

The Effect Of Thermal Treatment On The Characteristics Of Commercially Available Edible Vegetable Oils In Nigeria.

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Abstract: This study investigates the effect of thermal treatment on the characteristics of commercially available edible vegetable oils used in Nigeria. The saponification value of oil was found to be higher in C than in A and B. At 20 minutes of heating time, C has the highest value of value 194.30 mgKOH/g, followed by A with value of 185.90 mgKOH/g while B has the lowest value of 184.40 mgKOH/g after 20mins of heating time respectively. The saponification value decreases with an increase in heating time. The iodine value decreased for all samples as heating time increases. Sample A has the highest value of 102.50 g/100g while sample B has the lowest value of 92.0 g/100g respectively. As the heating time increase, the acid value and free fatty acid values also increases for all samples. Repeated heating of the oil eventually resulting in Lipid peroxidation and formation of hydro-peroxides and aldehydes. Increasing the heating time of edible oil accelerates oxidative degradation of lipids, forming hazardous reactive oxygen species and depleting the natural antioxidant contents of the cooking oil.

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1. Introduction

Frying involves heat and mass transfer. Frying with palm oil repeatedly for frying reduces expenses. When heated repeatedly, increases the viscosity and darkening the colour of the oil (Rani et al., 2010). Consumption of ready-made deep-fried food is high and could be detrimental to health (Leong et al., 2015; Srivastava, 2010). When oil is heated at high temperature, hydro-peroxides and aldehydes are formed. These toxic products are absorbed by the food, and eventually into the gastrointestinal tract and thereafter enter the systemic circulation after ingestion (Grootveld et al., 1998). The repeated heating of cooking oil result in oil that is more prone to lipid peroxidation (Jaarin et al., 2011). Furthermore repeated frying of oils is discarded only when the oil becomes foamy or smelly (Azman et al., 2012).

In oil, the major fatty acids present are the monounsaturated and saturated fatty acids (Edem, 2002). The use of heated cooking oil demonstrates genotoxic and preneoplastic change in the rat liver (Srivastava et al., 2010); it also impaired fluid and glucose intestinal absorption in rats (Obembe et al., 2011). Soriguer et al., (2003) found an independent positive association between the risk of hypertension and intake of heated cooking oil. Chronic intake of heated cooking oils increases the risk of cancer and cardiovascular diseases.

Heating diminished the vitamin E content and rendered the oils to lose their beneficial effects. The higher vitamin E content in the vegetable oil might contribute to lesser peroxide value. Vitamin E could effectively protect the fatty acids in the oil from oxidation. Vitamin E is consumed by scavenging the lipid free radicals which are derived from the oxidation of unsaturated fatty acids in the oils (Quiles, 1999). Rancidity of food items can be the result of auto and photo-oxidation, which are natural oxidation and chemical degradation processes of edible oils, where fatty acid esters of oils are converted into FFA giving a smell observed in many vegetable oils (Anwar et al., 2003).

Repeatedly heating the cooking oil through oxidation, hydrolysis, polymerization, and isomerization, eventually resulting in Lipid peroxidation (Choe and Min, 2007; Leong et al., 2015). When oil is exposed to deep frying temperatures, fatty acids in the oil undergo chemical configurationally changes from cis to trans isomers (Leong et al., 2015). Generation of oxidized products due to the reheating process leads to a deleterious effect on the vascular function (Leong et al., 2015). It has been documented that long-term intake of thermally oxidized oil alters the function of aorta isolated from rat (Owu et al., 1997).

This study investigates the effect of thermal treatment on the characteristics of commercially available edible vegetable oil consumed in Nigeria.

2. Material and Methods

Sample Collection and Preparation.

Three different refined commercially available oil were obtained from a local supermarket and labeled A, B, and C respectively. 300g each of the samples in a frying pan were placed in a hot plate; temperature was then raised to 180 °C. The heating process was started 20 min after the temperature reached 180 °C. The experiment was repeated for heating time of 5, 10 and 20 minutes respectively and was cooled. After the heating, each sample were removed from the hot plate and was kept immediately in a vacuum desiccators to cool it down to room temperature. The samples were analyzed immediately.

Sample analysis.

Determination of Peroxide and Acid Values

Peroxide value and acid value were determined according to Official American Oil Chemist's Society (AOCS) methods (AOCS, 1985). The values were expressed as meq of peroxide O₂ / kg oil and mg KOH / g oil, respectively.

Iodine value analyses

The iodine value (IV), the number of grams of iodine absorbed by 100 parts by weight of the oil or fat, were determined following the method of the AOAC as described by Horwitz (2002); Othman and Ngassapa, (2010).

Determination of Free fatty acid and Saponification value

Free fatty acid was determined, as percent by mass oleic, palmitic or lauric acid, and saponification value, as the number of milligrams of potassium hydroxide required to neutralize the fatty acids resulting from complete hydrolysis of one gram of oil or fat, was determined using the procedures adopted by Jayaraman (1985).

3. Results

The physiochemical parameters of the samples studied where presented in table 1 - 6.

Table 4.1 Physiochemical Parameters of the Samples Studied.

PARAMETERS	A	B	C
SV(mgKOH/g)	195.60	194.56	198.5
AV(mgKOH/g)	0.120	0.140	1.60
IV(g/100g)	132.00	128.50	115.20
FFA(% oleic acid)	0.098	0.20	0.75
PV(mg/kg)	7.70	6.30	9.40

SV = saponification, AV=Acid Value, IV =Iodine Value, FFA= Free Fatty Acid, PV = Peroxide Value

Table 4.2 Effect of heating time on the saponification value (mg KOH/g) of some selected cooking oil consumed in Nigeria.

Heating time (mins)	A	B	C
0	195.60	194.56	198.50
5	194.30	188.50	197.90
10	193.00	187.30	194.90
20	185.90	184.40	194.30

Table 3 Effect of heating time on the Acid value (mgKOH/g) of some selected cooking oil consumed in Nigeria.

Heating time (mins)	A	B	C
0	0.120	0.140	1.60
5	0.60	0.200	1.84
10	0.72	0.70	2.20
20	0.80	1.00	2.80

Table 4. Effect of heating time on the Iodine value (g/100g) of some selected cooking oil consumed in Nigeria.

Heating time (mins)	A	B	C
0	321.00	128.50	115.20
5	110.00	101.40	97.00
10	102.50	99.50	92.00
20	91.08	88.70	77.70

Table 5. Effect of heating time on the Free fatty Acid (% oleic acid) of some selected cooking oil consumed in Nigeria.

Heating time (mins)	A	B	C
0	0.601	0.070	0.830
5	0.300	0.100	0.920
10	0.360	0.350	1.110
20	0.400	0.500	1.420

TABLE 6. Effect of heating time on the peroxide value (mg/kg) of some selected cooking oil consumed in Nigeria.

Heating time (mins)	A	B	C
0	7.70	6.30	9.40
5	8.20	7.50	10.00
10	8.90	8.20	10.20
20	9.80	9.30	11.10

4. Discussions

The results for saponification value were found to be significantly higher in oil before heating than after heating of the oil (table 2). The saponification

value of oil was found to be higher in sample C than in A and B. At 20 minutes of heating time, C has the highest value of value 194.30mgKOH/g, followed by A with value of 185,90 mgKOH/g while B has the lowest value of 184.40 mgKOH/g after 20mins of heating time respectively. The saponification value decreases with an increase in heating time.

The acid values were presented in table 3 above. The acid value was found to be significantly lower in the three samples after 5mins of heating time; Sample C has the highest value of 1.84mgKOH/g while sample A has the lowest value of 0.60 mgKOH/g respectively. As the heating time increase, the acid value also increases for all samples. At 20 minutes heating time, local oil has the highest value of 2.80 mgKOH/g while King's oil has the lowest value of 0.80mgKOH/g respectively. The increase in acidity is undoubtedly due to the splitting of ester linkages of triglyceride molecules as a result of heating (Minar et al., 2003; Yoshida et al., 1992). It is evident from the results that variation in product regarding acid value remained non- significant while highly significant effect was observed on acid value of oil due to difference in condition of heating. Heating temperature and time are most significant factors that bring about changes in acid value of the product.

The iodine value (or "iodine adsorption value" or "iodine number" or "iodine index") in chemistry is the mass of iodine in grams that is consumed by 100 grams of a chemical substance. Iodine numbers are often used to determine the amount of unsaturation in fatty acids. This unsaturation is in the form of double bonds, which react with iodine compounds. The higher the iodine number, the more C=C bonds are present in the fat (Thomas, 2002). The iodine value presented in table 4 above decreased for all samples as heating time increases. A has the highest value of 102.50 g/100g while sample C has the lowest value of 92.0 g/100g respectively. This observation suggests that A is richer in unsaturated fatty acids than B and C.

Free fatty acid (FFA) of oil before and after heating of samples revealed that FFA was found to be significantly lower in oil before heating, B has 0.070 % oleic acid at 0 minutes of heating time, at 20 minutes of heating time, C has the highest value of 1.420 % oleic acid while A has the lowest value of 0.400 % oleic acid in the oil used for heating (table 5). Some researcher proposed the FFA value of 0.03 - 0.8 % in fresh refined oils. The increase in free fatty acids could be attributed to hydrolysis of fats particularly the polyunsaturated mono and diglycerides. Increase in values of free fatty acid, increases the rancidity of oil which may cause many qualitative defect in oils.

The Peroxide values (PV) of oil presented in table 6 shows that the peroxide values were found to

be significantly lower in oil before heating. After 5 minutes of heating time, C has the highest value of 10.00 mg/kg while B has the lowest value of 7.50 mg/kg of the three samples respectively. Increasing the heating time increases the peroxide values of the oil. This study is similar to the previous finding of several researchers who described the effect of deep fat heating on oxidative parameters of sunflower oil, (Bangash and Khattakmaiantun, 2006) and effect of heat treatment on the characteristics and oil yield of moringa oleifera Seeds (Adejumo et al., 2013).

Detection of peroxide gives the initial evidence of rancidity in unsaturated fats and oils (Grossi et al., 2015). Other methods are available, but peroxide value is the most widely used. It gives a measure of the extent to which an oil sample has undergone primary oxidation extent of secondary oxidation may be determined from p-anisidine test. The peroxide concentration, usually expressed as peroxide value, is measured by oxidation or rancidity in its early stages and should be not more than 10 (milliequivalents peroxide/1000g sample) in cooking oil (O'Brien, 2009).

The double bonds found in fats and oils play a role in autoxidation. Oils with a high degree of unsaturation are most susceptible to autoxidation. The best test for autoxidation (oxidative rancidity) is determination of the peroxide value. Peroxides are intermediates in the autoxidation reaction.

Autoxidation is a free radical reaction involving oxygen that leads to deterioration of fats and oils which form off-flavours and off-odours. Peroxide value, concentration of peroxide in an oil or fat, is useful for assessing the extent to which spoilage has advanced.

Oxidation of lipids is one more common and often undesirable chemical change that may influence flavor aroma nutritional quality and in some cases even the fineness of the product. The tertiary oxidation products; dimers and polymers are formed as a result of polymerization of secondary oxidation products. These products cause darkening of the oil color, formation of foam on the oil surface and an increase in viscosity of the oil (Kalem et al., 2015).

Conclusion

Heating oil contribute a significant proportion of the total fat, hydroperoxides and aldehydes consumed by the Nigeria people. Repeatedly heated oil has a taste, aroma, distinctive flavor and crunchy texture. During the present study, the samples studied produced more changes and degradation after thermal treatment of oils.

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