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Effect of Heat on the Physicochemical Properties of Groundnut Oil

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Abstract: ***Oil was extracted from fresh groundnut seeds (used as control) and groundnut seeds heated at 90 ^{0}C and 120 ^{0}C, and market roasted groundnut seeds (fried and bottled seeds purchased from a local market) using n-hexane. The various oil samples were analyzed for their relative densities, viscosities, refractive indices, iodine values and peroxide values. Results obtained show that oxidative rancidity of the oil samples increased with increase in temperature the seeds were subjected to. Relative density increased from 0.9115 ± 0.0005 (for oil from fresh groundnuts) to 0.9241 ± 0.0002 (for oil from the market roasted sample). The viscosities of the various samples also showed an increase from 33.02 M^2S^{-1} (for oil from fresh groundnuts) to 61.6 M^2S^{-1} (for oil from the market roasted seeds). A similar trend was observed for other parameters: refractive index decreased from 79.9470g/100g to 59.6430g/100g while peroxide values increased from 1.8mEq/kg to 7.6mEq/kg. The oil sample obtained from the market roasted seeds recorded the highest level of oxidative deterioration.***

Keywords: Groundnut oil, Oxidation, Heat.

1. Introduction

Groundnut oil is extracted from the seeds of the groundnut plant, *Arachis hypogaea*. It is an important food oil, with a good flavor, high quality and low free fatty acid value. The fatty acid composition and physicochemical analyses of samples obtained from different varieties have been investigated (Anyasor *et al*., 2009). Due to its high content of monounsaturated fatty acids, it is considered healthier than oils with saturated fatty acids and is relatively resistant to rancidity.

Edible oils from plant sources are of interest in various food and application industries. They provide characteristic flavors and textures to food as integral diet components (Odoemelam, 2005). During extraction, purification and usage, oils undergo a variety of' processing operations including heating, distillation and chemical modification which may alter their properties. Exposure to heat and light creates an environment favorable to chemical and enzymatic reactions resulting in hydrolysis and oxidation.

Oxidative rancidity in oil occurs due to the oxidation of the double bonds in unsaturated fatty acids present in the constituent triacylglycerols forming peroxides or hydroperoxides that later polymerize or decompose producing aldehydes, ketones and low molecular weight acids. The process of oxidative rancidity or peroxidation and the consequent rancidification is the major cause of loss of quality of edible oils. Oxidative rancidity affects flavor, aroma, color, texture, and also decreases the nutritive value of edible oils via the destruction of fat-soluble vitamins (especially vitamins A and E) and proteins (Schermer, 1990).

Oils and fats composed of unsaturated fatty acids particularly suffer attack from free radicals. Their chemical structures allow the removal of a hydrogen atom from a methylene (CH_2) group of the acyl chain and consequently a free radical is formed, starting the peroxidation process. This reaction may occur at environmental temperatures but can be rapidly increased in the presence of catalyzers such as other peroxides, metal ions, high temperatures and light. The combination of several free radicals of fatty acids produces a huge variety of stable final products: hydrocarbons, aldehydes. ketones, alcohols and organic acids.

Oxidative stability refers to the potential for deterioration and it is an important parameter in the characterization of edible fats and oils. The dynamics of oxidation or food deterioration depends mostly upon the fatty acid composition of the constituent lipids, contents and activities of antioxidants and pro-oxidants (air, heat, light, presence of trace metals, free fatty acids. various oxidation products, metal ions and moisture) (Vidrih, *et al*., 2010).
The physico-chemical properties of oil are amongst the most important properties that determine the quality and help to describe the present condition of oils (Barku, *et al*., 2012). These characteristics can be physical such as colour, viscosity, specific gravity, refractive index as well as chemical such as iodine value or flavor. These physicochemical characteristics are used to evaluate the quality of oils or fats with reference to known standards.

The aim of the present study is to compare the physicochemical properties of groundnut oil extracted from fresh seeds (without heating) with oil obtained from seeds subjected varying degrees of heat treatment.

2. Materials and Methods

2.1 Sample Collection

Fresh groundnut seeds were purchased from Mile 3 market in Port Harcourt. The roasted seeds (already fried and bottled groundnut seeds) were purchased from a supermarket. The fresh groundnut seeds were cleaned and divided into three parts, labeled A, B and C while the

roasted seeds were labeled D. A and D were milled as obtained while B and C were heated in a hot air oven for three hours at 90^0Cand 120^0C respectively before milling. Oil was extracted from the different seeds with n- hexane in a Soxhlet apparatus. All the oil samples were dried in a hot air oven at 120 ^{0}C for hour, allowed to cool to room temperature and stored in a freezer, until they were to be used.

2.2 Analysis of Physico-chemical Parameters

The relative density, viscosity, refractive index, iodine value and peroxide value of the various oil samples were determined following approved standard procedures.

3. Results and Discussion

The results obtained for different analyses are displayed in Table 1 below:-

Parameters	*Oil from fresh seeds*	*Oil from seeds heated to 90^0C*	*Oil from seeds heated to 120^0C*	*Oil from fried bottled seeds*
Relative Density (25^0C)	0.9115 ± 0.0005	0.9160 ± 0.0002	0.9179 ± 0.0002	0.9241 ± 0.0002
Refractive Index	1.46860 ± 0.002	1.46644 ± 0.003	1.46583 ± 0.002	1.46494 ± 0.0016
Iodine Value (g/100g)	79.9470	71.8254	62.4348	59.6430
Peroxide Value (mEq/kg)	1.8	4.2	5.4	7.6
Viscosity (M^2S^{-1})(40^0C)	33.02	40.8	42.2	61.6

3.1 Relative Density and Viscosity

The oil obtained from the fresh seeds (A) recorded the lowest relative density and viscosity (0.9115 ± 0.0005 and 33.02 M^2S^{-1} respectively. On the other hand, oil from the market roasted seeds (D) recorded had the highest relative density and viscosity (0.9241 ± 0.0002 and 61.6 M^2S^{-1} respectively). The increase in these parameters is attributable to the formation of high molecular weight products (peroxides) in the oil during the peroxidation process. Fekarurhobo, *et al*., (2009), Carlson, *et al*., (1976) and Hoffman, (1989) made similar observations.

3.2 Refractive Index

The refractive indices for the oil samples obtained from seeds subjected to heat treatment (B, C and D) changed only slightly compared to that of the control as can be seen in Table 1. All the oil samples subjected to heat treatment showed a decrease in refractive index compared to the control. The slight changes indicate that heat treatment of the seeds does not have much effect on the refractive index value of the oil samples (Sattar and de Man 1976, Zeb and Ahmad, 2004). The refractive index of the oil obtained from the roasted seeds (D) was the lowest (1.46494 ± 0.0016). Researchers have proved that refractive index increases as the double bonds in the fatty acids of a lipid molecule increase (Ermosele and Pascal, 2003). Therefore, the decrease in refractive index as temperature increased as depicted in Table 1 indicates that the number of double bonds decreased with increase in temperature. This is an indication of oxidation. Therefore, application of heat reduces the degree of unsaturation of a lipid molecule.

3.3 Iodine Value (Wij's)

The iodine values of the oil samples obtained from heat treated seeds showed a decrease compared to the control. The decreases can be accounted for by the loss of unsaturation with oxidation. The iodine value of the oil obtained from the fresh seeds (79.940g/100g) is similar to the value obtained by Pearson's (1981) 80g/100g. The high iodine value indicates that the oil is highly unsaturated. The decrease in iodine value with increase in temperature of the seeds is a proof that lipid oxidation had occurred (Joseph, 1997), since oxidation directly affects the number of double bonds in the fatty acids of a lipid molecule. The oil obtained from the market roasted seeds displayed the lowest level of unsaturation (59.6430g/100g); this agrees with the observations by Zeb and Ahmad (2004).

3.4 Peroxide Value

The peroxide values of the oil samples obtained from B, C and D (meq/kg) increased with increase in temperature indicating deterioration. The oil from the fresh seeds had the lowest peroxide value (1.8mEq/kg) which is close to the standard value (1.5mEq/kg). The increase in peroxide values with increase in temperature indicates that hydroperoxides were formed in the oils as a result of oxidation. Hydroperoxides have been identified to be the primary products of oxidation (Shahidi and Zhong, 2005). The oil obtained from the market roasted seeds had the highest peroxide value (7.6mEq/kg). Such increase has been reported by Jeorge, (1997), Zeb and Ahmad (2004) and Maduelosi, *et al*. (2012).

4. Conclusion

The results of the present study show that oxidation occurred in all the oil samples subjected to heat treatment and that the level of oxidation increased with elevation in temperature. Oil obtained from the roasted seeds exhibited the highest level of oxidative deterioration. The observation suggests that the seeds were possibly subjected to a temperature greater than 120^0C for more than three hours. Further studies should be carried out on the samples to ascertain the possible health implications of consuming fried groundnut seeds.

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