Effect of atmosphere and vacuum condition on the physicochemical properties of canola oil during frying

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Abstract

The aim of this study was to evaluation the effect of different frying condition include atmospheric and vacuum on some physicochemical properties (color properties, density, refract index, total polar and polymer compounds, viscosity, acid and peroxide value) of the oil during tenth day of process. In both condition chemical reaction was happened but with lower intensity in vacuum frying. It means in atmospheric frying oxidation and hydrolysis reaction was higher than vacuum frying, therefore density, refract index total polar and polymer compounds, viscosity, acid and peroxide value was higher in this condition than vacuum frying. According to this result vacuum frying at 115°C retain the oil quality and longer usage of oil in compare to atmospheric frying at 180°C.

Key word: Atmospheric , vacuum , frying.

Introduction

Deep-fat frying is one of the most important processes of food industry consists the immersion of foodstuff in hot oil. The aim of deep-fat frying is to produce the food rapidly with unique flavor characterization. Many different oils can be used for frying, like canola oil, palm oil, soya oil and sunflower oil (Naghshineh et al., 2009). One of the most important oils in oil industry was canola oil that after the soybean oil has the highest word production (Przybylski et al., 2002). Canola oil has low saturated fat and presence of 7% to 11% of linolenic acid in places it in a similar group with soybean oil with respect to oxidative stability and flavor. Its stability of this oil is affected by the presence of linolenic acid. Canola oil due to the low content of saturated fats and high level of essential fatty acid, recognized as the benefit for human health . Canola oil remains transparent (without precipitation) at refrigeration temperatures (3-50 °C) and therefore it is a pure salad oil or, as an ingredient in salad oil blends of several oils. The Intensity of this reaction are related with the properties of oil used, temperature, access of sunlight, and conditions in which the process takes place. The most important among this factor are present of oxygen with oxidation catalysts include heavy metals. Repetitive use of oil, and interactions between oil and different ingredient from product caused volatile and nonvolatile compounds are produced. Volatile compounds refer to substance with molecular weight lower than 1800 Da, include aldehydes, hydrocarbons, furans and carbocyclic acids. Nonvolatile component, with molecular weight exceeding 1800 Da, that refer to cyclic and its derivatives witch, accumulate in oil (Maniak et al., 2009). If diluted oxygen present in oil reacted with double bonds of unsaturated fatty acids and therefore formed hydroperoxides and secondary product like as alcohols, ketones and aldehydes finally polymerization was accrue. Formation of high level of polymers increased the consistency and density of fat (Maniak et al., 2009). These reactions increased the level of polar compounds and free fatty acid that have adverse effect on human health by causing a higher risk of: coronary heart disease, cancer especially lung cancer and high blood pressure (Kusucharid et al., 2009). the aim of this study was to evaluation physicochemical changes in canola oil during repeatedly frying of potato in vacuum and atmospheric condition.

MATERIALS AND METHODS

Canola oil and potato were purchased in the local store in Malaysia. Potato was cleaned, peeled, cut into pieces about 2 mm thick manually and before frying process, soaked in water due to inhibition of browning reaction.
Peroxide index was done according to AOAC standards NO. 965.33. The present of acidity was done according to National standard No. 4178. Refract index was done according to national standard NO. 5108. The soapy number was done according to national standard No. 4888. Iodine number was done according to national standard NO. 5108. Viscosity of sample was determined using a viscometer (25°C)(Brookfield DV-III, USA). Polar and polymer components were measure by method described by Amany et al, (2012). The color properties were determined by a spectrophotometer (Minolta CM-3500d).

Frying:

Frying process was down according to Kusucharid et all (2009).Sliced potato was fried under atmospheric conditions at 180°C 90 sec and under vacuum conditions at 110°C(630 mmHg) for 10 min. Frying was down every hour (eight times per day) for ten days. About 20 g of oil was collected at the end of every working day.

Data Analysis

Data collected from the aforementioned study samples were analyzed based on 0.05% coefficient of error. The data analysis was performed using MINITAB statistical software, release 14.2 (MINITAB Inc., state college, PA and USA).

Results and Discussion

Physicochemical properties of canola oil including color properties, peroxide value, acidity, viscosity, soapy material and non soapy material, polymer, and polar content, iodine number and refract index in experimental canola oils are shown in Table 1. Refract index, density, soapy and non soapy number for canola oil was 1.467, 0.917, 171.62 % and 2.37 % respectively and all of them were agreed with codex standard. As shown in Table 1, the iodine value of canola oil was 103.62. The polar component and viscosity of experimental canola oil was 5.13 % and 74.81 centipoise (cP) respectively. However, this oil was suitable quality as per its low viscosity, peroxide value, acid value and polar content; also it's free of polymer. Analyzed changes of physicochemical properties of canola oil during frying in both atmospheric and vacuum condition, include refract index, peroxide value, acidity, viscosity, polymer and polar compounds, are presented in Table 2 and 3. During atmospheric frying, acid value significantly ($p \leq 0.05$) increased sharply from 0.78 % in the first day to 2.01 % in the end of frying. Furthermore during vacuum condition acidity increased significantly ($p \leq 0.05$) but very moderate in compared to atmospheric frying. So in the first day acidity was 0.17 % and reached to 0.87 % in tenth day. Acid value shows free fatty acid (FFA) and refers to hydrolytic decomposition of TG that was occurring in present of water. Due to the high temperature in frying, water content of potato texture come out and introduced to oil and increased hydrolysis. In vacuum condition, due to low pressure of atmosphere water of system changed to vapor rapidly and removed so its effect on hydrolysis will be decreased. Therefore in vacuum frying acidity of oil was very lower than atmospheric condition. A similar result was observed by Kusucharid et al. (2009). Who reported that during usual deep frying acidity of palm oil from about 0.2 % increased and reached to about 1.5 % and vacuum condition decreased this value. During 6 first day of frying period, in usual method, peroxide value was increased and then decreased slightly. It means that in first day this value was 2.31 % and in six day increased to 11.05 % and finally decreased and reached to 9.75 %. This behavior was observed in vacuum condition but this increased and decreased was happened later than atmosphere condition. It means peroxide value in first day (2.01 %) to eighth day (12.03 %) was increased and then decreased to 10.23 % in end of frying period. This prevented was explain as below: During deep frying in atmospheric condition, oil is exposed to heat (180°c), oxygen and water, therefore oxidative and hydrolytic reaction of oil was occur. Oxidation of oils in first stage produced hydro peroxides, that is very unstable and convert to free radical. Due to high energy of this radicals, change to form a different of substance, for example, aldehydes, acids, ketones, alcohols, dimmers, polymer (Shyu et al., 1998). In vacuum condition due to low temperature (110°c) and pressure of oxygen, formation and decomposition of hydroperoxides was occurring later than atmospheric condition. This result of this study was in agreement with the study of Serjouie et al (2010). Who reported that during natural frying of canola oil at the first, hydroperoxide content was increased and reached to 10.53 and then decreased. The polar content is one of the most important properties and valid factor for the investigation of deterioration of oils. Polar substance in fresh oil includes free fatty acids, tocopherols, sterols, mono and triglycerides, and other oil-soluble components. This compounds increase during frying period as a result of oxidation reaction of fatty acids. It was found that the higher time of frying caused the higher content of polar component .polar content in fresh canola oil was 5.13%. During frying, oils undergo different reaction include hydrolysis and oxidation to produce polar component, such as, alcohols aldehydes, ketones, acids, mono and diglycerides. In both condition total polar content increased significantly ($P \leq 0.05$) as the frying period increased. The total polar components in atmosphere frying were 5.43 % in first day and reached to 38.42 % in tenth day. While the vacuum frying amount of polar was 5.22 % in first day and reached to13.82% in tenth day. This result reveled that the rate of increase in polar content under vacuum conditions was lower than atmospheric frying. This sharp increasing refers to high temperature which accelerated chemical reactions and therefore rapidly deteriorated the oil. According to international standard maximum acceptable level of polar component is 25 %, therefore in atmospheric frying up to 6 day oil is suitable and after that should be changed but in vacuum condition in all the period time (ten day) polar content was below 25 %, therefore the oil was suitable in point of polar content view. This result was matched to data obtained by Amany et al (2012), who observed that during frying of sun flower oil in both vacuum and atmosphere condition polar component increased but in atmosphere condition was more than vacuum. Also Serjouie et all (2010) repotted that polar content of canola oil during 5 days of frying from 6.94 % reached to 26.78%. Fresh canola oil was free of polymer (Table1) when the oxidation reaction of oil developed due to the collision and reaction of free radicals, high molecular weigh with long chain component was formed that know as polymer. In both condition of frying the polymer content showed significant increase with time, but this index was higher in atmosphere condition than vacuum frying. In the first day of atmosphere frying, polymer content was 1.16 % and after ten days reached to 12.71 %, while in vacuum condition, the content of polymer in initial and last day was 0.15 % and 7.02 % respectively. According to international standard maximum acceptable level of polymer is 10 %, so in atmosphere frying after 7 day oil will be expire and should be removed but in vacuum frying until last day of process, the oil was suitable. In atmosphere and vacuum condition, viscosity in first day was (75.14 cP and 74.83) and after tenth day reached to (93.32 cP and 75.19 cP) respectively. This data was matched with the results of Kusucharid et all (2009) who observed that during vacuum frying of palm oil the viscosity was constant, but in atmosphere condition viscosity increased. In another study Serjouie et all (2010) has shown that the viscosity of canola oil from 59.88 cP reached to 84.10 cP in atmosphere condition.

Conclusion

Vacuum condition in frying is an alternative method to retain the quality of oil. It is very important to identify the factor that indicates a progressive degradation of oil, as a result of the fact that different physicochemical properties of oil tend to change after extensive use. According to this result, it is clear that frying in vacuum condition can retain better oil quality than the atmospheric condition, and show economic benefits.

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Table 1: Physicochemical properties of fresh canola oil

Physicochemical properties	Canola oil	Canola oil standard[a]
Density	0.917±0.01	0.910-0.920
Acidity (%)	0.12±0.03	< 4
Peroxide value (meq/kg)	1.24±0.17	□□10
Iodine number	103.62±1.14	94-120
Soapy number (mg KOH/gr)	171.62±1.37	168-181
Non soapy material	2.37±0.18	□□20
Viscosity(cP)	74.81±	-
Polar content (%)	5.13±0.82	-
Polymer content	0	-
Refract index (40^c)	1.467±0.00	1.465-1.469
L* (Lightness)	113.53±0.72	-
a*(Redness)	-1.85±0.10	-
b*(Yellowness)	30.28±1.17	-

[a:] (Codex Alimentarius, 2001)

Table 2: Analyzed changes in canola oil during frying in atmospheric condition

Time (Day)	Viscosity (cP)	Acid value (mg KOH/g)	Peroxide value (meq/kg)	Polar content (%)	Polymer content (%)	Refractive index
1	75.14±1.84[a]	0.78±0.07[a]	2.31±0.04[a]	5.43±0.12 [a]	1.16±0.16[a]	1.467±0.01[a]
2	75.98±1.02[a]	0.97±0.03[a]	4.32±0.07[a]	8.54±0.44 [b]	2.18±0.07[a]	1.468±0.00[a]
3	76.73±1.24[a]	1.05±0.11[a]	6.73±0.05[b]	11.61±0.98 [c]	4.21±1.02[b]	1.470±0.00[a]
4	77.47±0.63[b]	1.12±0.05[b]	9.02±1.01[c]	16.85±1.74 [d]	5.92±0.36[b]	1.472±0.02[a]
5	78.94±1.5 4[b]	1.24±0.17[b]	10.23±0.31[c]	20.04±1. 46 [e]	7.34±0.79[c]	1.476±0.00[a]
6	83.91±1.15[c]	1.39±0.14[b]	11.05±0.19[c]	26.30±0.94 [f]	9.12±1.27[c]	1.480±0.01[b]
7	86.42±2.08[c]	1.51±0.08[b]	9.93±0.12[c]	29.61±1.20 [g]	10.02±0.79[c]	1.484±0.03[b]
8	89.00±091[d]	1.68±0.15[c]	8.92±0.23[c]	33.72±1.05 [h]	11.32±2.35[d]	1.489±0.03[b]
9	91.36±1.24[d]	1.80±0.20[c]	9.35±1.10[c]	35.03±1.12 [i]	12.19±1.52[d]	1.491±0.03[b]
10	93.12±1.34[d]	2.01±0.08[c]	9.75±0.31[c]	38.42±2.01 [j]	12.71±0.28[d]	1.493±0.02[b]

[a-j:] significant difference within column at confidence level of $p \leq 0.05$.

Table 3: Analyzed changes in canola oil during frying in vacuum condition

Time (Day)	Viscosity (cP)	Acid value (mg KOH/g)	Peroxide value (meq/kg)	Polar content (%)	Polymer content (%)	Refractive index
1	74.83±1.05[a]	0.17±0.02[a]	2.01±0.06[a]	5.22±1.01[a]	0.15±0.04[a]	1.467±0.01[a]
2	74.71±1.12[a]	0.21±0.07[a]	3.63±0.15[a]	6.03±0.07[b]	1.02±0.08[a]	1.467±0.00[a]
3	74.91±0.95[a]	0.29±0.03[a]	5.82±0.34[b]	6.98±0.16[b]	1.89±0.21[a]	1.467±0.02[a]
4	74.93±1.17[a]	0.37±0.04[a]	8.13±1.03[c]	7.83±0.23[c]	2.76±0.14[a]	1.467±0.00[a]
5	75.10±0.49[a]	0.46±0.01[b]	10.45±1.20[d]	8.80±0.20[c]	3.51±0.27[b]	1.468±0.01[a]
6	75.12±0.31[a]	0.59±0.02[b]	11.07±1.17 [d]	9.93±1.28[c]	4.16±1.63[b]	1.468±0.03[a]
7	75.11±1.73[a]	0.68±0.07[b]	11.94±1.09[d]	10.72±0.91[d]	5.21±0.79[a]	1.468±0.01[a]
8	75.14±1.50[a]	0.71±0.17[b]	12.01±0.62[d]	11.59±2.36[d]	5.97±1.09[b]	1.468±0.04[a]
9	75.17±1.94[a]	0.79±0.06[b]	11.87±1.02[d]	12.70±0.74[d]	6.39±0.54[c]	1.469±0.00[a]
10	75.19±1.08[a]	0.87±0.11[c]	10.23±1.10[d]	13.82±1.12[e]	7.02±1.04[c]	1.469±0.02[a]

[a-e:] significant difference within column at confidence level of $p \leq 0.05$.