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Physicochemical Characteristics of Some Imported Edible Vegetable Oils and Fat Marketed in Dar es Salaam

Othman O.C. * and Ngassapa F.N.
Chemistry Department, University of Dar es Salaam,
P.O. Box 35061, Dar es salaam, Tanzania.

ABSTRACT

The physicochemical properties (refractive index, saponification value, Free Fatty Acid content, iodine value, tocopherol content, acid value, peroxide value) of seven imported edible vegetable oils and fat sold in shops in Dar es Salaam were assessed using standard procedures. Also determined were the levels of these properties with respect to shelf storage of the products. When the measurement results were compared with physicochemical properties recommended by the Codex Alimentarius Commission of FAO/WHO and the specification of Tanzania Bureau of Standards, the imported edible vegetable oils and fat were found to be of good quality but of poor storage stability. For long storage life, the edible vegetable oils and fat should be stored in opaque (coloured) bottles, fully filled and tightly sealed.

Keywords: edible oil, physicochemical properties, storage stability, sunflower oil, palm oil

***** To whom correspondence may be addressed: othman@chem.udsm.ac.tz/ o_chande@yahoo.co.uk

INTRODUCTION

Many people in developing countries especially children under the age of five years suffer from acute and chronic protein and energy deficiencies. At the current trend of population increase, it is projected that, by the year 2010 there will be as many 300 millions chronically undernourished people in sub-Saharan Africa (Harsch 1997). There is definitely a need for food production to keep pace with the increase in world population. In order to achieve this national development strategies in many agriculture-based tropical countries are now biased towards increasing the diversity of consumable food products in order to alleviate malnutrition and stress on promotion and broadening of agricultural based industries to ensure that their products are both wholesome and safe.

The dietary roles of edible oils and fats are highly recognized. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have recommended an average daily intake of 55 g-fat per capita to compliment the requirement for energy (Kabyemela et al 1992) and a 20-30% conversion rate for fat to energy to ensure good health (WHO 1994). Vegetable oils and fats have wide application in foods where they are used in frying, salad dressing, shortening of pasty, margarine, cooking and ice cream manufacture. In Tanzania, vegetable oils and fat constitute about 80-85% of edible oils and fat consumed by the public (Fupi and Mørk 1982) but little is known about their quality with respect to storage stability and public health. This paper describes the quality of some imported edible vegetable oils and fat found marketed in Dar es Salaam, Tanzania.

EXPERIMENTAL

Samples: Imported edible vegetable oils and fat, eight brands (Table 1), were randomly collected, off the shelf, in shops within Dar es Salaam. Five samples of each brand were collected during the sampling exercise.

Table 1 Edible oils and fat, their brand and manufacturer names, collected off shelves from shops around Dar es Salaam

Type of Oil	Brand Name*	Manufacturer
(a) Sunflower oil	(i) Pride	Pride Oil Product Ltd., England.
(b) Corn oil	(i) Corona	Ngo Chew Hong Edible Oil Pte Ltd, Singapore.
	(ii) Pride	Pride Oil Product Ltd, England.
	(iii) Suna	Rift Valley Products Ltd, Kenya.
(c) Palm oil	(i) Maama	Maama oil refineries Ltd, Malaysia.
	(ii) Oki	Ngo Chew Hong Edible Oil Pte Ltd, Singapore.
(d) White cooking fat	(i) Kimbo	BIDCO Oil Refineries Ltd, Kenya.

* All brands indicated an expiry date of about a year at the time the oils were bought

Reagents: Analytical grade hydrochloric acid, sulphuric acid, ether, potassium iodide, sodium thiosulphate, diethyl ether, iodine, ethanol, sodium hydroxide, sodium sulphate, potassium hydroxide, chloroform and glacial acetic acid were used.

Equipment: A Sartorius digital balance (PL303), Electromantle (UK) refluxing equipment, a Ciba Corning Colorimeter (Chroma model 252) and an Abbe (UK) refractometer were used in the determination measurements.

Methods: All the samples collected were analyzed. Each sample was filled into two 250 cm^3 glass bottles that were then sealed airtight. One of these glass bottles was stored in a dark room while the other was left in ambient light. Each sample was also poured into a 500 cm^3 open beaker and initial refractive indices (RI), tocopherol, Free Fatty Acid (FFA) content, acid (AV), peroxide (PV), saponification (SV) and iodine (IV) values for the oils and fat were determined.

Thereafter every ten days, over a storage period of 60 to 90 days, aliquots of the samples were periodically withdrawn from the open beaker and sealed bottles and analyzed for FFA, AV and PV.

The refractive indices, η^{40}_{D}, (RI), of the oils and fat samples were measured using the Abbe refractometer connected to a thermostatically controlled water bath that maintained the temperature of the refractometer at 40 ± 0.1 ^{o}C. The determination of refractive indices was done following the procedures of Cocks and van Rede (1997).

Free fatty acid was determined, as percent by mass oleic, palmitic or lauric acid, and saponification value, the number of milligrams of potassium hydroxide required to neutralize the fatty acids resulting from complete hydrolysis of one gram of oil or fat, was determined using the procedures adopted by Jayaraman (1985).

The peroxide value (PV), the weight (mg) of active oxygen contained in one gram of the oil or fat, and the iodine value (IV), the number of grams of iodine absorbed by 100 parts by weight of the oil or fat, were determined following the method of the AOAC as described by Horwitz (2002).

The acid value (AV) was determined titrimetrically using the procedure of ISO 660 (1996) whereas tocopherol (vitamin E) content was obtained using the procedure described by Egan et al (1981). Capsules containing 100-mg α-tocopheryl acetate I.P. were used as standards.

RESULTS AND DISCUSSION

Table 2 contains the summarized standard requirement for essential composition and quality of oils and fat as specified by the Codex Alimentarius Commision (CAC) (FAO/WHO 1994) and by the Tanzania Bureau of Standards (TBS). The measurement results obtained are presented in Tables 3 to 9. The measured initial physicochemical properties of the imported edible vegetable oils and fat are presented in Table 3. The final physicochemical properties of the investigated edible oils and fat after sixty days of storage under specified conditions are presented in Table 9. Tables 4, 5 and 6 show the measured acid value, peroxide value and Free fatty acid content respectively for samples

exposed to ambient conditions. The peroxide values for the edible vegetable oils and fat samples exposed to light only are presented in Table 7. The results for peroxide determinations of the oils which were stored in the dark in airtight containers are presented in Table 8.

Table 2 Recommended (standard) physicochemical characteristics of edible oils as given by FAO/WHO (1994) and by Tanzania Bureau of Standards (TBS)

Oil type	RI at 40 °C	SV	IV (Wijs)	FFA as % Oleic acid	Acid value mg KOH per gram	Peroxide Value meq/Kg	Tocopherol
FAO/WHO STANDARDS							
Sunflower	1.467-1.469	188-194	110-143	0.085	≤ 0.6	≤ 10	50
Cottonseed	1.458-1.466	189-198	99-119	0.225	≤ 0.6	≤ 10	50
Corn oils	1.473-1.476	187-193	103-128	0.100	≤ 0.6	≤ 10	50
Palm oils	1.449–1.455*	190-209	50 - 55	1.376	≤ 0.6	≤ 10	50
TANZANIA STANDARDS (TZS 271: 1997 and TZS 272: 1986)							
Sunflower	1.464-1.480	188-194	110-143	0.085	≤ 0.5	≤ 3	Not limited
Cottonseed	1.463-1.466	190-198	99-112	0.225	≤ 0.5	≤ 3	Not limited
Corn oils	1.471-1.476	187-193	103-128	0.105	≤ 0.5	≤ 3	Not limited
Palm oils	1.449-1.455*	190-202	50.6-55.1	1.376	≤ 0.5	≤ 3	Not limited

* at 50 °C

Refractive Index

The oils and fat exhibited different refractive indices. The physicochemical values for oils of the same type though from different manufacturers were quite similar. This trend suggests that refractive index could be used in the preliminary identification of the oils and fat. Refractive indices did not show any significant change after sixty days of exposure to atmospheric light and oxygen (Tables 1 and 9) suggesting that during storage atmospheric oxygen and light do not affect refractive indices significantly. Therefore this parameter cannot be used in the determination of the rate of deterioration of oils and fat during storage.

Table 3 Initial physicochemical characteristics of the edible oils and fat samples from shops in Dar es Salaam

Oil brand name	Refractive Index (RI) at 40 ^{o}C	Saponification value (SV)	Iodine value (IV)	FFA % Oleic acid	Peroxide value (PV) (meq/kg)	Acid Value (AV)	Total Tocopherol (mg/kg)
Pride*	1.468	196	129	0.056	6.6	0.11	79
Corona	1.467	195	124	0.127	15.9	ND	86
Pride**	1.467	194	122	0.166	2.6	0.34	94
Suna	1.467	197	128	0.434	3.2	0.87	66
Maama	1.456	207	55	0.254	6.2	0.50	35
Oki	1.455	213	53	0.176	2.8	0.35	27
Kimbo	1.459	210	51	0.221	0.9	0.42	45
Av. Error	± 0.004	± 1	± 0.7	± 0.009	± 0.02	± 0.5	± 1

* Sunflower oil ** Corn oil

All results are averages of five samples of the same brand of oil

RI – Refractive Index

SV – Saponification Value

IV – Iodine Value

FFA – Free Fatty Acid

Table 4 Acid values (mg-KOH/g-oil) for edible oils and fat exposed to both atmospheric oxygen and light

Oil/ fat brand name	Storage time in days						
	0	10	20	30	40	50	60
Pride*	0.11	0.11	0.11	0.11	0.11	0.14	0.17
Corona	ND	ND	ND	ND	ND	ND	ND
Pride**	0.34	0.34	0.35	0.36	0.38	0.39	0.39
Suna	0.87	0.91	0.91	0.92	0.95	0.95	1.01
Maama	0.50	0.53	0.56	0.62	0.66	0.76	0.98
Oki	0.35	0.35	0.45	0.48	0.51	0.53	0.59
Kimbo	0.42	0.50	0.64	0.69	0.72	0.77	0.88
Av. error	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.03	± 0.04

* Sunflower oil ** Corn oil

Iodine Value

Iodine values for all the edible oils and fat studied were within the specification recommended by FAO/WHO and TBS. Sunflower oils exhibited higher iodine value then corn oils. This observation suggests that sunflower oils are richer in unsaturated fatty acids than Corn and Palm oils. Of the seven samples Kimbo (cooking fat) had the lowest iodine value and Pride (sunflower) the highest.

The low iodine value for Kimbo may have contributed to its greater oxidative storage stability according to Perkins (1992). The oxidative and chemical changes in oils during storage are characterized by increase in FFA content and a decrease in the total unsaturation of oils (Perkins 1992). Iodine values for the corn oils (Corona, Pride and Suna) compared well with the FAO/WHO and TBS recommended values.

Free Fatty Acid Content

The edible oils and fat had varied FFA content. This is attributed to the natural variation from one variety and sample to another, moisture contents, refining and deodorization. The largest initial values were obtained in Suna oil (Corn, 0.87 mg/g-KOH, 0.44 % oleic) and the lowest in Pride (sunflower, 0.11 mg/g-KOH, 0.056 % oleic). Free Fatty Acid values were lower for all oils as compared to the values recommended by FAO/WHO and TBS (1.376). This might be attributed to the variation in the refining and deodorization processes used and also the moisture contents.

Table 5 Free Fatty Acid (as % oleic acid) for edible oils and fat exposed to both atmospheric oxygen and light

Oil /fat brand name	Storage Time in days						
	0	10	20	30	40	50	60
Pride*	0.056	0.056	0.059	0.061	0.066	0.070	0.084
Corona	0.127	0.15	0.16	0.18	0.19	0.19	0.21
Pride**	0.166	0.16	0.15	0.18	0.19	0.19	0.19
Suna	0.434	0.45	0.46	0.46	0.48	0.48	0.51
Maama	0.254	0.272	0.279	0.287	0.317	0.387	0.497
	0.247 [a]	0.25[a]	0.25[a]	0.26[a]	0.28[a]	0.34[a]	0.45[a]
Oki	0.176	0.18	0.23	0.24	0.26	0.27	0.29
	0.15[a]	0.17[a]	0.21[a]	0.22[a]	0.23[a]	0.24[a]	0.27[a]
Kimbo	0.221	0.25	0.32	0.34	0.36	0.39	0.44
Av. Error	± 0.01	± 0.02	± 0.02	± 0.03	± 0.02	± 0.02	± 0.02

* Sunflower oil ** Corn oil [a] As palmitic acid

Saponification Value

Saponification value gives a measure of the average length of the fatty acid chain that makes up a fat. Thus of the three types of oils investigated, the Oki (palm type) had a saponification value above the respective CAC Standards (Table 2) and as recommended by the Tanzanian standards for edible vegetable oil (Table 2). An elevated saponification value in Oki could be attributed to the presence of high FFA content (Hui 1992). Pride (sunflower type) had a slightly elevated saponification value as compared to values recommended by the CAC Standards (Table 2) and the Tanzanian standards (Table 2).

Table 6 Peroxide values (meq/kg-oil) for edible oils and fat exposed to atmospheric oxygen and light

Oil /fat brand name	Storage time in days									
	0	10	20	30	40	50	60	70	80	90
Pride*	6.6	10.7	18.2	24.3	36.5	42.1	71.3	89.4	101.3	119.5
Corona	15.9	12.7	19.0	29.0	37.9	53.9	64.9	72.9	48.9	94.5
Pride**	2.6	2.7	2.9	3.9	6.0	14.1	19.9	26.3	35.3	47.6
Suna	3.2	7.9	18.5	30.8	43.4	53.7	78.4	86.7	94.9	111.4
Maama	6.2	7.7	8.0	12.6	13.2	20.7	24.1	24.1	20.8	32.9
Oki	2.8	4.6	6.2	7.4	10.4	11.9	13.8	15.5	22.6	22.7
Kimbo	0.9	1.3	2.5	3.9	5.2	5.8	5.4	11.8	12.4	16.3
Av. Error	± 0.1	± 0.1	± 0.1	± 0.1	± 0.1	± 0.2	± 0.2	± 0.2	± 0.2	± 0.2

* Sunflower oil ** Corn oil

Peroxide Values

Initial peroxide values for the edible oils and fat ranged between 0.9 and 15.9 meq/kg-oil. The highest value was found in Corona corn oil (5.9 meq/kg-oil) and the lowest value from Kimbo cooking fat (0.9 meq/kg-oil). The values for all the edible oils were within the FAO/WHO and TBS standards for edible vegetable oils. Peroxide values increased during storage. The rate of peroxidation differed from oil to oil as related to different treatment to which the oils were subjected. In general the peroxide value increased with storage time. Oils exposed to both atmospheric oxygen and light showed a much larger increase in peroxide value during storage.

Table 7 Peroxide values (meq/kg-oil) for edible oils and fat exposed to light only

Oil /fat brand name	Storage Time in days						
	0	10	20	30	40	50	60
Pride*	6.6	7.7	10.9	27.0	33.3	41.3	60.8
Corona	15.9	24.2	26.4	32.3	36.7	44.8	51.7
Pride**	2.6	4.4	6.1	7.1	8.6	9.7	11.4
Suna	3.2	3.6	6.2	13.8	28.5	34.9	47.8
Maama	6.2	5.8	8.9	10.6	12.6	14.8	17.6
Oki	2.8	3.6	5.6	8.6	11.5	13.2	14.5
Kimbo	0.9	1.7	1.9	2.9	3.7	4.6	5.4
Av. Error	± 0.2	± 0.2	± 0.2	± 0.2	± 0.3	± 0.2	± 0.3

* Sunflower ** Corn oil

Increase of peroxide value with storage time has also been reported by Kamau and Nanua (2008) for locally produced Kenyan Sunflower oil. Greater average increase in peroxide values of oil with

storage can probably be related to the respective total unsaturation of the fatty acids (Hui 1992). Oils and fat samples stored in airtight condition in the dark had comparatively lower increase in peroxide value compared to oils /fat exposed to light only as well as oils /fat samples exposed to both atmospheric oxygen and light (Table 8). The trend shows that when the edible oils and fat are not exposed to air and light, the oils/fat show very little increase in peroxide value and thus samples maintain their initial properties.

Acid value

The acid value measured for the edible oils and fat ranged from 0.11 to 1.01 mg-KOH/g oil. AV increases with days of storage under ambient conditions. Suna and Maama oils had initial AV higher than specification values of the FAO/WHO and TBS. Kimbo fat and Oki oil samples initial AV conform to the standards of FAO/WHO and TBS but contravene the standards, under ambient conditions, after 20 days and 40 days of ambient storage respectively.

Table 8 Peroxide values (meq/kg-oil) for edible oils and fat subjected to different treatment procedures

Oil /fat brand name	Initial Values	Oil /fat stored airtight in the dark (90 days)	Oil /fat exposed to light only (60 days)	Oil / fat at atm. oxygen and light (60 days)	Oil / fat exposed to atm. oxygen and light (90 days)
Pride*	6.6	13.4	60.8	71.2	119.5
Corona	15.9	31.4	51.7	64.9	94.5
Pride**	2.6	4.2	11.4	19.9	47.6
Suna	3.2	10.0	47.8	78.4	111.6
Maama	6.2	7.7	17.6	24.1	32.9
Oki	2.8	4.6	14.5	13.8	22.7
Kimbo	0.9	2.4	5.4	8.4	16.3
Av. Error	± 0.2	± 0.2	± 0.3	± 0.2	± 0.2

* Sunflower oil ** Corn oil

Tocopherol content

Tocopherol (vitamin E) contents detected in the edible oils and fat brands studied ranged from 27 to 94 mg/100-g of oil/fat (Table 3), the lowest being for Oki palm oil and the highest being for Pride corn oil. Tocopherol contents for Maama and Oki palm oil and Kimbo cooking fat were found to be within permissible values for FAO/WHO and TBS standards, while contents for Pride and Suna corn oils and Pride and Corona sunflower oils exceeded the permissible values of FAO/WHO. Results showed that oils with larger tocopherol contents showed longer induction periods.

Table 9 Final physicochemical characteristics of the imported edible oils and fat after 60 days of storage in ambient conditions (exposed to air and light)

Oil brand name	Refractive index at 40 ºC	Free fatty acid (as % oleic acid)	Acid value (mg-KOH/g)	Peroxide value (meq/kg-oil)
Pride*	1.468	0.084	0.17	71.2
Corona	1.468	0.21	ND	64.9
Pride**	1.468	0.19	0.39	19.9
Suna	1.467	0.51	1.01	78.4
Maama	1.456	0.497	0.98	24.1
Oki	1.455	0.29	0.59	13.8
Kimbo	1.459	0.44	0.88	8.4
Av. Error	± 0.004	± 0.02	± 0.04	± 0.02

* Sunflower ** Corn oil ND Not determined

CONCLUSION

Before storage, the imported edible vegetable oils physicochemical characteristics largely conform to both local standards set by TBS and international standard of the FAO/WHO. The physicochemical properties changed significantly depending on storage time and also with the mode of storage. With storage the quality of oils deteriorated. The peroxide value of the oils and fat exposed to atmospheric oxygen and light being the highest changing property. Oils kept in tightly sealed containers and stored in the dark exhibited very minor changes in their physicochemical properties.

RECOMMENDATION

Edible vegetable oils and fat should be stored not exposed to atmospheric conditions i.e. not exposed to light and atmospheric air. Therefore it is recommended that the edible vegetable oils and fat should be marketed in tightly closed opaque containers that do not allow light to fall onto the oil or fat product so that the product can have a longer stable storage.

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