

Quality changes of *Moringa oleifera* variety of Blantyre, seed oil during frying

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MODIFICAZIONI NELLA QUALITÀ DELL'OLIO DI SEMI DI MORINGA OLEIFERA, VARIETÀ BLANTYRE, DURANTE IL PROCESSO DI FRITTURA

È stato studiato il comportamento a ripetute operazioni di frittura dell'olio di semi di *Moringa oleifera*, varietà Blantyre (zona di Malawi), prodotto con tre sistemi: per pressione a freddo, estratto con n-esano ed estratto con una miscela di cloroformio-metanolo. L'olio è stato usato per frittiture continue per 5 giorni consecutivi di patate e di filetti di merluzzo, a $175 \pm 5^\circ\text{C}$. A queste condizioni si verifica una decomposizione termica ed ossidativa. Sono stati valutati i cambiamenti chimici negli oli: il contenuto in acidi grassi liberi, il numero di perossidi, l'estinzione specifica a 232 nm, il colore dei componenti polari e la viscosità aumentano mentre il numero di iodio, il punto di fumo, gli acidi grassi poliinsaturi, il periodo di induzione e la concentrazione in tocoferoli diminuiscono. Si è esaminato inoltre l'effetto di questi oli sulle qualità organolettiche degli alimenti fritti. I dati analitici e sensoriali indicano che il minor deterioramento si verifica nell'olio ottenuto per pressione a freddo ed il maggiore nell'olio estratto con n-esano.

The frying performance of *Moringa oleifera*, local variety of Blantyre, area of Malawi, seed oil (produced by cold pressure, extraction with n-hexane and a mixture of chloroform-methanol) was studied especially as regards repeated frying operations. The oils were used for intermittent frying of potato slices and cod filets at a temperature of $175 \pm 5^\circ\text{C}$ for 5 consecutive days. Under such conditions thermal and oxidative decomposition of the oils take place. The chemical changes occurring in the oils were evaluated. Free fatty acid content, peroxide value, specific extinction at 232 nm, polar compounds colour and viscosity of the oils all increased, whereas the iodine values, smoke points, polyunsaturated fatty acid content, induction period and tocopherol concentration decreased. The effect of the oils on the organoleptic quality of these fried foods was also determined. The analytical and sensory data showed that the lowest deterioration occurred in the oil produced by cold pressure and the highest in the oil extracted by n-hexane.

INTRODUCTION

Deep-fried foods and especially fried potatoes and cod are becoming more and more popular in Greece.

Deep-frying is a very important method of cooking in the food services industry. It is estimated that nearly one-half of all lunch and diner food orders in commercial restaurants include one or more deep-frying items [1].

During deep-frying the oil is exposed to elevated temperatures in the presence of air and moisture. A number of chemical reactions including oxidation and hydrolysis, occur during this time as do changes due to thermal decomposition [2].

Chang et al. [3] and Landers et al. [4] have reported that the chemical reactions taking place during deep oil frying differ from those which occur when the oil is heated continuously, thus reactions occurring in studies conducted with oils heated in the presence of air, with or without agitation, may not be representative of those of the same oils used under normal intermittent frying conditions. The decomposition products formed during frying can be divided into two broad classes: volatile and non-volatile products. Volatile decomposition products have been shown to be retained in the fried food and also inhaled by the deep-frying operator and could thus have an effect on the health of these individuals [3].

The formation of non-volatile decomposition products is due largely to the thermal oxidation and polymerisation of the unsaturated fatty acids present in the frying medium and is of concern since these products not only remain in the frying oil to prevent further degradation but are also absorbed by the fried food and hence consumed [2].

Investigations of commercial frying have generally indicated that these oils have no deleterious effects upon human health [9, 10].

MATERIAL AND METHODS

Vegetable oils

The oil from whole seeds (shell plus kernel) of *Moringa oleifera* local variety of Blantyre area of Malawi was produced

by cold pressure (CP) and extracted by the use of n-hexane (H) and a mixture of chloroform : methanol (50:50) (CM), as solvents.

Cold pressure - The extraction procedure for the cold pressure was performed as follows: the seeds were milled to a fine powder with a Vorwerk Thermomix 3300 (Vorwerk France S.A., Paris) at a speed of 12 with the addition of water (in a ratio of 1 seed/2 water). Prior to extraction which was done with a O.M.F.B. pm 25-S/1 simple hydraulic hand press (Costruz. Mecc. Oleodinamiche Provaglio d'Iseo, Brescia, Italy) with a max. pressure of 300 kg/cm² the paste was wrapped in a thick heavy-duty cloth.

n-Hexane - The solvent extraction was executed using a two litre soxhlet apparatus. The seeds were milled to a fine powder with a Vorwerk Thermomix 3300 (Vorwerk France S.A., Paris) at a speed of 12. The paste was positioned in a paper ampoule and the ampoule in a two litre soxhlet apparatus. Then the heater was turned on. After 12 hours the extraction was stopped. The n-hexane was evaporated under reduced pressure with a Heildolph WB 200 Rotary Evaporator, and the oil was kept in sealed bottles under refrigeration (0 - 4°C) for further processing and analysis.

Chloroform:Methanol (50:50) - The solvent extraction was executed using a two litre soxhlet apparatus. The seeds were milled to a fine powder with a Vorwerk Thermomix 3300 (Vorwerk France S.A., Paris) at a speed of 12. The paste was positioned in a paper ampoule and the ampoule in the two litre soxhlet apparatus. Then the heater was turned on. After 10 hours the extraction was stopped. The chloroform: methanol (50:50) was evaporated under reduced pressure with a Heildolph WB 200 Rotary Evaporator, and the oil was kept in sealed bottles under refrigeration (0 - 4°C) for further processing and analysis.

Degumming - There was a need for degumming because the oils were cloudy and they were going to be used for frying. The oil was heated at 75°C and 20% boiling water was added. The mixture was mixed for 10 minutes with the aid of a

glass rod. After cooling, the oil was centrifuged for 10 minutes in 3,500 rpm in tubes of 200 cm³ using a Sorvall General Purpose RC-3 Automatic Refrigerated Centrifuge (Ivan Sorvall INC., Newtown Connecticut, USA).

METHODS

The frying method used was adapted from that developed by Tsaknis [7]. Potatoes and skinless cod fillets (*Gadus Morhua*) were deep-fried independently, each in 2 litres of oil. The potatoes were peeled and washed about 1 h before use, and sliced into discs 0.5 cm thick and 2.5 cm in diameter, using a mechanical slicer.

The skinless cod fillets were cut into square pieces (3 cm x 3 cm x 1.5 cm) and coated with wheat flour. When the temperature of the oil reached 175°C a batch of 100 g of each were fried in separate oil samples.

Repeat fryings were carried out at half hour intervals for 2 h. The frying time was 8 min for cod fillets and 6 min for potatoes. A total of five fryings were done per day for five consecutive days. At the end of each day 50 g sample of oil was removed from each fryer and stored at 0°C. The lid of the fryer was replaced and the fryings were continued the following day. Fresh oil was not added to the frying pans.

Colour was measured with a Lovibond tintometer (The Tintometer Ltd., Salisbury, England). Free fatty acid content was measured according to the method described by IUPAC [8]. The viscosity was measured using a Brookfield viscometer with spindle No 2 at temperature of 24°C. Ultra-violet absorption (at 232 nm) of the oils was determined using the method of IUPAC [8]. Smoke point was measured according to the method described by British Standards Methods of Analysis (BS 684: Section 1.8). Iodine value was measured according to the Wijs method as described by Pearsons [10].

The polar compounds were determined using the IUPAC (1987) method. The determination of the fatty acids composition was done by gas-liquid chromatography according to the method described by Tsaknis [7]. The FAMES preparation was done using the following procedure: about 25 mg of oil were accurately weighed into a screw cap tube, and 1.5 cm³ methanolic sodium hydroxide was added, mixed and heated at 100°C for 7 minutes. After cooling, 2 cm³ of boron trifluoride were added and heated at 100°C for 5 minutes. The tube was cooled to 30 - 40°C and 1 cm³ of iso-octane was added, capped and shaken using whirli mix for 30 seconds. 5 cm³ of saturated sodium chloride solution was immediately added and the tube was shaken again. The tube contents were allowed to separate and the top (iso-octane containing fatty acid methyl esters) layer was removed and the lower layer was extracted again with an addition of 1 cm³ iso-octane. The two iso-octane extracts were combined (dried over anhydrous sodium sulfate) and concentrated to approximately 1 cm³ with a stream of nitrogen.

Analysis of fatty acid methyl esters was performed on a Varian 3600 Gas chromatograph (Varian, Palo Alto, California, USA) equipped with a Supelcowax 10 (Supelco, Inc., Supelco Park, Bellefonte, PA 16823-0048) fused silica capillary column 30 x 0.32 mm ID, 0.25 µm film thickness. The temperature program was 60°C for 10 min and then 2°C min⁻¹ up to 220°C. Injector and FID temperatures were set at 160°C and 280°C respectively, sample volume was 0.2 µl, the carrier gas was N₂ at a flow of 30 ml min⁻¹, chart speed was set at 0.5 cm min⁻¹ and the attenuation at 10⁻¹⁰ x 32. The internal standard used was nonadecanoic acid. Methyl esters were identified and quantified by comparing the retention times and peak area of the unknowns with those known FAME standard mixtures. Samples were prepared and measured separately in triplicates, for each way of extraction (three ways in total).

The method used for the determination of tocopherols was a modification of that reported by Carpenter's [11]:

a) 1 g of oil was accurately weighed into a 3 dram sample vial wrapped in foil paper to prevent oxidation. The oil was dis-

solved in a 5 cm³ n-hexane before injection.

b) A 20 µl sample was injected into the Waters 600E HPLC pump (Millipore Corporation, Waters Chromatography Division, Massachusetts, MA 01757, USA) fitted with a Waters µ-Polarisil, 125 Å, 10 µm, 3.9x300 mm column.

Detection was performed with a Waters 486 Tunable Absorbance Detector set at 295 nm. Iso-propanol: n-hexane: absolute ethanol (2: 97.5: 0.5) at 1 cm³/min was used as the mobile phase. A total of 5 min was necessary to assay the tocopherols. The external standards used were di-α-tocopherol (Merck) and (+)-δ-tocopherol (Sigma). Tocopherols were identified by comparing the retention times and quantified based on peak area percent of the unknowns with those of known standards. Samples were prepared and measured separately in triplicates, for each way of extraction (three ways in total).

The determination of peroxide value was done using the method adapted from Lea [12]. The determination of the induction period was done as follows: two and a half grams (2.5 g) of oil were accurately weighed into each of the six reaction vessels and the following procedure was carried out. The "Metrohm Rancimat 679" (Metrohm Ltd., CH-9101, Herisau, Switzerland) was switched on until the temperature of the oil batch reached the temperature of 120°C. Then 50 cm³ of distilled water was placed into each of the six conductivity cells and the airflow rate was set at 20 L h⁻¹. The temperature was checked to ensure it had a constant value. The air supply was connected to the tubes containing the oil samples and the chart recorder was started. The determination continued automatically until the conductivity reached the maximum value and the induction period was read.

RESULTS AND DISCUSSION

Fish and potatoes are the most commonly fried foods in homes and restaurants. In view of this an investigation was carried out to study the physical and chemical changes which occur in oils used for frying.

Free fatty acid (FFA) content

Tables I, VII and XIII illustrate the changes in free fatty acids of oils used for frying potatoes and Tables IV, X and XVI illustrate the changes in free fatty acids of oils used for frying cod. No significant increases were observed after 5 days of frying in all the oils at the 95% level of significance (student's t-test). The cold pressure oil showed the lowest increase and the n-hexane oil the highest. The steady rise in the formation of FFA can be attributed partly to the hydrolysis and partly to the component carboxylic groups present in polymeric products of frying [13]. The acidity was mainly formed by hydrolysis of triglycerides, which was promoted by the presence of food moisture, and by oxidation or by the reaction of oil with moisture formed during other deterioration reactions [14]. The oils used for frying cod seemed to follow the same trend. Although cod was found to cause a more rapid increase in the free fatty acid content.

Peroxide value

Tables I, VII and XIII illustrate the changes in peroxide value of oils used for frying potatoes and Tables IV, X and XVI illustrate the changes in peroxide value of oils used for frying cod. All the oils showed an increase at the initial stages of frying until 6 h or 8 h of frying followed by a decrease in PV. Further frying resulted in a new increase in PV. Peroxides under the heating conditions used are unstable, and react to form secondary oxidation products. An increase in the initial stage of frying would be expected to be followed by a decrease with further frying, because the hydroperoxides tend to decompose at 180°C to form secondary oxidation products [15]. The overall increase in peroxide value is connected with the cooling period of the oil. The length of time required to cool the oils

at room temperature (28°C) was more than 4 h. During the cooling period the oils were exposed to air at high temperature and hydroperoxides were formed again [16]. In view of these factors, peroxide value is not to be recommended for measuring heating oil deterioration. The method suggested by Tsaknis et al. [17] would be more suitable for measuring frying oil deterioration, because it determines malondialdehyde, which is a stable secondary oxidation product. The oils used for frying cod seemed to follow the same trend with the only exception of cold pressure oils used for frying cod that showed a continuous increase of PV.

Iodine value

Tables I, VII and XIII illustrate the changes in iodine values of oil used for frying potatoes. Tables IV, X and XVI illustrate the changes in iodine values of oil used for frying cod. The results showed that there were not significant changes between the fresh and used oils after 5 days of frying. The decrease of iodine value correlated well with the decrease of unsaturated fatty acids ($r = 0.992$), and more over this analysis confirmed that less oxidation of unsaturated fatty acids has taken place in cold pressure oil. The oils used for frying cod seemed to follow the same trend.

Viscosity

Tables I, VII and XIII illustrate the changes in viscosity of oils used for frying potatoes and Tables IV, X and XVI illustrate the changes in viscosity of oils used for frying cod. As the oxidation is accelerated by heat proceeded, the values of viscosity progressively increased [13]. Cold press oil showed the lowest change in viscosity after 10 h of frying, while chloroform-methanol and n-hexane oil showed much higher changes. These results clearly indicated the higher deteriorative effect of oxidation and polymerisation of chloroform-methanol and n-hexane oil compared to cold pressure oil. The increase in viscosity of frying oils was due to polymerisation which resulted in formation of higher molecular weight compounds (carbon to carbon and/or carbon to oxygen-to carbon bridges) between fatty acids [14]. The oils used for frying cod seemed to follow the same trend. Although cod was found to cause a more rapid increase in viscosity.

Smoke point

Tables I, VII and XIII illustrate the changes in smoke point of oils used for frying potatoes and Tables IV, X and XVI illustrate the changes in smoke point of oils used for frying cod. As expected a decrease of smoke point of the oils was observed. The chloroform-methanol and n-hexane oil showed a significant decrease in smoke point after 4 days of frying, while the cold pressure oil showed no significant increase after 5 days of frying. Morton and Chidley [18] reported that the amount of smoke emanating from a cup is directly proportional to the concentration of low molecular weight decomposition products in the oil. The free fatty acids and other volatile substances leaving the fat as gases, will not appear as smoke until their concentration is great enough to permit aggregation to colloidal sized particles. The oils used for frying cod seemed to follow the same trend. Although cod was found to cause a higher decrease in the smoke point.

Polar compounds

Tables I, VII and XIII illustrate the changes in polar compounds of oils used for frying potatoes and Tables IV, X and XVI illustrate the changes in polar compounds of oils used for frying cod. The results demonstrated that cold pressure oil exhibited the lowest increase in polar compounds, while the n-hexane oil the highest. Fritch [19], reported that the analysis of percentage polar compounds is considered to be one of the more reliable indicators of the state of the oil deterioration. This latter statement is supported by those of other research workers [20].

Colour

Tables II, VIII and XIV illustrate the changes in colour of oils used for frying potatoes and Tables V, XI and XVII illustrate the changes in colour of oils used for frying cod. Darkening is attributed to the presence of unsaturated carbonyl compounds or to non-polar compounds of foodstuff solubilised in the oil [21]. The results indicated that there was an increase in red units of the colour measurement of frying oils, while yellow units showed only minor changes. The colour change was a result of the diffusion of pigments into the oil during frying. n-Hexane oil showed the highest increase in colour while cold pressure oil showed the lowest. Although cod was found to cause less increase in red units of colour. The higher increase of oil colour during frying of potatoes than that during oil frying cod is due to the fact that reactions between the aldehyde group of sugar and amino acids give brown products. Burton [22] reported that the alpha, beta unsaturated carbonyl compounds, derived from the sugars are the first formed intermediates that react with substances containing alpha-amino groups to give carbonyl-nitrogen compounds which conjugate to form brown products.

FAME analysis by gas-liquid chromatography

Tables III, IX and XV illustrate the changes in fatty acid composition of oils used for frying potatoes and Tables VI, XII and XVIII illustrate the changes in fatty acid composition of oils used for frying cod. It was observed that there was a decrease in polyunsaturated fatty acids and a resulting increase in the saturated acids content. However, the changes in polyunsaturated fatty acids were not statistically significant. Changes in fatty acid profile of all oils during frying are basically among the unsaturated fatty acids, whereas the saturated fatty acids (myristic, palmitic and stearic) were slightly increased [13].

HPLC of tocopherols

Tables II, VIII and XIV illustrate the changes in colour of oil used for frying potatoes and Tables V, XI and XVII illustrate the changes in tocopherols of oil used for frying cod. The relative decomposition rates after 5 days of frying were $\delta > \alpha$. The results are in agreement with those of Sonntag [23], who reported that the decomposition rates of tocopherols, after 10 hours frying, were $\gamma > \alpha$. Lea [24] showed that the order of antioxidant activity changed with the oil used for the experiment. In contrast Miyagawa et al. [25], in their experiments, using a mixture of soybean and rapeseed oils to fry potatoes, found that the decomposition rates of tocopherols were $\gamma > \delta > \alpha$ after 32 batches of frying. Also Carlson and Tabach [26], reported that the decomposition rates of tocopherols in fried soybean oil with french fries were $\gamma > \delta > \alpha$.

Specific extinction ($E_{1cm}^{1\%}$) at 232 nm

Tables II, VIII and XIV illustrate the changes in specific extinction at 232 nm of oils used for frying potatoes and Tables V, XI and XVII illustrate the changes in specific extinction at 232 nm of oils used for frying cod. The specific extinction at 232 nm which measures the degree of the primary oxidation products increased during time and was significant after the first day of frying in all the used oils.

Induction Period

Tables II, VIII and XIV illustrate the changes in induction period of oils used for frying potatoes and Tables V, XI and XVII illustrate the changes in induction period of oils used for frying cod. The results showed that cold pressure oil had the longest induction period followed by chloroform-methanol and n-hexane oil. Induction period measurements were carried out on frying oils in order to provide a quick indication of the trends in resistance to oxidative rancidity of the heated oils. The induction period determined via accelerated oxidation methods

on the original oil cannot guarantee or predict the actual frying performance of the oil as other factors will be introduced once frying commences (e.g. badly operated fryer or heat exchanger will ruin even the best quality oil). Nevertheless, it is considered that the "Rancimat" induction period can be useful to act as a "screening" test and eliminate the possibility of introducing lower stability oils into the production area with all the attendant consequences [18]. The oils used for frying cod seemed to follow the same trend. Although cod was found to cause a higher decrease in induction period.

The oils used for frying cod, showed higher deterioration in all the quality parameters, with the exception of colour, compared with the same oils used for frying potatoes. This greater deterioration could be due to the leaching of fish oil from the cod which is rich in polyunsaturated fatty acids which are rapidly oxidised.

Sensory evaluation

A number of panellists were chosen to taste potatoes and cod for the overall characterisation of the organoleptic proper-

ties (appearance, colour, flavour and texture) after each batch had been fried. A taste panel score sheet with a numerical scale of rating was developed, using descriptive terms against each numerical score for each quality parameter. Throughout the frying time the overall acceptance scores showed a significant difference in overall acceptance of fried potatoes with cold pressure and chloroform-methanol oil after 5 days of frying, while this difference was significant after 4 days of frying with n-hexane oil. The overall acceptance scores showed that fried cod was unacceptable after having been fried in oil for 5 days in cold pressure oil, after 4 days of frying in chloroform-methanol oil and after 3 days in n-hexane oil. The panel scores confirmed that cold pressure oil is the most suitable oil for repeating frying compared to the other oils involved in this study.

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TABLE I - Changes of the quality characteristics of *Malawi Moringa oleifera* (cold pressure) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq. O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	1.20 (0.12)	0.19 (0.12)	65.83 (0.46)	91.00 (0.21)	204 (2.0)	3.04 (0.33)
2	1.22 (0.21)	0.44 (0.18)	65.77 (0.54)	91.06 (0.88)	204 (1.7)	3.21 (0.73)
4	1.30 (0.38)	1.16 (0.73)	65.68 (0.56)	91.15 (1.04)	203 (2.0)	3.50 (0.46)
6	1.39 (0.16)	1.01 (0.65)	65.52 (0.56)	91.33 (0.76)	202 (1.0)	3.98 (0.92)
8	1.54 (0.30)	1.95 (0.77)	65.30 (0.95)	91.55 (1.14)	201 (2.0)	4.58 (0.62)
10	1.74 (0.17)	4.13 (0.95)	65.05 (0.69)	91.86 (1.25)	200 (1.0)	5.47 (0.55)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE II - Changes of the quality characteristics of *Malawi Moringa oleifera* (cold pressure) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	$E_{1\text{ cm}}$ at 232 nm	Induction period (h)	α -tocopherol (mg/kg oil)	γ -tocopherol (mg/kg oil)	δ -tocopherol (mg/kg oil)	Colour red, yellow
0	1.30 (0.18)	34.70 (0.8)	93.03 (2.99)	26.44 (1.01)	71.47 (5.76)	2.00, 28.00 (0.14), (3.50)
2	1.36 (0.09)	34.47 (0.36)	92.66 (2.18)	24.99 (1.65)	70.57 (2.18)	2.14, 28.00 (0.80), (1.13)
4	1.47 (0.13)	34.17 (0.81)	91.81 (3.14)	23.29 (0.96)	68.11 (1.83)	2.25, 28.00 (0.60), (0.90)
6	1.68 (0.10)	33.84 (0.45)	90.72 (1.42)	21.57 (2.16)	64.84 (2.40)	2.44, 28.00 (0.70), (1.10)
8	2.01 (0.34)	33.62 (0.76)	88.43 (2.17)	19.42 (1.77)	60.81 (2.13)	3.00, 28.00 (0.55), (0.45)
10	2.51 (0.39)	32.78 (0.55)	85.59 (0.94)	16.83 (0.74)	55.90 (3.16)	5.44, 28.00 (0.90), (0.65)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE III - Fatty acid composition of *Malawi Moringa oleifera* (cold pressure) oil during frying potatoes at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω 9	16:1 ω 7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1 cis	26:0
0	0.03 (0.01)	0.10 (0.05)	5.40 (0.35)	0.11 (0.04)	0.98 (0.68)	0.04 (0.01)	5.80 (0.22)	67.65 (0.66)	0.69 (0.33)	0.20 (0.06)	3.72 (0.28)	2.64 (0.29)	6.74 (0.41)	0.12 (0.04)	0.90 (0.09)
2	0.04 (0.02)	0.10 (0.03)	5.40 (0.28)	0.10 (0.02)	0.98 (0.43)	0.04 (0.01)	5.85 (0.31)	67.69 (0.81)	0.68 (0.49)	0.18 (0.07)	3.74 (0.36)	2.63 (0.44)	6.75 (0.42)	0.11 (0.06)	0.90 (0.24)
4	0.06 (0.03)	0.11 (0.07)	5.41 (0.14)	0.09 (0.06)	0.94 (0.60)	0.05 (0.02)	5.86 (0.39)	67.66 (0.41)	0.66 (0.25)	0.16 (0.09)	3.75 (0.76)	2.62 (0.28)	6.78 (0.14)	0.09 (0.05)	0.87 (0.18)
6	0.07 (0.01)	0.12 (0.06)	5.39 (0.72)	0.10 (0.03)	0.92 (0.26)	0.06 (0.03)	5.89 (0.14)	67.64 (0.26)	0.62 (0.17)	0.14 (0.05)	3.77 (0.43)	2.61 (0.24)	6.79 (0.38)	0.09 (0.07)	0.85 (0.22)
8	0.09 (0.04)	0.13 (0.02)	5.42 (0.41)	0.08 (0.02)	0.91 (0.34)	0.03 (0.01)	5.94 (0.14)	67.61 (0.77)	0.59 (0.24)	0.11 (0.04)	3.78 (0.65)	2.59 (0.13)	6.80 (0.44)	0.08 (0.02)	0.82 (0.40)
10	0.08 (0.05)	0.14 (0.05)	5.37 (0.66)	0.07 (0.05)	0.90 (0.43)	0.02 (0.01)	6.08 (0.55)	67.54 (0.31)	0.55 (0.34)	0.07 (0.03)	3.77 (0.26)	2.58 (0.27)	6.82 (0.21)	0.07 (0.04)	0.80 (0.17)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE IV - Changes of the quality characteristics of *Malawi Moringa oleifera* (cold pressure) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq. O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	1.20 (0.12)	0.19 (0.12)	65.83 (0.46)	91.00 (0.21)	204 (2.0)	3.04 (0.33)
2	1.25 (0.51)	0.44 (0.25)	65.74 (0.90)	91.11 (0.47)	204 (1.0)	3.27 (0.56)
4	1.34 (0.36)	1.12 (0.70)	65.55 (0.77)	91.23 (0.86)	202 (3.0)	3.70 (0.83)
6	1.50 (0.63)	0.94 (0.27)	65.49 (0.66)	91.42 (0.77)	201 (2.0)	4.29 (0.66)
8	1.70 (0.32)	2.63 (0.80)	65.26 (0.55)	91.73 (0.99)	200 (3.0)	5.06 (0.69)
10	1.98 (0.44)	4.17 (0.94)	65.00 (1.10)	92.16 (1.02)	198 (2.0)	6.00 (0.70)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE V - Changes in the quality characteristics of *Malawi Moringa oleifera* (cold pressure) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	E _{t cm} at 232 nm	Induction period (h)	α-tocopherol (mg/kg oil)	γ-tocopherol (mg/kg oil)	δ-tocopherol (mg/kg oil)	Colour red, yellow
0	1.30 (0.18)	34.70 (0.80)	93.03 (2.99)	26.44 (1.01)	71.47 (5.76)	2.00, 28.00 (0.14), (3.50)
2	1.38 (0.26)	34.41 (0.40)	92.57 (1.82)	24.91 (1.95)	70.40 (0.74)	2.12, 28.00 (0.28), (3.44)
4	1.52 (0.70)	34.07 (0.66)	91.60 (2.40)	23.11 (0.96)	67.81 (1.15)	2.18, 28.00 (0.54), (2.77)
6	1.75 (0.41)	33.65 (0.74)	89.93 (1.80)	21.09 (0.78)	64.09 (0.94)	2.31, 28.00 (0.76), (2.12)
8	2.22 (0.55)	32.88 (0.56)	87.53 (1.30)	18.62 (1.34)	59.91 (1.34)	2.60, 29.01 (0.78), (2.12)
10	2.85 (0.63)	31.82 (0.66)	84.15 (2.41)	15.04 (1.09)	54.64 (1.95)	3.36, 29.03 (0.63), (1.72)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE VI - Fatty acid composition of the *Malawi Moringa oleifera* (cold pressure) oil during frying cod at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω9	16:1 ω7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1cis	26:0
0	0.03 (0.01)	0.10 (0.05)	5.40 (0.34)	0.11 (0.04)	0.98 (0.68)	0.04 (0.01)	5.80 (0.22)	67.65 (0.66)	0.69 (0.33)	0.20 (0.06)	3.72 (0.28)	2.64 (0.29)	6.74 (0.41)	0.12 (0.04)	0.90 (0.09)
2	0.03 (0.02)	0.12 (0.04)	5.40 (0.17)	0.09 (0.04)	0.95 (0.37)	0.06 (0.03)	5.81 (0.18)	67.67 (0.29)	0.67 (0.16)	0.18 (0.11)	3.74 (0.26)	2.62 (0.12)	6.77 (0.22)	0.10 (0.07)	0.88 (0.21)
4	0.04 (0.02)	0.14 (0.09)	5.44 (0.23)	0.07 (0.03)	0.92 (0.26)	0.07 (0.05)	5.85 (0.33)	67.61 (0.16)	0.64 (0.30)	0.16 (0.10)	3.77 (0.16)	2.60 (0.30)	6.80 (0.11)	0.09 (0.06)	0.86 (0.11)
6	0.06 (0.03)	0.16 (0.11)	5.47 (0.20)	0.09 (0.16)	0.92 (0.13)	0.04 (0.02)	5.86 (0.38)	67.59 (0.34)	0.58 (0.25)	0.13 (0.09)	3.75 (0.50)	2.58 (0.14)	6.83 (0.37)	0.08 (0.04)	0.80 (0.27)
8	0.08 (0.04)	0.16 (0.09)	5.50 (0.32)	0.08 (0.04)	0.93 (0.38)	0.05 (0.04)	5.89 (0.20)	67.55 (0.47)	0.54 (0.21)	0.10 (0.08)	3.78 (0.45)	2.57 (0.19)	6.84 (0.21)	0.07 (0.04)	0.76 (0.46)
10	0.10 (0.05)	0.20 (0.07)	5.52 (0.29)	0.09 (0.03)	0.93 (0.24)	0.08 (0.03)	5.93 (0.44)	67.52 (0.41)	0.44 (0.36)	0.06 (0.02)	3.80 (0.44)	2.54 (0.36)	6.85 (0.46)	0.06 (0.03)	0.71 (0.36)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE VII - Changes in the quality characteristics of *Malawi Moringa oleifera* (n-hexane) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq. O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	0.82 (0.11)	0.23 (0.13)	65.74 (0.50)	62.00 (0.17)	202 (2.0)	3.96 (0.44)
2	0.88 (0.34)	1.10 (0.59)	65.70 (0.62)	62.29 (0.65)	200 (3.0)	4.27 (0.88)
4	0.99 (0.26)	2.17 (0.84)	65.64 (0.76)	62.74 (0.90)	198 (1.0)	4.71 (1.14)
6	1.14 (0.41)	3.78 (1.04)	65.52 (0.48)	63.31 (1.16)	196 (2.0)	5.70 (0.60)
8	1.45 (0.52)	4.61 (0.85)	65.25 (0.34)	64.14 (0.78)	194 (1.0)	6.99 (0.55)
10	1.98 (0.54)	3.65 (0.58)	64.59 (0.57)	65.04 (1.17)	191 (2.0)	8.68 (0.56)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE VIII - Changes in the quality characteristics of *Malawi Moringa oleifera* (n-hexane) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	E _{1 cm} at 232 nm	Induction period (h)	α-tocopherol (mg/kg oil)	γ-tocopherol (mg/kg oil)	δ-tocopherol (mg/kg oil)	Colour red, yellow
0	1.44 (0.20)	23.70 (0.50)	51.10 (4.01)	25.35 (1.13)	18.29 (2.11)	1.20, 70.00 (0.40), (2.20)
2	1.51 (0.70)	23.07 (0.84)	49.15 (2.70)	22.53 (1.65)	11.71 (1.36)	1.53, 70.00 (0.50), (1.80)
4	1.64 (0.54)	22.07 (1.14)	46.33 (3.40)	18.93 (2.35)	0	1.91, 70.00 (1.05), (1.30)
6	2.23 (0.58)	20.94 (1.27)	42.12 (1.80)	13.25 (0.98)	0	2.66, 70.00 (0.70), (1.20)
8	2.88 (0.96)	19.68 (0.80)	37.16 (2.30)	7.01 (1.33)	0	3.67, 71.00 (0.90), (1.20)
10	3.98 (0.91)	18.18 (0.46)	31.10 (1.17)	0	0	5.68, 71.00 (0.90), (0.50)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE IX - Fatty acid composition of the *Malawi Moringa oleifera* (n-hexane) oil during frying potatoes at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω9	16:1 ω7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1 cis	26:0
0	0.02 (0.01)	0.10 (0.06)	5.51 (0.36)	0.11 (0.05)	1.10 (0.74)	0.04 (0.01)	5.86 (0.33)	67.79 (0.67)	0.71 (0.41)	0.21 (0.07)	3.78 (0.29)	2.60 (0.28)	6.81 (0.56)	0.11 (0.01)	0.98 (0.10)
2	0.03 (0.02)	0.11 (0.04)	5.52 (0.24)	0.11 (0.06)	1.08 (0.31)	0.05 (0.03)	5.88 (0.27)	67.76 (0.19)	0.69 (0.30)	0.20 (0.06)	3.79 (0.14)	2.58 (0.40)	6.82 (0.22)	0.10 (0.05)	0.96 (0.25)
4	0.05 (0.04)	0.11 (0.07)	5.53 (0.13)	0.09 (0.05)	1.06 (0.40)	0.07 (0.04)	5.93 (0.14)	(0.39)	0.65 (0.43)	0.18 (0.08)	3.80 (0.16)	2.56 (0.31)	6.84 (0.35)	0.09 (0.07)	0.95 (0.43)
6	0.07 (0.04)	0.13 (0.08)	5.54 (0.44)	0.08 (0.04)	1.02 (0.61)	0.09 (0.03)	5.96 (0.28)	67.68 (0.44)	0.60 (0.22)	0.16 (0.09)	3.82 (0.27)	2.53 (0.18)	6.86 (0.60)	0.08 (0.04)	0.92 (0.16)
8	0.08 (0.06)	0.14 (0.10)	5.57 (0.35)	0.08 (0.03)	1.00 (0.35)	0.11 (0.06)	6.00 (0.55)	67.63 (0.15)	0.42 (0.31)	0.12 (0.06)	3.84 (0.19)	2.51 (0.24)	6.89 (0.37)	0.06 (0.03)	0.89 (0.28)
10	0.12 (0.04)	0.16 (0.11)	5.59 (0.26)	0.05 (0.02)	0.96 (0.18)	0.15 (0.07)	6.06 (0.43)	67.57 (0.61)	0.18 (0.20)	0.05 (0.03)	3.88 (0.32)	2.47 (0.18)	6.94 (0.51)	0.04 (0.02)	0.84 (0.33)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE X - Changes of the quality characteristics of *Malawi Moringa oleifera* (n-hexane) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq. O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	0.82 (0.11)	0.23 (0.13)	65.74 (0.50)	62.00 (0.17)	202 (2.0)	3.96 (0.44)
2	0.93 (0.50)	0.65 (0.43)	65.68 (1.90)	62.34 (1.48)	201 (1.0)	4.34 (1.65)
4	1.11 (0.35)	1.27 (0.92)	65.57 (2.30)	62.78 (1.48)	199 (3.0)	4.86 (2.20)
6	1.34 (0.81)	2.43 (1.12)	65.38 (1.70)	63.37 (1.90)	197 (2.0)	5.73 (1.30)
8	1.70 (0.56)	2.07 (1.30)	64.96 (1.50)	64.39 (1.10)	194 (1.0)	7.06 (1.10)
10	2.10 (0.74)	4.57 (1.60)	64.48 (1.40)	65.64 (0.90)	190 (3.0)	9.22 (0.98)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XI - Changes in the quality characteristics of *Malawi Moringa oleifera* (n-hexane) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	E _{1 cm} at 232 nm	Induction period (h)	α-tocopherol (mg/kg oil)	γ-tocopherol (mg/kg oil)	δ-tocopherol (mg/kg oil)	Colour red, yellow
0	1.44 (0.20)	23.70 (0.50)	51.10 (4.01)	25.35 (1.13)	18.89 (2.11)	1.20, 70.00 (0.40), (2.20)
2	1.54 (0.72)	23.16 (0.75)	49.63 (2.71)	22.05 (0.91)	12.73 (1.22)	1.45, 70.00 (0.90), (1.60)
4	1.72 (0.56)	22.20 (0.39)	46.30 (1.87)	17.27 (1.60)	5.06 (1.13)	1.85, 70.00 (0.60), (2.50)
6	2.17 (0.92)	20.95 (0.76)	41.84 (1.33)	9.33 (1.43)	0	2.55, 70.00 (0.45), (3.20)
8	3.04 (0.85)	19.56 (0.61)	35.72 (1.92)	0	0	3.42, 70.00 (1.10), (0.80)136
10	4.36 (0.28)	17.76 (0.97)	26.30 (0.90)	0	0	4.55, 71.00 (0.75), (0.90)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XII - Fatty acid composition of heated *Malawi Moringa oleifera* (n-hexane) oil during frying cod at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω9	16:1 ω7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1cis	26:0
0	0.02 (0.01)	0.10 (0.06)	5.51 (0.36)	0.11 (0.05)	1.10 (0.74)	0.04 (0.01)	5.86 (0.33)	67.79 (0.67)	0.71 (0.41)	0.21 (0.07)	3.78 (0.29)	2.60 (0.28)	6.81 (0.56)	0.11 (0.01)	0.98 (0.10)
2	0.02 (0.02)	0.11 (0.08)	5.51 (0.25)	0.11 (0.08)	1.08 (0.50)	0.05 (0.02)	5.88 (0.24)	67.76 (0.80)	0.69 (0.30)	0.20 (0.12)	3.80 (0.75)	2.58 (0.31)	6.83 (0.40)	0.11 (0.08)	0.97 (0.51)
4	0.05 (0.03)	0.12 (0.09)	5.53 (0.44)	0.10 (0.06)	1.06 (0.38)	0.08 (0.04)	5.92 (0.63)	67.72 (0.90)	0.65 (0.43)	0.18 (0.10)	3.81 (0.47)	2.55 (0.31)	6.85 (0.60)	0.10 (0.07)	0.96 (0.48)
6	0.07 (0.04)	0.13 (0.05)	5.55 (0.36)	0.09 (0.07)	1.00 (0.40)	0.09 (0.28)	5.96 (0.39)	67.70 (0.28)	0.52 (0.27)	0.13 (0.09)	3.84 (0.27)	2.53 (0.52)	6.88 (0.33)	0.08 (0.06)	0.95 (0.29)
8	0.10 (0.07)	0.15 (0.11)	5.57 (0.22)	0.07 (0.04)	0.98 (0.37)	0.13 (0.10)	6.01 (0.34)	67.64 (0.72)	0.29 (0.12)	0.06 (0.02)	3.87 (0.48)	2.50 (0.26)	6.91 (0.25)	0.05 (0.03)	0.91 (0.48)
10	0.12 (0.08)	0.18 (0.09)	5.57 (0.53)	0.02 (0.01)	0.93 (0.47)	0.18 (0.12)	6.10 (0.58)	67.54 (0.75)	0.03 (0.01)	0	3.90 (0.83)	2.46 (0.60)	6.95 (0.68)	0.02 (0.01)	0.84 (0.56)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XIII - Changes in the quality characteristics of *Malawi Moringa oleifera* (chloroform:methanol) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq. O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	0.98 (0.42)	0.15 (0.09)	65.59 (0.50)	71.00 (0.18)	206 (2.0)	3.24 (0.92)
2	1.58 (0.33)	0.98 (0.36)	65.63 (0.91)	71.13 (0.94)	206 (2.0)	3.48 (0.56)
4	1.63 (0.28)	2.14 (0.76)	65.49 (1.10)	71.34 (0.88)	205 (1.0)	3.90 (0.35)
6	1.71 (0.19)	1.56 (0.44)	65.28 (0.77)	71.71 (0.59)	203 (3.0)	4.63 (0.91)
8	1.95 (0.38)	2.96 (0.93)	65.01 (1.13)	72.16 (0.83)	201 (2.0)	5.55 (0.88)
10	1.61 (0.76)	4.75 (1.07)	64.69 (0.66)	72.92 (1.03)	197 (1.0)	6.72 (0.67)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XIV - Changes in the quality characteristics of *Malawi Moringa oleifera* (chloroform:methanol) oil during frying potatoes at 175°C

Time (h)	DETERMINATION					
	E _{1 cm} at 232 nm	Induction period (h)	α-tocopherol (mg/kg oil)	γ-tocopherol (mg/kg oil)	δ-tocopherol (mg/kg oil)	Colour red, yellow
0	1.19 (0.16)	31.80 (0.60)	70.06 (7.08)	29.29 (1.85)	22.32 (1.32)	15.50, 79.00 (3.10), (2.70)
2	1.23 (0.27)	31.64 (0.44)	69.28 (0.39)	26.60 (0.34)	19.56 (0.34)	15.65, 79.00 (1.80), (0.80)
4	1.32 (0.16)	31.28 (0.72)	66.94 (0.28)	23.44 (0.66)	16.02 (0.39)	15.87, 80.00 (1.20), (0.70)
6	1.69 (0.34)	30.75 (0.31)	64.68 (0.43)	19.53 (0.38)	10.11 (0.92)	16.20, 80.00 (1.30), (0.90)
8	2.18 (0.55)	29.92 (0.41)	62.13 (0.54)	14.52 (0.63)	2.76 (0.83)	17.20, 81.00 (0.65), (1.40)
10	2.89 (0.25)	28.52 (0.47)	59.06 (0.25)	8.51 (0.30)	0	18.46, 81.00 (1.50), (1.80)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XV - Fatty acid composition of the *Malawi Moringa oleifera* (chloroform:methanol) oil during frying potatoes at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω9	16:1 ω7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1cis	26:0
0	0.02 (0.01)	0.10 (0.06)	5.46 (0.32)	0.11 (0.04)	1.11 (0.73)	0.04 (0.01)	5.82 (0.29)	67.80 (0.65)	0.69 (0.35)	0.19 (0.05)	3.77 (0.51)	2.61 (0.31)	6.78 (0.33)	0.11 (0.06)	0.96 (0.08)
2	0.03 (0.01)	0.11 (0.04)	5.47 (0.19)	0.11 (0.06)	1.10 (0.44)	0.05 (0.03)	5.84 (0.14)	67.79 (0.42)	0.66 (0.31)	0.18 (0.07)	3.79 (0.21)	2.60 (0.14)	6.79 (0.40)	0.11 (0.04)	0.93 (0.17)
4	0.03 (0.02)	0.11 (0.06)	5.48 (0.37)	0.10 (0.04)	1.09 (0.17)	0.06 (0.02)	5.84 (0.21)	67.77 (0.17)	0.60 (0.52)	0.17 (0.11)	3.81 (0.18)	2.56 (0.35)	6.80 (0.20)	0.10 (0.07)	0.90 (0.35)
6	0.04 (0.03)	0.13 (0.07)	5.47 (0.14)	0.09 (0.04)	1.08 (0.13)	0.06 (0.03)	5.92 (0.36)	67.74 (0.28)	0.52 (0.26)	0.12 (0.06)	3.83 (0.19)	2.54 (0.18)	6.83 (0.25)	0.09 (0.03)	0.89 (0.42)
8	0.06 (0.02)	0.16 (0.09)	5.50 (0.42)	0.08 (0.02)	1.06 (0.21)	0.08 (0.04)	5.96 (0.48)	67.70 (0.37)	0.41 (0.36)	0.10 (0.04)	3.84 (0.22)	2.51 (0.30)	6.87 (0.22)	0.07 (0.04)	0.84 (0.28)
10	0.08 (0.04)	0.14 (0.07)	5.52 (0.27)	0.07 (0.03)	1.04 (0.07)	0.10 (0.04)	6.01 (0.09)	67.66 (0.12)	0.35 (0.20)	0	3.87 (0.50)	2.48 (0.27)	6.92 (0.44)	0.02 (0.01)	0.79 (0.32)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XVI - Changes in the quality characteristics of *Malawi Moringa oleifera* (chloroform:methanol) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	Acidity (% as oleic acid)	Peroxide value (meq O ₂ /kg of oil)	Iodine value (g of I ₂ /100 g of oil)	Viscosity (mPa · s)	Smoke point (°C)	Polar compounds (g/100 g oil)
0	0.98 (0.42)	0.15 (0.09)	65.59 (0.50)	71.00 (0.18)	206 (2.0)	3.24 (0.92)
2	1.04 (0.56)	0.90 (0.35)	65.55 (0.66)	71.22 (0.97)	205 (1.0)	3.51 (0.72)
4	1.11 (0.34)	1.78 (1.05)	65.39 (0.39)	71.55 (1.28)	203 (2.0)	3.98 (0.63)
6	1.27 (0.29)	2.97 (0.86)	65.17 (0.44)	71.95 (0.88)	201 (1.0)	4.75 (1.25)
8	1.53 (0.55)	3.99 (0.44)	64.90 (1.04)	72.48 (0.63)	199 (2.0)	5.82 (0.98)
10	1.96 (0.72)	3.55 (0.70)	64.58 (0.87)	73.36 (1.17)	196 (3.0)	7.32 (1.09)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XVII - Changes in the quality characteristics of *Malawi Moringa oleifera* (chloroform:methanol) oil during frying cod at 175°C

Time (h)	DETERMINATION					
	E ₁ cm at 232 nm	Induction period (h)	α-tocopherol (mg/kg oil)	γ-tocopherol (mg/kg oil)	δ-tocopherol (mg/kg oil)	Colour red. yellow
0	1.19 (0.16)	31.80 (0.60)	70.06 (7.08)	29.29 (1.85)	22.32 (1.32)	15.50, 79.00 (3.10), (2.70)
2	1.26 (0.24)	31.42 (0.55)	69.10 (3.43)	26.47 (2.93)	18.90 (1.84)	15.61, 79.00 (3.20), (1.30)
4	1.44 (0.38)	30.93 (0.67)	66.74 (0.94)	20.85 (1.97)	13.17 (1.23)	15.79, 79.80 (0.66), (0.70)
6	1.83 (0.55)	30.14 (0.48)	64.29 (1.45)	13.08 (3.12)	5.10 (2.17)	16.08, 79.90 (1.80), (0.40)
8	2.45 (0.64)	28.91 (0.88)	60.06 (1.84)	3.04 (1.14)	0	16.87, 79.90 (0.80), (0.50)
10	3.47 (0.86)	27.16 (0.74)	53.26 (1.70)	0	0	17.82, 80.60 (1.30), (1.40)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.

TABLE XVIII - Fatty acid composition of the *Malawi Moringa oleifera* (chloroform:methanol) oil during frying cod at 175°C

Time (h)	FATTY ACIDS														
	8:0	14:0	16:0	16:1 ω9	16:1 ω7	17:0	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1cis	26:0
0	0.02 (0.02)	0.10 (0.06)	5.46 (0.30)	0.11 (0.04)	0.11 (0.73)	0.04 (0.01)	5.82 (0.29)	67.80 (0.65)	0.69 (0.35)	0.19 (0.05)	3.77 (0.51)	2.61 (0.31)	6.78 (0.33)	0.11 (0.06)	0.96 (0.08)
2	0.03 (0.02)	0.11 (0.07)	5.46 (0.14)	0.11 (0.08)	1.09 (0.36)	0.06 (0.03)	5.84 (0.37)	67.77 (0.51)	0.65 (0.56)	0.17 (0.11)	3.78 (0.27)	2.61 (0.19)	6.80 (0.57)	0.09 (0.07)	0.95 (0.40)
4	0.04 (0.03)	0.12 (0.08)	5.48 (0.37)	0.10 (0.06)	1.07 (0.29)	0.07 (0.04)	5.88 (0.43)	67.74 (0.44)	0.62 (0.39)	0.13 (0.10)	3.80 (0.40)	2.59 (0.36)	6.82 (0.61)	0.08 (0.04)	0.92 (0.51)
6	0.07 (0.04)	0.13 (0.11)	5.49 (0.27)	0.09 (0.05)	1.05 (0.34)	0.08 (0.06)	5.90 (0.51)	67.73 (0.26)	0.51 (0.40)	0.09 (0.07)	3.81 (0.17)	2.57 (0.14)	6.84 (0.70)	0.05 (0.03)	0.90 (0.61)
8	0.09 (0.06)	0.15 (0.12)	5.52 (0.54)	0.08 (0.04)	1.03 (0.19)	0.10 (0.09)	5.93 (0.29)	67.70 (0.49)	0.37 (0.30)	0.03 (0.01)	3.83 (0.48)	2.55 (0.14)	6.86 (0.39)	0.04 (0.02)	0.87 (0.40)
10	0.11 (0.07)	0.20 (0.11)	5.57 (0.41)	0.05 (0.03)	1.01 (0.46)	0.11 (0.07)	6.00 (0.36)	67.64 (0.49)	0.23 (0.16)	0	3.86 (0.40)	2.50 (0.38)	6.89 (0.48)	0.02 (0.01)	0.86 (0.43)

Values are means of triplicate determinations and percentage coefficient of variation is given in parenthesis.