of crude oil and cold pressed oil increases. The addition of sunflower hulls to peanut kernels before pressing affects the utilisation of crude oil. As the quantity of added hulls increases, the amount of obtained crude oil and cold pressed oil increases as well, with the reduction of oil cake waste. The tested natural antioxidants are efficient in protecting peanut oil from oxidative degradation, apart from α-tocopherol (0.05%). The addition of rosemary extract (type OxyLess CS) resulted in higher oil protection when compared to other tested natural antioxidants. The use of dry olive pomace extract (type ramDOPE) resulted in significant oil protection from oxidative degradation. The addition of sage extract and dry olive pomace extract (type hpDOPE) resulted in approximately equal levels of antioxidant activity. The tocopherol mixture has a negligible effect on the reduction of oxidative degradation in peanut oil. The synthetic antioxidant propyl gallate is more efficient in protecting peanut oil from oxidation when compared to butylated hydroxyanisole.

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