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Research Article

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Assessment of Quality of Commercially Available Some Selected Edible Oils Accessed in Ethiopia

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Abstract

In the present study, an effort has been performed to determine trans fatty acid, free fatty acid, and cholesterol content of some selected edible oils in Ethiopia. Five brands of locally made different edible oil samples were purchased from super markets of Ethiopia. The quality of these edible oils was analyzed by evaluating their chemical properties such as acid, saponification and peroxide values using standard methods (titrimetric technique). The results of the study revealed that maximum and minimum acid value was 5.59± 0.02 mg/g for Beksa (Niger oil) and 0.11±0.02 mg/g for Tena (sunflower) oil respectively. Similarly, the saponification value showed (223.2±0.39 mg/kg) for Tena and (173.4±0.46 mg/kg) for Beksa. The maximum peroxide value was observed in Lulu (vegetable oil; 11.67±0.11 meq O2/kg) and minimum value found in Sunny (sunflower oil; 2.84±0.05 meq O2/kg). The highest total free fatty acid as oleic acid was observed in Beksa (2.95±0.03%) and lowest total free fatty acid in Tena oil (0.06±0.03%). On the other hands, two trans fatty acids; oleic acid (C 18:1) and linoleic acid (C 18:2) were detected in the 5 edible oils by using GC method.

Keywords: Edible Vegetable Oil, Health Effect, Quality Parameters

Introduction

Edible oil is an essential nutrient and an important source of energy. For oil to be utilized as a source of energy it must be well digested and absorbed into the body [1,2]. Oils in the diet are available to the body as fatty acids, which are excellent sources of dietary calorie intake. Fatty acids (FAs) are classified as saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and poly unsaturated fatty acids (PUFA) [3, 4, 5]. Major edible oil is extracted from soybean, sunflower, cottonseed, canola and olive [6,7]. Fats consist of a wide group of compounds that are soluble in organic solvents and insoluble in water.

Different physical and chemical parameters of edible oil were used to monitor the compositional quality of oils [8,9]. These physicochemical parameters include iodine value (IV), saponification value (SV), viscosity, density and peroxide value (PV). Edible oils are one of the main constituents of the diet used for cooking purposes. Several researchers studied the impact of temperature on the stability, viscosity, peroxide value, and iodine value to assess the quality and functionality of the oil [10, 11].

Quality of cooking oil can be judged by testing different parameter of cooking oil. Free fatty acid (FFA) value indicates quality of raw material, processing, degree of purity and storage condition. PV is also an indicator of quality of oil and fats. To measure oxidative rancidity, PV is used. Colors values give information about quality of bleaching. Hydrolysis of ester by moisture or enzyme is called hydrolytic rancidity. By enzymatic action it produces FFA. At higher temperature it may cause non-enzymatically by producing FFAs [12, 13, 14]. By oxidative and hydrolytic degradation commercial shelf life of oils decreases which results in low quality of product [15].

The unsaturated fatty acids help to reduce our blood cholesterol levels, and the saturated fatty acids bring about an increase in our blood cholesterol levels. An exception to this rule is the trans-fatty acids. The presence of TFA in vegetable oil is becoming debating issue after the industrial production of trans acids like elaidic acid [16]. Edible oils play an important role in the body as carriers of essential fatty acids (EFA). EFA are not synthesized in the body but are needed through the diet to maintain the integrity of cell membranes. It has been essential to consume authenticated edible oils based on maintenance of good diet and control health issues. Therefore, consumers need meaningful and honest information so that they can make an informed choice of their diet and the foods they purchase [17]. Of the different parameters that can be used for

the quality analysis of oils, Peroxide value, Acid value, Saponification value and Free fatty acids have been analysed in this study by Titrimetric method and fatty acid profiles by GC-MS analysis technique. Thus, we are concerned with the accumulation of processed vegetable oils in Ethiopian markets which are consumed in the country and those labeled to be according to WHO standards. Accordingly, the aim of this study was to assess the quality of commercially available oils via determining the quality parameter, free fatty acids, trans fatty acid and cholesterol present in some selected edible oils.

Main texts

Materials and methods

Materials and chemicals

In the present study; Fatty acid standards, Silver nitrate, Ethanol, Diethyl ether, n-hexane, heptane, Phenolphthalein, Hydrochloric acid, Glacial acetic acid, Chloroform, potassium hydroxide, potassium iodide, ethanol, potassium iodide, BF3/MeOH were obtained from Sigma-Aldrich, USA. Cholesterol, Liberman- Burchard reagent (Acetic anhydride & Sulphuric acid (Sigma-Aldrich), UV-Vis and GC-MS were used during analysis. Triundecanoin (C11:0), elaidic acid (C17 :0) were used as an internal standard. Fatty acids were derivatized to fatty acid methyl esters (FAME) using BF3/MeOH and analyzed by GC-MS with a FID, and a SP-2560 column (100 m × 0.25 mm ID).

Sample collection

Five edible oils; sunny (soybean oil), Tena (sunflower oil), Dukem and Beksa (Niger oil) and Lulu (vegetable oil) were collected from commercially available markets, Addis Ababa, Ethiopia. The collected edible oil samples were packed in plastic bags and stored under room temperature in the laboratory until they were required for analysis.

Determination of the chemical parameters of edible oils

The chemical parameters were performed for edible oil samples using titrimetric and titration method following standard procedures described for the determination of acid value, saponification value, free fatty acid and peroxide value [18]. All these tests were performed in triplicates

Acid value

Each oil sample (1.0 g) was weighed and dissolved with 50 mL of ethanol in a conical flask. Two drops of phenolphthalein indicator was added and titrated to pink end point with 0.1 N potassium hydroxide solution (KOH). Acid value was calculated according to Equation 1 below:

$$\textbf{Acid value} = \frac{56.1xVxC}{m} \quad (1)$$

Where 56.1 is equivalent weight of KOH, V is the volume in mL of standard volumetric KOH solution used, C is the exact concentration in KOH solution used (0.1 N); m is the mass in grams of the test portion (1 g).

Saponification value

Saponification value was determined according to titrimetric method. Two grams of oil samples were weighed into a conical flask and 25 mL ethanolic potassium hydroxide was added. The solution was refluxed for 2 h while shaking. One mL phenolphthalein was added and titrated with 0.5 N hydrochloric acid (HCl). The value was calculated according to equation 2 below.

$$\textbf{Saponification value} = \frac{(Vo - V1)xCx56.1}{m} \quad (2)$$

Where 56.1 is equivalent weight of KOH, V0 is the volume in ml of standard HCl solution use for the blank test, V_1 is the volume in ml of the standard HCl solution use for sample, C is the exact concentration of the standard HCl (0.5 N) solution and m is the mass in gram of the test portion (2 g).

Peroxide value

Five grams of oil samples were weighed into a conical flask and 30 mL of solvent mixture of glacial acetic acid-chloroform in the ratio of 3:2, was added to the oil samples. Half mL saturated potassium iodide (KI) solution was added to the solution and allowed to stand for 1 min thereafter, 30 mL of distilled water was added and titrated with 0.01 N sodium thiosulfate solution using starch indicator until the yellow color was discharged. Then peroxide value was calculated using equation 3 below.

$$\textbf{Peroxide value} = \frac{10\ x\ (V1-V2)}{m} \quad (3)$$

Where: V1 volume of $Na_2S_2O_3$ for determination of test sample in ml, V2 volume of $Na_2S_2O_3$ for determination of blank solution in ml and m is mass of test portion in g (5 g).

Determination of Fatty Acid Profiles

Analysis of fatty acid compositions of the edible oils were conducted by using GC-MS by standard methods. The FAC was determined by conversion of the oil to fatty acid methyl esters (FAMEs) using the standard method [19].

Results & Discussion

Quality analysis results

The quality of some selected edible oils: sunny, Tena, Dukem and Beksa and Lulu were analyzed by evaluating their quality parameters such as peroxide, acid and saponification values. In addition to the quality parameters, trans fatty acid and cholesterol content of the edible oils were analyzed. The result obtained for parameters were presented in Table 1.

Table 1: Chemical analysis of five edible oils at room temperature

Parameters					
S/No	Edible oils	Acid value (mg/g)	Saponification value (mg/g)	Peroxide value (meq/kg)	FFA (%) (as oleic acid)
1	Beksa	5.59 ± 0.02	173.4 ± 0.46	4.67 ± 0.07	2.95 ± 0.02
2	Dukem	0.99 ± 0.05	182.0 ± 0.30	3.12 ± 0.03	0.52 ± 0.03
3	Lulu	0.22 ± 0.04	177.3 ± 0.43	11.67 ± 0.11	0.12 ± 0.02
4	Sunny	0.22 ± 0.03	176.2 ± 0.20	2.84 ± 0.05	0.12 ± 0.04
5	Tena	0.11 ± 0.02	223.2 ± 0.39	8.04 ± 0.06	0.06 ± 0.03
	WHO	≤ 0.6	187-209	≤ 10	≤ 0.2

The data from Table 1 revealed that, the free fatty acid (% oleic acids) of the fat extracted from the oils ranged from 2.95% - 0.06%. The FFA values are used to indicate the level of rancidity and edibility of oils. In this study the acid values ranged from 0.11 mg - 5.59 mg. The higher the acid values which occur due to conversion of triglycerides of oil are converted into fatty acids and glycerol, the lower the possibility of the oils to be used as cooking purpose [20]. From the result of acid value, Lulu, Sunny and Tena are found to be in the range of the recommended value whereas the acid value of Dukem and Beksa oil are deviated from the permissible limit. The presence of free fatty acid in an oil sample indicates a level of deterioration by lipase activity and other hydrolytic or oxidative activity which is usually due to the conditions under which the oil was stored [21].

The Saponification value obtained for the oil samples showed that Tena has highest and Beksa oil has lowest value. Saponification value provides the information of the average chain length and molecular weight of the fatty acid in the oil. The shorter the average chain length of the fatty acids, the higher the saponification value. This may imply that the fat molecules did not interact with each other [22]. The highest saponification value observed for Tena oil is above the permissible limit set by WHO, but can be considered as potential to be used for cosmetic industry [23].

Peroxide value is used as a measure of the extent to which rancidity reactions have occurred during storage. In this study, sunny, Beksa and Dukem oil showed the lower peroxide values in the range of 2-5 meq/kg oil which indicates a relatively good quality of these oils and has good agreement with the standard [23]. On the other hand, Tena and Lulu oil showed higher values in the range of 8-12 meq /kg oil which is relatively above the permissible value set by WHO and causes rancid odor and bad taste [24]. The successive increase in peroxide value indicates the rancidity of oils due to relative higher oxidation in oils.

The results of the determination of fatty acid compositions was described in Table 2. It indicates that the fatty acid profile of Tena contains a high percentage of oleic and linoleic acids. Lulu oil contains the least percentage of oleic and linoleic acid with highest amount of palmitic acid which makes it not good for consumption and production of functional foods [22]. On the other hand, two trans fatty acids: oleic acid (C18: 1) and linoleic acid (C18: 2) were detected for edible oils under investigation.

Table 2: Saturated fatty acid composition of different types of vegetable oils (w/w %)

RT (min)	Identified compound	Formula	Relative area %
Beksa (Niger oil)			
10.05	Dodecanoic acid, methyl ester	$C_{13}H_{26}O_2$	0.01
12.11	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.04
14.66	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	10.27
15.25	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	0.15
15.37	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	0.06
16.14	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	0.09
17.86	Methyl stearate	$C_{19}H_{38}O_2$	3.83
18.72	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	48.07
19.46	Ethyl Oleate	$C_{20}H_{38}O_2$	0.43
20.43	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	31.55
21.28	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$	0.28
22.95	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	1.08

24.22	11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	0.92
32.03	Arachidonic acid methyl ester	$C_{21}H_{34}O_2$	1.72
41.22	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	1.52
Dukem (Niger oil)			
8.37	Decanoic acid, methyl ester	$C_{11}H_{22}O_2$	0.04
12.10	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.11
14.64	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	10.42
15.19	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	0.09
15.39	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	0.08
16.13	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	0.02
17.88	Methyl stearate	$C_{19}H_{38}O_2$	8.54
18.68	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	6.39
20.48	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	73.13
21.26	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$	0.73
22.98	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	0.46
Lulu (vegetable oil)			
8.43	Decanoic acid, methyl ester	$C_{11}H_{22}O_2$	0.02
10.04	Dodecanoic acid, methyl ester	$C_{13}H_{26}O_2$	0.15
12.10	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.82
13.30	Pentadecanoic acid, methyl ester	$C_{16}H_{32}O_2$	0.04
14.82	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	25.82
15.25	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	0.33
15.43	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	0.21
16.17	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	0.10
16.90	7-Hexadecenoic acid, methyl ester, (Z)-	$C17H_{32}O_2$	0.04
18.10	Methyl stearate	$C_{19}H_{38}O_2$	5.02
19.05	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	39.01
19.63	(E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	0.43
20.74	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	$C_{19}H_{34}O_2$	24.77
21.39	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$	0.28
22.31	Z,Z,Z-4,6,9-Nonadecatriene	$C_{19}H_{34}$	0.08
23.13	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	2.85
27.04	Heneicosanoic acid, methyl ester	$C_{22}H_{44}O_2$	0.05
Sunny (soya oil)			
8.35	Decanoic acid, methyl ester	$C_{11}H_{22}O_2$	0.02
12.03	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.09
14.60	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	12.61
15.15	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	0.16
15.31	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	0.09
16.05	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	0.11
17.80	Methyl stearate	$C_{19}H_{38}O_2$	4.38
18.62	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	24.73
19.39	Ethyl Oleate	$C_{20}H_{38}O_2$	0.22
19.96	9,12-Octadecadienoic acid, methyl ester, (E,E)-	$C_{19}H_{34}O_2$	0.30

20.39	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	50.99
21.14	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$	0.70
22.83	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	5.30
41.43	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	0.10
42.52	15-Tetracosenoic acid, methyl ester, (Z)-	$C_{25}H_{48}O_2$	0.22
Tena (sunflower)			
12.09	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.10
14.65	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	6.90
15.24	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	0.04
15.39	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	0.07
16.14	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	0.04
17.89	Methyl stearate	$C_{19}H_{38}O_2$	3.65
18.73	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	32.05
19.47	Ethyl Oleate	$C_{20}H_{38}O_2$	0.11
20.07	9,12-Octadecadienoic acid, methyl ester, (E,E)-	$C_{19}H_{34}O_2$	0.39
20.52	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	55.52
21.28	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$	0.17
22.97	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	0.21
24.37	11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	0.18
32.07	Arachidonic acid methyl ester	$C_{21}H_{34}O_2$	0.58
Remark: C14, myristic acid; C16, palmitic acid; C18, linoleic acid; C20, behenic acid; C24, lignoceric acid.			

The data presented in Table 3 confirms none of the samples were completely free of trans components. In all edible oil samples under investigation analyzed trans-fat content was in the range of 0.6-1.3%. However, WHO standard indicates that the trans fatty acid content in edible oil has to be less than 1%. Highest concentration of trans fats was found in Sunny and also found to be above the WHO report. Few researchers have been conducted study on the effect level of TFA on serum cholesterol level. The finding indicates that TFA at <1% has little adverse effect on the serum cholesterol level [25]. In the current study the trans fatty acid content of the edible oils were within the recommended range of WHO standard except in Sunny oil.

Table 3: Fatty acid profile of the five edible oils

S/No	Edible oils	Source	Saturated Fatty acids (%)	Unsaturated Fatty acids (%)	Trans Fatty acids (%)
1	Beksa	Niger oil	17.63 ± 0.03	81.68 ± 0.31	0.71 ± 0.02
2	Dukem	Niger oil	19.22 ± 0.05	80.06 ± 0.07	0.73 ± 0.04
3	Lulu	Vegetable oil	32.35 ± 0.08	66.96 ± 0.09	0.71 ± 0.05
4	Sunny	Soya oil	17.47 ± 0.44	81.33 ± 0.12	1.22 ± 0.04
5	Tena	Sunflower oil	11.31 ± 0.90	88.03 ± 0.29	0.67 ± 0.04

In natural vegetable oils, the unsaturated fatty acids are present in the cis form. Trans fatty acid content in refined edible oil can be up to 3% [27]. A value of 0% trans-fat acid per serving can be labeled if trans-fat acid content is below 0.5%. The trans-fat acid in edible oils under investigation are greater than limitation according to standard and cannot be declared as 0% trans-fat acid. However, it was quite clear that none of the sample contain trans-fat acid in critical safe limit i.e. 2-4% set by WHO, which is a threatening dilemma to focus in future [28, 29].

Conclusions

The Peroxide value ranges for all edible oils under investigation are closely related to the standard. The detected trans fatty acids value of trans fat content in all samples is below 2%, therefore they can be declared as '0' trans. Most of the oils under this study contain a high percentage of oleic and linoleic that indicates their importance for consumption as one of the best sources of fatty acids in food and potentially can be used as a footstock in the production of functional foods.

Limitation of the study

Even though many types of vegetable oils consumed in the country, only five oil samples subsequently used in the study are were considered for the investigation.

Abbreviations

CHD: coronary heart diseases; EFA: essential fatty acids; FAMEs: fatty acid methyl esters; FAs: Fatty acids; FFA: Free fatty acid; GC: gas chromatography; GC-MS: gas chromatography-mass spectrometer; HCl: hydrochloric acid; HDL High Density Lipoprotein; IV: iodine value; KI: potassium iodide; KOH: potassium hydroxide; LDL: lower density lipoprotein; MUFA: monounsaturated fatty acid; PUFA: poly unsaturated fatty acids; PV: peroxide value; SFA: saturated fatty acid; SV: saponification value; TFA: trans fatty acid; WHO: World Health Organization.

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Authors' contributions

GFA and TFC involved in the proposal development, lab works and report writing; LDT and TKG involved in guiding the work, data analysis and manuscript writing. All the authors read and approved the manuscript.

Ethical approval and consent to participate

Ethical approval was obtained from Institutional ethical review board of the Institute of public health, College of public health sciences, Mettu University. Support letter was obtained from Mettu town trade and industry office.

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