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EFFECT OF GARLIC ON SOME QUALITY CHARACTERISTICS OF GROU NDNUT OIL REPEATEDLY USED FOR DEEP-FRYING.

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ABSTRACT

Most street food vendors use vegetable oils numerous times to deep fry before discarding them to reduce cost. This practice leads to the accumulation of products of both hydrolytic and oxidative reaction products in the oil. Long-term ingestion of food prepared using reheated oil could therefore severely compromise one's antioxidant defense network, leading to pathologies such as hypertension, diabetes, and vascular inflammation. Natural spices like garlic contain compounds with high antioxidant activities, which could reduce the deteriorative changes during repeated deep frying. this study aimed to assess garlic's effect on some quality characteristics of groundnut oil repeatedly used for deep frying. Fresh groundnut oil containing 0% (GS0), 4% (GS1), and 7% (GS2) chopped garlic lobes were used repeatedly to fry potato chips for 6h every day. Twenty-one batches of 100g fresh potato chips were fried each day and the frying cycle was repeated for 5 days. Untreated groundnut oil served as a control frying oil. The free fatty acid value, TBA value, peroxide value, and vitamin A content of the frying oils was determined after each day of frying. Sensory evaluation of the fried potatoes was conducted after each day of frying. There were significant differences ($p<0.05$) among the samples in all the parameters evaluated after the 5 days of frying. Free fatty acid, peroxide, and TBA increased significantly with frying periods ranging from 0.69 to 1.1, 6.42 to 13.44, and 0.21 to 0.36 respectively. The incorporation of garlic led to a significant decrease in free fatty acids. The addition of garlic led to a significant reduction in the vitamin A content in frying oil. Sensory evaluation scores of fried potato chips after the first day of frying showed that the incorporation of garlic in oil repeatedly used for deep frying had no effect ($p>0.05$) on all the sensory parameters evaluated except for oiliness. Overall acceptability score in appearance, taste, and aroma ranged from 6.30 – 6.95 for potato chips fried in 7% garlic and 0% garlic-containing oil respectively. Sensory scores after the fourth day of frying revealed that overall acceptability for the control decreased significantly while the chips fried with 7% garlic-containing oil had the highest score.

It could be concluded that the addition of garlic to groundnut oil used repeatedly for deep frying potato chips could reduce the deterioration in oil quality. More research is however needed to determine the levels of some potential toxic breakdown products in the oil.

Keywords: Antioxidant, Repeated frying, Garlic, Food Chain.

1.0: INTRODUCTION

Deep frying of food is one of the oldest and most popular food preparation techniques, with the fried food quality dependent on the frying temperature and time, food being fried, frying oil, and the number of times it is used. Deep frying is a cooking method whereby food is completely immersed in hot oil until cooked. Deep frying impacts unique and desirable organoleptic properties on food hence its wide use in cooking (Janny, 2019).

Most street food vendors use vegetable oils numerous times to fry before discarding them to reduce cost. Previous research studies have shown that vegetable oils are used to fry 3- 6 times before they are discarded (Obeng M. E 2013). During deep frying, the oil decomposes by oxidative or hydrolytic reactions to produce short-chain aldehydes and ketones which are objectionable in taste and odour, fatty acids, polar materials, and polymeric compounds. Even though a certain amount of potentially toxic products produced during frying such as polar compounds or polymers, fried foods are generally considered safe. Repeated heating of oil however increases these deteriorative reactions, forming hazardous reactive oxygen species and reducing the natural antioxidant contents of the cooking oil. Long-term ingestion of food prepared using reheated oil could therefore severely compromise one's antioxidant defence network, leading to pathologies such as hypertension, diabetes, and vascular inflammation.

Natural antioxidants from spices and herbs have attracted a lot of attention in lipid oxidation as it has been a traditional practice to enhance the aroma and taste of food (Caporaso et al., 2013). Natural antioxidants are mainly polyphenolic compounds that help to stabilize oils and food, trapping free radicals and retarding oxidative processes. The effectiveness of natural antioxidants in reducing or retarding deterioration of oil during frying has been reported in using rosemary and sage extracts which reportedly have a very good thermal resistance and strong antioxidative characteristics (Diamante et al, 2014).

Garlic has been used as a spice in natural medicine (Perara, 2020). Garlic is known to contain natural antioxidants that can reduce reactive oxygen species (ROS) formation, and reduce lipid peroxides and low-density lipoprotein (LDL) oxidation (Zhang et al., 2020). Fresh raw garlic bulbs comprise 66% water, 27% carbohydrate, 2.5% protein, 1.3% amino acids, 1.6% fiber, fatty acids, phenols, trace minerals, and more than 34 (2.4%) sulfur-containing compounds. The phytochemicals majorly belong to polyphenols, amino acids, benzenoids, sulfur-containing compounds, fatty acyls, glycerophospholipids, heteroaromatic compounds, indoles, phenol lipids, pyrrolizines, quinolines, steroid derivatives, tetrahydrofurans and other compounds (Ceccanti et al., 2021).

Groundnut oil is the most popular oil used in the northern part of Nigeria, due to its abundant nature, nutty aroma, by-products, and fatty acid composition. Groundnut oil comprises about 80% unsaturated fatty acids and 20% fatty acid due to its high amount of polyunsaturated fats they are susceptible to becoming oxidized due to its higher amount of unstable double bonds. Simply, heating or exposing this oil to air, sunlight, or moisture can ignite lipid oxidation (Akhtar et al., 2014).

Fried potato chips are a type of snack highly consumed by the food services sector and households. Potatoes contain very little fat and once fried, the potato absorbs the frying oil thereby increasing its fat contents significantly (Jagtap et al., 2019). There is a dearth of information on the effect of natural spices on the quality characteristics of groundnut oil that has been repeatedly used for frying potato chips. It is therefore against this background that this study was conducted to assess the effect of garlic on some quality characteristics of groundnut oil repeatedly used in frying potato chips.

Plate 1: Deep frying of potato chips

2.0: MATERIALS AND METHODS

2.1: Procurement of raw materials

The raw materials used for this research work include refined groundnut oil (Marshal Pure Groundnut Oil), potato, and garlic which were purchased from Ogige market, Nsukka. Equipment and reagents of analytical grade were obtained from the Departments of Food Science and Technology, University of Nigeria, Nsukka. The potato was assembled for immediate processing in the food processing laboratory of the Department of Food Science and Technology, University of Nigeria, Nsukka.

2.2: Preparation of potato chips

The potato was washed, peeled, washed, and sliced into chips of 3 x 3mm using a potato slicer to achieve uniform slices, soaked in water at room temperature, and drained before frying.

2.3: The Frying Experiment

Garlic was added at 7% and 4% into two portions of the oil (2 liters) before frying. The third portion of the oil was not treated with garlic which served as the control. The three portions of oil were placed in an electric thermostatically controlled deep-fryer using a Binatone deep fryer (DF 2500) and heated at 180˚C. Fresh potato chips (100g per batch of frying) were fried in the oil for 5 minutes every 15 minutes intervals, making it 21 batches in a day. At the end of each day, 100 ml of the frying oil was collected, allowed to cool, filtered into capped amber bottles, stored in the dark at 4˚C, and used for analysis within one week. Sensory analysis was conducted on each batch of potatoes fried in each oil sample.

Plate 2: Fresh garlic cloves

PHYSICOCHEMICAL *ANALYSIS*

The following physicochemical *analyses were carried out on the deep-fried oils*

2.4: Determination *Free Fatty Acids*

This was determined using standard AOAC methods. Diethyl ether of 25ml will be mixed with 25ml alcohol and 1ml phenolphthalein solution (1%) and carefully neutralized with 0.1M NaOH. Three (3g) gram of the oil was dissolved in the mixed neutral solvent and titrated with aqueous 0.1M NaOH shaking constantly until a pink colour, which persists for 15 seconds is obtained.

$$\text{Acid value} = \frac{\text{titre (ml)} \times 5.61}{\text{weight of sample used}} \quad \ldots\ldots (1)$$

2.5: Determination of Peroxide value

The peroxide value of the samples was carried out by the IFRA method. The sample (3g) was accurately weighed and transferred into a 250 ml Erlenmeyer flask with a glass stopper. An appropriate solvent mixture of 50ml (glacial acetic acid: chloroform 3:2) and 1ml of saturated potassium iodide solution, freshly prepared and allowed to react for 60 seconds ± 1 second and shaking thoroughly during this period. Then 100 ml of water is added and shaken. It is then titrated with 0.01 mol/l sodium thiosulfate solution, or 0.1 mol/l sodium thiosulfate solution at higher usages, using 1 ml starch solution or 0.1 g of Thyodene indicator. The indicator was added towards the end of the titration but the pale straw colour is still present. During titration, the mixture is shaken until the blue colour disappears. A blank titration is carried out under the same conditions. Peroxide value is therefore calculated

$$\text{PV (MeqKg)} = \frac{(V1-V0)\times c\times 1000\times T)}{m} \quad \ldots\ldots (2)$$

Where:

PV = peroxide value

V1 = consumption of 0.01 mol/l or 0.1 mol/l sodium thiosulfate solution in the main test

V0 = consumption of 0.01 mol/l or 0.1 mol/l sodium thiosulfate solution in the blank test

c = molar concentration (molarity) of the sodium thiosulfate solution

T = titre of the thiosulfate solution

m = weighed portion of substance in grams

2.6: Determination of Thiobarbituric acid value

The thiobarbituric acid test is used to determine deterioration in extractable and non-extractable lipids. A mass of 10 g of oil was macerated into 50 mL of water for 2 min and washed into a distillation flask with 47.5 mL water. A 2.5 mL solution of 4N HCl was added to bring the pH to 1.5 and followed by the addition of a few glass beads. The flask was heated using an electric heating mantle and 50 mL distillate was collected 10 min after boiling commenced. After which 5 mL of the distillate was pipette into a glass tube and then 5 mL of TBA reagent (0.2883 g/100 mL of 90% glacial acetic acid) was added, shaken, and heated in boiling water for 35 min. A blank was prepared similarly using 5 mL water with 5 mL reagent. The tubes were cooled in water for 10 min and the absorbance (D) was measured against the blank at 538 nm using 1 cm cells.

TBA number = (mg malonaldehyde per kg sample) =7.8 (D)……………………. (3)

2.6.1:Vitamin A

The methods of AOAC were used. A weighed sample was saponified with an alcoholic solution of potassium hydroxide in the presence of benzene 1,2, 3-triol. This would remove the vitamin from food matrixes. A mixture of diethyl ether and petroleum ether was used to extract the unsaponified matter. The extracted sample was extracted under nitrogen and the residue dissolved in methanol. A reverse phase column chromatography separates the extract to 95 % mobile phase and 5% water. The retinol was separated and quantified using a UV absorbance detector at 328 nm.

2.7: Sensory evaluation

Sensory evaluation of the potato chips was conducted using 20 semi-panel members. Samples were presented in identical containers coded with three digits (letters). A 9-point hedonic scale was used ranging from like extremely (9) to dislike extremely (1). The chips were rated for appearance, crunchiness, taste, colour, aroma, crispiness, oiliness, aftertaste, and overall acceptability.

2.8: Experimental design and statistical analysis

The experimental design was based on CRD. All analyses were conducted in triplicate. Data will be analyzed statistically through two-way ANOVA by Duncan's multiple range tests using the commercially available software, the SPSS 16 software program (SPSS Inc., Chicago, IL, USA). A p-value of less than 0.05 ($p < 0.05$) was used to denote statistical significance.

3.0: RESULTS AND DISCUSSIONS

3.1: REE FATTY ACID VALUE

The result of FFA is shown in **Figure 1**. There were significant differences in FFA among the frying oil samples at the end of the frying period. The initial free fatty acid content of the oil before frying was **0.63±0.01mgKOH/g**. At the end of the frying period, the total mean value for the free fatty acid content of the samples was **0.77±0.12mgKOH/g**, **0.80±0.12mgKOH/g**, **0.88±0.16mgKOH/g** for Sample GS2 (7% garlic), Sample GS1 (4% garlic) and Sample GS0 (0% garlic) respectively. The free fatty acid value of the frying oil increases with the number as both frying days increase.

During the frying hydrolytic breakdown of fat molecules into free fatty acids and glycerol. the longer the frying period the higher the FFA produced. It could be observed from the figure that, the levels of FFA in the oils decreased in samples containing garlic compared to the control sample. This implies that the addition of garlic reduces the hydrolytic reaction of frying oil. This could be attributed to the phenolic compounds in garlic, which suppress the oxidation reactions. The activity of garlic in reducing the formation of the free fatty acid value of frying oil was in agreement with the findings of Perera et al. (2020), which reported that the free fatty acid of coconut oil was found to be increasing with the frying time and the addition of natural spices can decrease the free fatty value

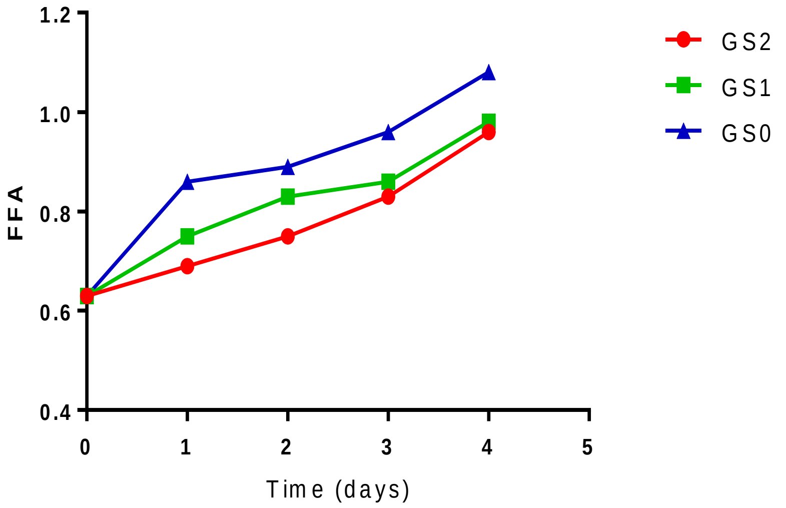

Figure 1: Effect of garlic on free fatty acid value in groundnut oil

3.2: THIOBARBITURIC ACID REACTIVE SUBSTANCES (TBARS VALUE)

According to **Figure 2**, the initial Thiobarbituric Acid Reactive Substances value was **0.21±0.00** before treatment. At the end of the frying period, the total mean scores of TBARS values were **0.25±0.04**, **0.27±0.03**, and **0.30±0.05** for Sample GS2 (7% garlic), Sample GS1 (4% garlic), and Sample GS0 (untreated groundnut oil) respectively and each sample formulation were significantly different ($p<0.05$) from each other. The TBARS value of all groundnut oil samples increased with frying time and it was significantly different ($p<0.05$).

The increase in TBARS value indicates the formation of a secondary oxidation product. Samples GS2 and Sample GS1 were significantly lower compared to Sample GS0 and, this may be attributed to the presence of the antioxidants such as phenolic compounds contained in garlic. The results showed that the control consistently had the highest TBARS values among the three samples throughout the four consecutive days of frying.

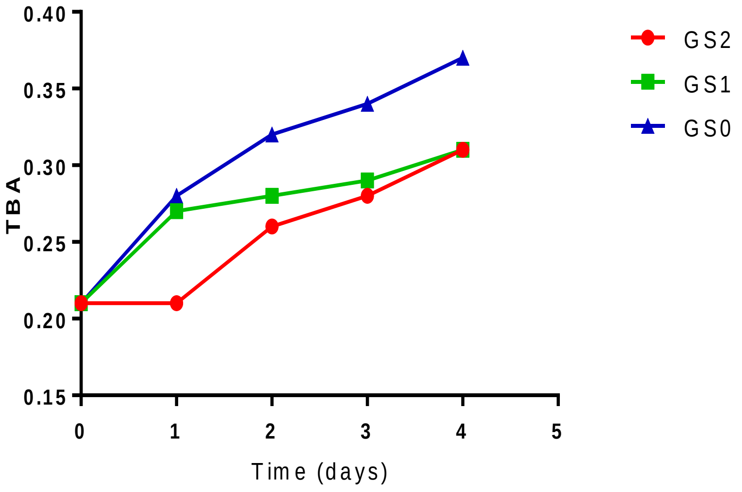

Figure 2: Effect of garlic on the TBARS value in groundnut oil

3.3: PEROXIDE VALUE

The initial peroxide value of the oil before frying was **5.93±0.01meq/kg**. At the end of the frying period, the total mean scores of peroxide values were **7.29±1.05meq/kg**, **8.60±1.80meq/kg**, and **9.32±2.60meq/kg** for Sample GS2 (7% garlic), Sample GS1 (4% garlic) and Sample GS0 (untreated groundnut oil) respectively and each were significantly different ($p<0.05$), a higher peroxide value was observed in untreated groundnut oil sample compared to groundnut oil containing garlic. A high peroxide value is an indicator of the initial stage of oil deterioration (Diamante et al.,2014). The peroxide value of all groundnut oil samples increased with frying time and on each frying day, there was a significant difference ($p<0.05$).

Perera et al. (2020) reported that the peroxide value of coconut oil was found to be increasing with the frying time and reported that adding natural spices can decrease peroxide value. The Anova table has shown there was an interaction between the concentration and frying period and this was also significantly different ($p<0.05$).

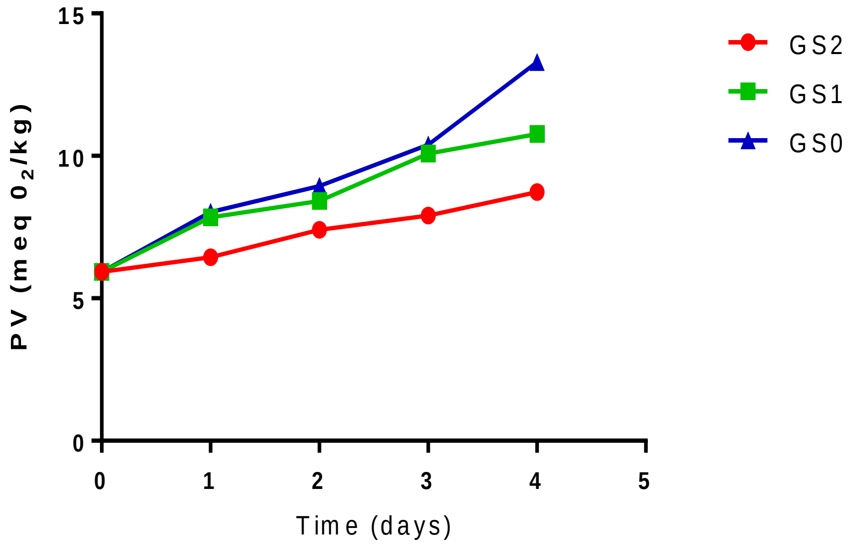

Figure 3: Effect of garlic on the peroxide value in groundnut oil

VITAMIN A

The initial vitamin A content of the oil before frying was **16.71±0.02ug/g**. At the end of the frying period, the total mean value for the vitamin A content of the samples were 13.74±2.55ug/g, 13.18±2.80ug/g, 10.65±3.69ug/g for Sample GS2 (7% garlic), Sample GS1 (4% garlic) and Sample GS0 (untreated groundnut oil) respectively and each sample formulation was significantly different ($p<0.05$). The vitamin A content of the frying oil decreased with the number of frying and each frying day was significantly different ($p<0.05$). However, the rate of decrease in samples containing garlic was lower compared to the control sample and this differed significantly ($p<0.05$) among the samples. This implies that the addition of garlic prevents the degradation of the vitamin a content in groundnut oil. The Anova table has shown there was an interaction between the concentration and frying period and this was also significantly different ($p<0.05$).

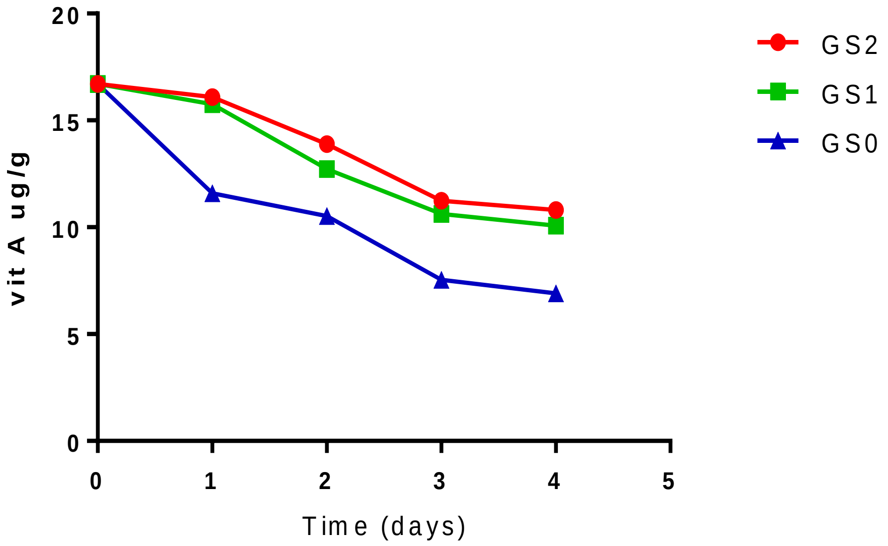

Figure 4: Effect of garlic on the Vitamin A content in groundnut oil

Table 1: Sensory Scores of Potato Chips Fried with In the Oil Samples (First Day)

Samples	Appearance	Crunchiness	Taste	Colour	Aroma	Crispness	Oiliness	After taste	Overall Acceptability
GS2	6.50[a] ± 1.96	5.10[a] ± 2.15	5.80[a] ±1.94	6.90[a] ± 1.71	6.25[a] ± 2.17	5.00[a] ±2.15	5.35[a] ± 2.08	5.90[a] ± 1.71	6.30[a] ± 2.16
GS1	6.95[a] ± 1.19	5.50[a] ± 1.96	6.20[a] ±2.17	7.05[a] ± 1.00	6.25[a] ± 1.89	5.25[a] ±1.94	6.65[b] ± 1.31	6.20[a] ± 1.99	6.85[a] ± 1.57
GS0	6.80[a] ± 1.82	5.15[a] ± 2.28	6.35[a] ± 1.90	7.45[a] ± 1.19	6.60[a] ± 1.96	5.20[a] ± 2.26	6.10[ab] ± 1.68	6.55[a] ± 1.61	6.95[a] ± 1.19

Table 2: Sensory Scores of Potato Chips Fried with The Oil Samples (Fourth day)

Samples	Appear-ance	Crunchiness	Taste	Colour	Aroma	Crispiiness	Oiliness	After taste	Overall Acceptability
GS2	6.50[a] ± 1.82	3.60[a] ± 2.16	6.30[a] ±1.94	5.85[a] ± 1.50	6.30[a] ± 1.95	4.05[a] ±1.93	6.20[a] ± 1.64	6.40[a] ±1.27	6.85[a] ± 0.86
GS1	5.80[a] ± 2.07	3.80[a] ± 2.04	5.60[a] ±1.85	5.90[a] ± 1.94	6.90[a] ± 1.52	3.10[a] ±1.74	5.50[b] ± 1.82	5.60[a] ±1.50	6.45[a] ±1.32
GS0	6.30[a] ±	3.95[a] ±	5.95[a] ±1.73	5.95[a] ±	6.55[a] ±	3.75[a] ±1.92	5.20[ab] ±1.82	5.70[a] ±1.53	6.20[b] ± 1.24

	1.59	1.79		1.73	1.50				

*Values are means of duplicate determinations ± SD. Values on the same column bearing different superscripts are significantly different at $p<0.05$

Key:

GS2 = Groundnut oil with 7% of garlic

GS1 = Groundnut oil with 4% of garlic

GS0 = Groundnut oil without garlic (Control)

4.0: CONCLUSION

This study was carried out to evaluate the effect of garlic on the physical and chemical properties of repeatedly used groundnut oil and the sensory properties of the fried potato chips produced with different concentrations of garlic.

Groundnut oil samples with acceptable physicochemical could be produced using garlic to improve its oxidative stability. Groundnut oil was selected for this study because it is widely used for cooking purposes. To prepare the samples, garlic was incorporated into oil samples. Treated and standard groundnut oil samples of this study showed different physiochemical properties. Free fatty acid and peroxide values were decreased relative to the same parameter of the untreated groundnut oil sample.

Due to the antioxidant property of the garlic, the thermal stability of the treated samples was better than that of untreated groundnut oil. The increment of the free fatty acid level and peroxide value of treated groundnut oil samples occurred at a slower rate than untreated groundnut oil samples during the study period. It has been shown that the addition of garlic up to 7% level in groundnut oil used for deep frying can significantly stabilize the oil and increase the acceptability of potato chips repeatedly fried in it for 5 days.

Further research should be done on the food prepared with repeatedly used oil to check the effect of the oils on the nutritional content of the food. The use of garlic should not be limited to use in groundnut oil, but rather further studies should be carried out to include other vegetable oils such as sunflower oil, palm olefin, palm oil, and amongst others. The knowledge obtained from this study can be adopted by health bodies to prevent health challenges arising from the repeated use of groundnut oil.

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