Asian Journal of Applied Chemistry Research

5(3): 32-38, 2020; Article no.AJACR.55326
ISSN: 2582-0273

Quality Evaluation of Some Commonly Consumed Oils and Fats

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Authors' contributions

This work was carried out in collaboration between both authors. Authors OSM and AAB designed the study, managed the analyses and wrote the first draft of the manuscript. Both Authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJACR/2020/v5i330137
Editor(s):
(1) Cheikh Sall, Université de Thiès, Senegal.
Reviewers:
(1) Alexandre Ricardo Pereira Schuler, Universidade Federal de Pernambuco, Brasil.
(2) Paul Kweku Tandoh, Kwame Nkrumah University of Science and Technology, Ghana.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55326

Original Research Article

Received 02 March 2020
Accepted 15 March 2020
Published 19 May 2020

ABSTRACT

Aim: To evaluate and compare the quality parameters of some commonly consumed oils and fats.
Study Design: Laboratory experimental design was used.
Place and Duration of Study: Cultured *Clarias gariepinus* was collected from a fish pond, *Glycine max* was purchased from a local market while pork, chicken and beef fats were collected from Oko Oba Abattoir, Agege, Lagos State, Nigeria. The study was carried out between September 2019 - February 2020 at the Oilseed Laboratory of Federal Institute of Industrial Research, Oshodi, Lagos State, Nigeria.
Methodology: Oil available in *C. gariepinus* and *G. max* were extracted using Soxhlet extraction method while the animal fats were pre-treated to remove the impurities present in them. The chemical properties of the oils and fats were determined using standard methods of analysis while the fatty acid composition were analysed using Gas Chromatography-Mass Spectrophotometer.
Results: Beef fat had the lowest peroxide (3.02mEQ/kg), anisidine (4.32mEQ/kg) and TOTOX value (10.36mEQ/kg), indicating that the fat could be stored for a long period of time without undergoing deterioration. The fatty acid composition shows that *G. max* oil, *C. gariepinus* oil and pork fat contains high concentration of polyunsaturated fatty acids while beef fat contains large number of saturated fatty acids.

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Conclusion: This study shows that *G. max* oil, *C. gariepinus* oil and pork fat have more nutritive value compared to chicken fat and beef fat although will be easily susceptible to oxidation due to the large number of double bonds present in them.

Keywords: Quality; fish oil; vegetable oil; animal fats; polyunsaturated; oxidation.

1. INTRODUCTION

Oils and fats are important parts of human diet. More than 90 percent of the world production from vegetable, animal and marine sources is used as food or as an ingredient in food products. Oils and fats are a rich source of dietary energy and contain more than twice the caloric value of equivalent amount of sugar. Their functional and textural characteristics contribute to the flavour and palatability of natural and prepared foods. They contain certain fatty acids which play an important role in nutrition and are also carriers of fat soluble vitamins.

Fat quality is a significant factor having critical correlations to nutrition, sensory characteristics, shelf-life and safety. For instance, the most notable deleterious impacts of fat quality are the development of rancidity and off flavours which affect the high relative levels of oxidative degradation products that can have implications on human health [1].

Animal fats are rendered tissue fats that can be obtained from a variety of animals. They are by-products of the meat packaging industry usually made available as a result of the preparation of meat for sale or from the manufacture of meat product [2].

The fat compositions of animals are very important when talking about the quality especially in terms of human health [3]. The composition of fat that's of animal origin can be influenced by diet (forage and grain), the digestive system, species, breed, and the biosynthetic processes of the [4,5]. In ruminants, the fatty acid profile does not depend on the feed or diet is not a direct factor due to the complex reactions of biohydrogenation caused by rumen microorganisms [6].

Fish oils are rich source of natural bioactive lipid components [7] which are commercially used in pharmaceutical and food industries. Fish is being considered as an important diet due to its polyunsaturated fatty acid (PUFAS) contents. The curative and preventive effects of fish oils are well recognized in treating cardiovascular diseases, autoimmune disorders and various kinds of inflammation [7].

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Cultured *Clarias gariepinus* was collected from a fish pond, the fish was cut into small sizes and dried using electric oven at 100°C for 6hrs to reduce the moisture content. The dried fish was grinded to powdery form to increase the surface area for oil extraction. *Glycine max* was purchased from a local market, the seeds were sorted to remove foreign materials and grinded into powdery form for easy extraction. Pork, chicken and beef fats were collected from Oko Oba Abattoir, Agege, Lagos State, Nigeria. The fats were melted at 100°C to reduce the moisture content and filtered using muslin cloth to remove other impurities. The grinded *C. gariepinus* and *G. max* powder with the melted fats were stored in air tight container for further analysis.

2.2 Extraction of Oil

C. gariepinus and *G. max* oils were extracted according to the method described by [8] with some modifications. Pulverized samples (5 g) each were extracted in a thimble of the Soxhlet apparatus with 200 mL n-hexane in triplicate for 6 hrs at 65°C. The mixture was concentrated to remove the n-hexane used using evaporator (Heidolph, Germany). The extracted oil was further air-dried to remove residual solvent vapour and measured.

2.2.1 Chemical properties of the oils and fats

The chemical properties were determined according to the standard methods of [9] with some modifications.

2.2.1.1 Acid Value

Mixture of ethanol and petroleum ether (V/V) (50 mL) with the addition of 3 drops of phenolphthalein indicator was neutralized with 0.1 M KOH solution. 0.5 mL of sample was added to the neutralized solution in the presence

of 3 drops of phenolphthalein and was finally titrated against 0.1M potassium hydroxide solution till a permanent pink colour was attained.

$$\text{A.V} = \frac{\text{Vol. of KOH used} \times \text{mass of KOH}}{\text{Mass of sample}}$$

Free Fatty Acid= $\frac{\text{Acid Value}}{2}$

2.2.1.2 Peroxide Value

The peroxide value of the oil and fat samples were determined by dissolving 0.5 mL of the oil in a solvent mixture (1:2) of acetic acid and chloroform. Potassium iodide (1.3 g) was added to the resulting solution. The mixture was place in a dark cupboard for 1 hr, after which, 75mL of distilled water was added followed by 3 drops of starch indicator, the mixture then was titrated against 0.05M sodium thiosulphate.

Peroxide value = $\frac{((\text{S}-\text{B})\text{X N X } 1000)}{\text{W}}$

Where, B= Vol. of standard potassium thiosulfate used for titration of blank, S= Vol. of standard potassium thiosulfate used for titration of sample, N= normality of sodium thiosulfate solution, W= weight of sample.

2.2.1.3 Anisidine Value

The anisidine values of the samples were determined by weighing accurately (0.5 g) each of the sample into a 25 mL volumetric flask. The samples were dissolved and made up to the flask volume with isooctane. The samples were properly mixed with isooctane. The absorbance of the fat solution against pure isooctane was measured at 350 nm in a 1cm glass cell. 5mL each of fat solution and isooctane were pipetted into different test tube A and B, the test tubes were stoppered, shaked vigorously and placed in dark cupboard for 110 mins. The absorbance of the content of test tubes A was measured against the absorbance of the content of test tubes B at 350nm in a 1cm glass cell.

Anisidine value =$\frac{25(1.2\text{XEb}-\text{Ea})}{\text{W}}$

TOTOX Value= 2P.V + A.V

2.2.1.4 Iodine Value

The iodine values of the oil and fat samples were determined by Wijjs method. Oil sample (0.5 mL was dispensed into a conical flask and mixed with chloroform (5 mL) and Wijjs reagent (8 mL), (9 mL of iodine trichloride and 10 g of iodine in chloroform (300 mL)/acetic (700 mL) solution). The conical flask was shaked and placed in the dark for 1 hr. After which, 7 mL of potassium iodide and 75 mL of distilled water were added and titrated against 0.05M sodium thiosulphate solution using starch as the indicator. A blank test was carried out simultaneously without the fat under the same conditions.

$$\text{I.V.} = \frac{(\text{Blank} - \text{sample})\text{X } 0.01269}{\text{W}} \text{X } 100$$

S= (Vol. of $N_2S_2O_3$ for blank – Vol. of $N_2S_2O_3$ for sample)

W= Weight of sample

2.2.2 Determination of fatty acids profile

The fatty acid composition contained in the oils and fats were determined using the method described by [10] with slight modifications. 60 µL of oil was dissolved in 2 mL of 3M methanolic potassium hydroxide. The mixture was then vigorously vibrated for 180s and placed into a water bath at 70°C for 15 mins. After cooling to room temperature, 5 mL hexane was added into mixture. The mixture was vigorously vibrated for 180s and allowed to stand for 5 min for the upper layer to become clear. The fatty acid methyl ester layer was collected and analysed using a Hewlett Packard HP 6890 Series gas chromatograph coupled with a Hewlett Packard 5973 mass spectroscopy detector (GC-MS) system. A HP-5 MS capillary column (30 m length, 0.25 mm i.d., 0.25 µm film thickness) was used for the GC system. The temperature program was set up from 50°C to 250°C with 4°C/min, both the injector and detector temperatures were 280°C and He was used as carrier gas.

3. RESULTS AND DISCUSSION

3.1 Chemical Properties of the Samples

G. max oil had the lowest acid value (1.10 mg KOH/g) which was lower than 1.81 mg KOH/g reported by [11], while Beef fat had the highest acid value (1.84 mg KOH/g) which was in close range to 1.99 mg KOH/g reported by [12]. Acid value, free fatty acid, peroxide and anisidine values are used to determine the quality of oils since they determine the extent of deterioration of the oils. The acid values of all the animal fats

do not exceed the value (2.5 mg KOH/g) stated by the CODEX STANDARD of 1999 for tallow. Acid value indicates the level to which triglycerides in oils and fats had been decomposed by lipase action. However, the acid values of all the oils and fats shows that they are of good quality. Like the acid value, the free fatty acids of the animal fats fall within the acceptable limit of 1.25% according to CODEX STANDARD of 1999 for tallow while those of the oils falls within the acceptable limit of 5% recommended as the maximum for non-rancid oil [13]. A high free fatty acid value is associated with a high deterioration rate of oil and thus resulting in the development of flavour and odour. Peroxide value measures the hydroperoxide and the primary oxidation products of the oil which contains mostly polyunsaturated acids which easily undergoes oxidation [14]. It is associated with oxidative rancidity; oxidative rancidity is the addition of oxygen across the double bonds in unsaturated fatty acids in the presence of enzyme or certain chemical compounds. The odour and flavour associated with rancidity are due to liberation of short chain carboxylic acids [15]. High peroxide values are associated with higher rate of rancidity whereas low peroxide values of the oils indicate that they are less liable to oxidative rancidity at room temperature [16, 17]. Beef fat had the lowest peroxide value (3.02mEQ/kg) which was in close range to 3.0 mg EQ/kg reported by Muhammad et al. [12] while G. max oil had the highest peroxide value (4.15mEQ/kg) which was lower than 12.995mEQ/kg reported by Adel et al. [11]. The difference in the peroxide value of *G. max* oil could be due to the fact that the author purchased already extracted oil while the *G. max* oil used in this study was freshly extracted from the seeds. The low peroxide value indicates the fat could be stored for a long time without deterioration. This was also due to the difference in the number of unsaturated fatty acid content, since rate of autoxidation of fats and oils increases with increasing level of unsaturation [18]. However, the peroxide value of all the animal fats and oils still falls within the acceptable limit of ≥10mEQ/kg (CODEX STANDARD, 1999). Anisidine value is used to quantify secondary oxidation products of oil by measuring the aldehydes, principally 2, 4-dienals [19]. Anisidine value measures 2-alkenals, hydroperoxide decomposition products that can be used to determine how much per oxidized material that has already broken down [20]. *G. max* oil had the highest anisidine value (5.44 mEQ/kg) while Beef fat had the lowest anisidine value (4.32 mEQ/kg). The anisidine values of the oils and fats are within the limit for edible oils according to [21]. Total Oxidation (TOTOX) is an industry-standard indicator of oil oxidation, calculated from the measurements of peroxide value and p-anisidine value. It is conceived as a way to give a complete view of oxidation by including primary and secondary oxidation measurements. The TOTOX value of all the oils and fats were lower than 20 mEQ/kg which is within the limit recommended by German Society for Fat Sciences for crude and refined oils. Iodine value is a measure of the degree of unsaturation of fatty acids present in oils and fats [22]. It helps in determining the quality of the oil. A high iodine value implies that the oil is unsaturated. The iodine value is also an index for assessing the ability of oil to become rancid [23]. *G. max* oil had the highest iodine value (115mgI_2/100 g), this was higher than 110.985mgI_2/100 g reported by [11]. The iodine value of *G. max* oil indicates that the oil is highly unsaturated and could be easily susceptible to oxidation. The iodine value of Beef fat was (56.17mgI_2/100 g) which was higher than 50.34mEQ/kg reported by Esonye et al. [24]. This is an indication that Beef fat is saturated and will be able to withstand long time storage without going rancid.

Table 1. Chemical properties of the samples

Parameters	C. gariepinus Oil	G. max Oil	Pork Fat	Chicken Fat	Beef Fat
Acid Value (mg KOH/g)	1.23±0.025	1.10±0.004	1.41±0.012	1.54±0.008	1.84±0.024
Free Fatty Acid (%)	0.62±0.005	0.55±0.014	0.71±0.002	0.77±0.01	0.92±0.02
Peroxide Value (mEQ/kg)	4.02±0.05	4.15±0.023	3.67±0.01	3.15±0.008	3.02±0.02
Anisidine Value (mEQ/kg)	5.21±0.013	5.44±0.004	5.01±0.025	4.43±0.03	4.32±0.014
TOTOX Value (mEQ/kg)	13.25±0.01	13.74±0.005	12.35±0.012	10.73±0.006	10.36±0.03
Iodine Value (mgI_2/100g)	123±0.013	115±0.004	87.20±0.03	82.15±0.015	56.17±0.006

Values are mean ± standard deviation of triplicate determinations

Table 2. Fatty acid composition of the samples

Fatty Acid	Fatty Acid No	*C. gariepinus* Oil (%)	*G. max* Oil (%)	Pork Fat (%)	Chicken Fat (%)	Beef Fat (%)
Caproic acid	C6:0	ND	ND	ND	0.03	ND
Caprylic acid	C8:0	ND	0.02	0.05	0.05	ND
Pelargonic acid	C9:0	ND	0.01	ND	ND	ND
Capric acid	C10:0	ND	ND	1.02	0.09	1.00
Lauric acid	C12:0	ND	ND	0.06	1.00	0.07
Myristic acid	C14:0	6.97	0.05	0.50	0.98	1.85
Pentadecylic acid	C15:0	1.02	0.01	0.10	0.42	2.65
Palmitic acid	C16:0	ND	10.80	2.40	10.48	19.05
Margaric acid	C17:0	0.03	1.01	5.01	0.19	2.71
Stearic acid	C18:0	1.98	3.97	8.22	4.09	12.19
Arachidic acid	C20:0	1.23	0.10	0.43	0.25	1.01
Behenic acid	C22:0	3.38	0.12	0.02	0.05	1.00
Lignoceric acid	C24:0	0.15	0.02	0.03	0.08	0.15
∑SFA		14.76	16.11	17.84	17.71	41.68
Myristoleic acid	C14:1	6.68	ND	0.01	1.14	0.25
cis-Hypogeic acid	C16:1n-9c	8.01	3.97	1.10	3.02	1.09
Trans-Hypogeic acid	C16:1n-9t	ND	ND	0.05	10.42	3.16
Oleic acid	C18:1n-9c	15.12	19.89	16.80	20.10	15.14
Elaidic acid	C18:1n-9t	ND	ND	30.12	35.27	30.78
Vaccenic acid	C18:1	ND	ND	0.11	0.04	0.24
Eicosenoic acid	C20:1n-9	1.24	ND	ND	ND	ND
Erucic acid	C22:1n-9	3.98	ND	0.28	0.14	0.08
Nervonic acid	C24:1n-9	2.45	ND	0.06	0.10	ND
∑MUFA		37.48	23.86	48.53	70.19	47.67
Linoleic acid	C18:2n-6c	4.14	50.01	20.01	8.19	1.00
9-Hydroxylinoleic acid	C18:2n-6t	ND	ND	5.15	0.03	0.09
Rumenic acid	C18:2n-7	ND	ND	ND	ND	0.03
α-Linolenic acid	C18:3n-3	37.54	10.01	3.97	1.12	2.04
γ-Linolenic acid	C18:3n-6	ND	0.01	1.87	0.97	0.54
Stearidonic acid (SDA)	C18:4n-3	1.05	ND	ND	ND	ND
Eicosatrienoic acid (ETE)	C20:3n-3	0.97	ND	1.02	0.91	1.06
Dihomo-gammalinolenic acid (DGLA)	C20:3n-6	0.23	ND	0.47	0.03	0.12
Eicosatetraenoic acid (ETA)	C20:4n-3	0.97	ND	0.45	0.25	0.25
Arachidonic acid	C20:4n-6	1.13	ND	0.12	0.17	0.03
Eicosapentaenoic acid(EPA)	C20:5n-3	ND	ND	0.15	0.12	1.03
Heneicosapentaenoic acid (HPA)	C21:5n-3	0.02	ND	0.07	0.06	0.01
Docosadienoic acid	C22:2n-6	0.01	ND	0.03	0.05	0.05
Adrenic acid (AdA)	C22:4n-6	0.25	ND	0.02	0.03	0.14
Clupanodonic acid	C22:5n-3	1.15	ND	0.03	0.01	1.10
Docosapentaenoic acid	C22:5n-6	ND	ND	0.11	0.02	0.01
Cervonic acid	C22:6n-3	0.30	ND	0.04	0.04	0.06
Tetraacosapentaenoic acid	C24:5n-3	ND	ND	0.12	0.10	0.02
∑PUFA		47.76	60.03	33.63	12.10	7.58
∑n-3		42.00	10.01	5.79	2.61	5.57
∑n-6		5.76	50.02	27.78	9.49	1.98
∑n-7		-	-	-	-	0.03

3.2 Fatty acid Composition of the Samples

Beef fat contains highest concentration of C18 fatty acids and also had the highest number of saturated fatty acids (41.68%). This result was closely related to the one reported by [25], though the authors reported 30.35% saturation but still had the highest concentration of saturation among the animal fats studied. *G. max*

oil had the highest concentration of polyunsaturated fatty acids (60.03%) with omega 6 fatty acids carrying the bulk of it, this was closely related to 57% reported by (Adel *et al.,* 2018) followed by *C. gariepinus* oil that contains 47.76% polyunsaturated fatty acids, this is also within the range of 45.78%-57.97% reported by [26]. Among the animal fats, pork fat had the highest concentration of polyunsaturated fatty acids (33.63%), this is closely related to 30.01% reported by Amat et al. [25]. *C. gariepinus* oil contains large amount of omega-3 fatty acids (42%). Polyunsaturated fatty acids composition of cell membrane is largely dependent on dietary intake [27]. The long chain omega-3 fatty acid, docosahexaenoic acid (DHA), is a major lipid in the brain, recognized as essential for normal brain function [28]. Insufficient dietary intake of omega-3 fatty acids and excessive intake of omega-6 fatty acids is believed to be a significant contributing factor to aging [29] as well as various diseases such as neurodegenerative and neurological disorders [30,31] inflammatory conditions [32] and cardiovascular diseases [33]. Out of all the oils and fats studied, *C. gariepinus* oil is the oil with the highest nutritional value due to the health benefits attached to omega-3 fatty acid that is more dominant in the oil.

4. CONCLUSION

The study showed that Beef fat can withstand long storage period without being oxidized which reflects in the peroxide, anisidine and totox values, this is due to the highest concentration of saturated fatty acids present in the fat. *C. gariepinus* oil, *G. max* oil and Pork fat are highly prone to oxidation due to the large number of double bonds within the fatty acid chain but are more nutritive than Beef fat because of the health benefits attached to polyunsaturated fatty acids.

ETHICAL APPROVAL

Animal ethic Committee approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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