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Effect of heating and added antioxidant on the fatty acid profile of refined groundnut oil

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Abstract

The effects of constant temperature heating, time of continuous heating and different levels of added antioxidant, on the quality characteristics of heated refined groundnut oil and the changes in fatty acid profile on continuous heating on addition of antioxidant in refined groundnut oil were studied. Synthetic antioxidant, butylated hydroxyanisole (BHA) at different concentration levels was added in the oil and the oil samples were heated at different times and temperatures for the present study. Fatty acid analysis showed that heating constantly altered the structure and composition of oil. Severe damage occurred to poly unsaturated fatty acids (PUFA) at high temperature heating, but addition of antioxidant protected the oil. Results of fatty acid analysis showed decrease in oleic acid and linoleic acid in the oil heated at 225°C for 12 hours without BHA. Addition of 75 ppm BHA protected oleic acid and linoleic acid of the oil sample heated at 225°C for 12 hours. BHA when added substantially protected the oil against alterations in unsaturated fatty acids.

Keywords : Antioxidant, fattyacid profile, groundnut oil

Introduction

A good oil should possess pleasing colour, odour and long shelf life apart from its transparency. Economic aspects are also to be considered while selecting the oil. When oil is heated for short time, practically no change is reportedly produced up to 200°C, thereafter decomposition occurs, forming irritating Acroleins (1). The specific heat value of oil increases with increase in unsaturation of fatty acids. Unsaturated fatty acids in oils undergo polymerization due to heat, oxidation, free radicals and catalysts. This results in a change in colour, molecular weight, refractive index and viscosity. The heat transfer efficiency of oil is affected as a result affecting the quality of the product and the nutritional quality of oil.

Oils and fats that have been heated to very high temperatures for long period of time may undergo chemical and physical changes. Continuous heating of fat and oil for over eight hours results in thermal oxidation (2). The oxidation of oils or fats give rise to rancidity or off flavour. Heating of fat or oil results in formation of compounds with anti-nutritional properties. These compounds formed may be enzyme inhibitors, vitamin destroyers, lipid oxidation products, gastro intestinal irritants or potential mutagens. Heating of fat or oil also results in decrease in moisture, iodine value and refractive index.

The effect of deep fat frying on the quality characteristics of the frying medium and the fried products have been studied extensively. The damage caused during the frying is influenced by the heat induced damages on the cooking medium, effect of temperature fluctuation during frying, effect of temperature drop in cooking medium upon intermittent addition of moist food to be fried, effect of steam generated and sparged through the oil, effect of antioxidant principles naturally present in cooking media and food fried and added synthetically, rate of absorption of frying media by products and ratio of media to product during frying. To understand the contribution of each of these factors on the quality of oil and products, these factors are to be taken up individually and studied independent of the others. So the stability of cooking medium independent of the product to be fried is to be elucidated as it is believed that one of the factors leading to quick spoilage of cooking media is uncontrolled heating as is normally existing at household level frying.

This study was taken up to investigate the effect of heating and added antioxidant on fatty acid profile of refined groundnut oil.

Material and methods

Vegetable oil

The experimental material consists only refined groundnut oil. In this experiment refined groundnut oil without any added synthetic antioxidant was used and this oil was obtained directly from oil mill in sealed tin container.

Antioxidant

Only one synthetic antioxidant *viz.*, butylated hydroxyanisole (BHA) was used at different concentration levels. BHA was dissolved in small amounts of oil and diluted to the required concentration in large amount of warm oil.

Heating

In order to obtain uniform heat transfer in oil and constant surface area to volume ratio during the entire experiment, preliminary trials were conducted to find the normally encountered ratio in household frying. The ratio ranged from 0.420 to 0.446 cm^2/ml. So all the samples in the present study were heated in uniform glass breakers of 500 ml capacity. The volume of sample was fixed at 140 ml to obtain a constant surface area to volume ratio of 0.427 cm^2/ml. The gas chromatography was conducted as per Munshi (3) on Gas Chromatogram Model Auto System XL (Perkin Elmer, USA).

Results and discussion

The oil used in this study was refined groundnut oil without any added synthetic antioxidant. Crude groundnut oil tastes and smells like roasted groundnut and contains free fatty acids and other compounds that render it unstable. Groundnut oil has been refined to remove free fatty acids, colouring matter and all groundnut odor and flavour.

The fatty acid profile of three samples of refined groundnut oil respectively fresh refined groundnut oil, oil heated 225°C for 12 hrs. without BHA and oil heated at 225°C for 12 hrs. with 75 ppm BHA were determined by gas chromatography. In the chromatogram different peaks were obtained. The chromatogram of fatty acid profile of three samples (i) fresh refined groundnut oil, (ii) oil heated at 225°C for 12 hrs. without BHA and (iii) oil heated at 225°C for 12 hrs. with 75 ppm BHA, respectively are presented in Appendices 3, 4 and 5.

Fatty acid profile of fresh refined groundnut oil, oil heated at 225°C for 12 hrs. without BHA and oil heated at 225°C for 12 hrs. with 75 ppm BHA respectively are given in Appendices 6, 7 and 8. Appendix 9 shows the characteristics of the three oil samples used for gas chromatography. The peak of the component fatty acid of each samples were identified on the basis of retention time and then quantified according to their peak areas. The data so obtained are presented in Table 1.

The data on fatty acid profile showed that fresh refined groundnut oil contains saturated $C_{16:0}$ and $C_{18:0}$ fatty acids (palmitic acid and stearic acid) of 10.86 per cent, Archidonic acid ($C_{20:0}$) at 3.17 per cent, behenic acid ($C_{22:0}$) of 1.50 per cent and lignoceric acid ($C_{24:0}$) of 1.22 per cent making the total saturated fatty acids at 16.75 per cent. It contained monounsaturated fatty acid (MUFA) *i.e.* oleic acid ($C_{18:1}$) at 56.64 per cent

Table 1. Fatty acid composition of fresh refined groundnut oil, oil heated without BHA and oil heated with BHA for 12 hrs. at 225°C

Fatty acid	Retention time (min.)	Fatty Acid (%)		
		Fresh oil	Heated* without BHA	Heated* with 75 ppm BHA
$C_{16:0}$ Palmitic acid and $C_{18:0}$ stearic acid	14.690	10.86	11.69	11.73
$C_{20:0}$ Archidic acid	18.308	3.17	3.29	3.11
$C_{18:1}$ Oleic acid	18.543	56.64	52.50	57.26
$C_{18:2}$ Linolenic acid	19.143	23.72	9.50	19.25
$C_{22:0}$ Behenic acid	22.453	1.50	1.74	1.78
$C_{24:0}$ Lignoceric acid	22.680	1.22	1.32	1.41
C_{14} or lower carbon components	10.160	-	5.19	-

at 225 °C for 12 hrs

and polyunsaturated fatty acids (PUFA) linolic acid ($C_{18:2}$) of 23.72 per cent making up for the total unsaturated fatty acid content of 80.36 per cent.

From the data obtained on gas chromatography, it can be found that heating constantly altered the structure and composition of refined groundnut oil. The total saturated fatty acid content according to retention time of the components and area of peak, appears to increase from 16.75 per cent to 18.04 per cent in the case of oil heated at 225°C for 12 hours without any added antioxidant. For oil heated with added BHA, the increase was form 16.75 per cent to 18.03 per cent. So, it shows that the total saturated fatty acid per cent increased slightly up on heating, but there was no appreciable effect of added antioxidant (BHA) on the change.

In contrast, it is observed that oleic acid (MUFA) content decreased from 56.64 per cent to 52.50 per cent on heating in the absence of added BHA. On addition of 75 ppm BHA, there was no decrease in the level of oleic acid in the oil (it appears to slightly increase in the sample heated with BHA). In the case of linoleic acid (PUFA $C_{18:2}$), the influence of heating on breakdown was very pronounced. Linoleic acid content decreased from 23.72 per cent to 9.50 per cent on heating in the absence of added BHA, showing extreme sensitivity of linoleic acid to heat. However, in the presence of BHA, heating reduced linoleic acid content only from 23.72 per cent to 19.25 per cent, showing substantial level of protection by antioxidant to PUFA. Further, fresh groundnut oil, or the one heated with BHA, did not show any C_{14} or lower molecular weight components. In contrast, in the case of heating in the absence of BHA at 225°C for 12 hrs., 5.19 present of such molecules were recorded on the chromatogram, suggesting extensive heat damage and molecular breakdown of fatty acids especially PUFA.

From the above, it can be concluded that severe damage occurred to PUFA's at high temperature heating of oils, but antioxidant considerably arrested the damage.

Saturated fatty acid level in the oil increasing and unsaturated fatty acid level decreasing on heating was reported by Kalyobi (4). Increase in level of palmitic (16:0), stearic (18:0) and oleic (18:1) and Narsimhamurthy and Raina (5) also reported decrease in level of linoleic acid (18:2) on heating oils. Houhoula *et al.* (6) also reported increase in level of palmitic acid and decrease in linoleic acid in heated oils. They also reported decrease in oleic acid level.

Temperature is an important factor in any cooking or frying operation and has the greatest contribution on the product in heating and frying. Since in household frying temperature is the most difficult to control, development and popularization of temperature controlled household frying equipment can go a long way in improving the nutritional quality of fried foods and the economy of frying.

Conclusion

Substantial decrease in the levels of oleic acid and linoleic acid was observed in oil heated without antioxidant (BHA) at 225°C for twelve hours. Severe damage occurred to PUFA in oil heated at 225°C for twelve hours, but addition of 75 ppm BHA protected the oil. MUFA was also protected by addition of BHA at the selected level.

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